University of Mumbai

No. AAMS_UGS/ICC/2022-23/ 105

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office circular No. UG/166 of 2016-17 dated 19th November, 2016 relating to the revised syllabus F.Y.B.Sc.(Chemistry) (Sem . I & II) (CBCS).

They are hereby informed that the recommendations made by the Board of Studies in **Chemistry** at its meeting held on 09th June, 2022 and subsequently passed in the Faculty and then by the Board of Deans at its meeting held on 5th July, 2022 **vide** item No. 6.5 (R) have been accepted by the Academic Council at its meeting held on 11th July, 2022 **vide** item No. 6.5 (R) and that in accordance therewith, the revised syllabus of F.Y.B.Sc.(Chemistry) (Sem . I & II) (CBCS). has been brought into force with effect from the academic year 2022-23. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
11th October, 2022

(Dr. Shailendra Deolankar)
I/c Registrar

To

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.5(R)/11/07/2022

****

No. AAMS_UGS/ICC/ 2022-23/ 105 11th October, 2022

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies Chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Information & Communication Technology,
6) The Co-ordinator, MKCL.

(Dr. Shailendra Deolankar)
I/c Registrar

Desktop/Circular Faculty of Science/priya

Copy to :-

1. **The Deputy Registrar, Academic Authorities Meetings and Services (AAMS),**
2. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
5. **The Deputy Registrar, Executive Authorities Section (EA),**
6. **The Deputy Registrar, PRO, Fort, (Publication Section),**
7. **The Deputy Registrar, (Special Cell),**
8. **The Deputy Registrar, Fort/ Vidyanagari Administration Department (FAD) (VAD), Record Section,**
9. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

1. **P.A to Hon'ble Vice-Chancellor,**
2. **P.A Pro-Vice-Chancellor,**
3. **P.A to Registrar,**
4. **All Deans of all Faculties,**
5. **P.A to Finance & Account Officers, (F.& A.O),**
6. **P.A to Director, Board of Examinations and Evaluation,**
7. **P.A to Director, Innovation, Incubation and Linkages,**
8. **P.A to Director, Board of Lifelong Learning and Extension (BLLE),**
9. **The Director, Dept. of Information and Communication Technology (DICT) (CCF & UCC), Vidyanagari,**
10. **The Director of Board of Student Development,**
11. **The Director, Department of Students Walfare (DSD),**
12. **All Deputy Registrar, Examination House,**
13. **The Deputy Registrars, Finance & Accounts Section,**
14. **The Assistant Registrar, Administrative sub-Campus Thane,**
15. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
16. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
17. **The Assistant Registrar, Constituent Colleges Unit,**
18. **BUCTU,**
19. **The Receptionist,**
20. **The Telephone Operator,**
21. **The Secretary MUASA**

for information.

AC – 11/07/2022

ItemNo. 6.5 (R)

UNIVERSITYOF MUMBAI

Revised Syllabus for

F.Y.B.Sc.

(Chemistry)

Semester:I&II

(CBCS)

(Witheffectfrom the academic year 2022-23)

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	F.Y.B. Sc. (Chemistry)
2	Eligibility for Admission	**12th Science of all recognized Board**
3	Passing Marks	40%
4	Ordinances / Regulations (if any)	
5	No. of Years /Semesters	Two
6	Level	UG
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic Year	From Academic Year: 2022-2023

Date:

Dr Vishwanath Patil
Chairman BoS in Chemistry

Signature:

Dr. Anuradha Majumdar
Dean, Science and Technology

Proposed syllabus for CBCS

F. Y. B. Sc. Chemistry

For the subject of chemistry, there shall be two papers for 45 lectures each comprising of three units of 15 L each.

Semester-I

1. Paper-I / II (General Chemistry) Unit-I will be for PhysicalChemistry
2. Paper-I / II Unit-II will be for Inorganic Chemistry
3. Paper- I / II Unit-III will be for OrganicChemistry.

Semester-II

1. Paper-I /II (General Chemistry) Unit-I will be for PhysicalChemistry
2. Paper-I / II Unit-II will be for Inorganic Chemistry
3. Paper-I / II Unit-III will be for OrganicChemistry

Choice Based Credit System F.Y.B.Sc. Chemistry
Syllabus To be implemented from the
Academic year 2022-2023

SEMESTER I

Course Code	Unit	Topic	Credits	L/per week
USCH101	I	Chemical Thermodynamics	2	1
		Chemical calculations		
	II	Atomic structure		1
		Periodic Table and periodicity		
	III	Basics of Organic Chemistry:		1
		Bonding and Structure of organic compounds		
		Fundamentals of organic reaction Mechanism		
USCH102	I	Chemical Kinetics	2	1
		Liquid States		
	II	Comparative Chemistry of Main Group elements		1
	III	Stereochemistry I		1
USCHP1	Chemistry Practical		2	6

SEMESTER II

Course Code	Unit	Topic	Credits	L/per week
USCH201	I	Gaseous State	2	1
		Electrochemistry – I		
		Chemical Equilibria and Thermodynamic Parameters		
	II	Concept of Qualitative Analysis		1
		Acid Base Theories		
	III	Chemistry of Aliphatic Hydrocarbons		1
USCH202	I	Ionic Equilibria	2	1
		Photochemistry Molecular Spectroscopy		
	II	Chemical Bond and Reactivity		1
		Oxidation Reduction Chemistry		
	III	Stereochemistry II		1
		Aromatic Hydrocarbons		
USCHP2		Chemistry Practical	2	6

Programme Outcomes
B.Sc. Chemistry

The student graduating with the Degree B.Sc Chemistry should be able to acquire;

i) Core competency: Students will acquire core competency in the subject Chemistry, and in allied subject areas.

ii) A systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, and all other related allied chemistry subjects.

iii) Students will be able to use the evidence-based comparative chemistry approach to explain chemical synthesis and analysis.

iv) Students will be able to characterize, identify and separate components of organic or inorganic origin and will also be able to analyze them by making use of the modern instrumental methods learned.

v) Students will be able to understand the basic principle of equipmentand instruments used in the chemistry laboratory.

vi) Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry

vii) The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

viii) Appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues, and key issues facing our society in terms of energy, health, and medicine.

ix) Lifelong learner: The course curriculum is designed to inculcate a habit of learning continuously through the use of advanced ICTtechniques and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

SEMESTER I
Paper I
UNIT I

1.1	**Chemical Thermodynamics (10 L)** **Thermodynamic terms;** System, surrounding, boundaries, types of system, Intensive and Extensive properties, State functions and path functions, Thermodynamic processes. **First law of thermodynamics:** Concept of heat (q), work (w), internal energy (U), enthalpy, heat capacity, relation between heat capacities, sign conventions, calculations of heat, work, internal energy and enthalpy (H). **Thermochemistry:** Heat of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculations of bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation (Numerical problems expected wherever necessary)
1.2	**Chemical Calculations: (5L)** Methods of expressing concentration of solutions: Normality, Molarity, Formality, Mole fractions, Weight ratio, Volume ratio, Weight to volume ratio, ppm, ppb, millimoles, milliequivalents, Preparation of solutions. (Numerical problems expected wherever necessary)
	UNIT II
2.1	**Atomic structure:(8 L)**
	Historical perspectives of the atomic structure; J. J. Thomson Model, Rutherford's Atomic Model- alpha particle scattering experiment, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Structureof hydrogenatom. **Hydrogenicatoms:** 1. Simple principles of quantummechanics 2. Atomicorbitals i) Hydrogenic energylevels ii) Shells, subshells and orbitals iii) Electronspin iv) Radial shapes oforbitals v) Angular shapes oforbitals. Aufbauprinciple, Hund's rule of maximum multiplicity and Pauli exclusion principle
2.2	**Periodic Table and periodicity:(7 L)** **Long form of Periodic Table;** Classification for elements as main group, transition and inner transition elements. **Periodicity in the following properties:** Atomic and ionic size, electron gain enthalpy, ionization enthalpy, effective nuclear charge (Slater's rule), electronegativity, Pauling and Mulliken methods. (Numerical problemsexpected, wherever applicable.)
	Unit III
3	**Basics of Organic Chemistry**
3.1	**Classification and Nomenclature of Organic Compounds: (5L)** **Nomenclature of mono and bi-functional aliphatic compounds on the basis of priority order of the following classes of compounds**: Alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid

	derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines and their cyclic analogues.
3.2	**Bonding and Structure of organic compounds: (4L)** **Hybridization**: sp3, sp2, sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide) **Overlap of atomic orbitals:** Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules. **Shapes of molecules;** Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne).
3.3	**Fundamentals of organic reaction mechanism: (6L)** **Electronic Effects:** Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications. Dipole moment**;** Organic acids and bases; their relative strengths. **Basic terms & concepts**:: Homolytic and Heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Nucleophilicity and basicity, Electrophilicity and acidity. **Types (primary, secondary, tertiary, allyl, benzyl), shape and their relative stability of the following reactive intermediates**: i. Carbocations ii. Carbanions and iii. Free radicals **Introduction to types of organic reactions:** Addition, Elimination and Substitution reaction. (With one example of each)
	Semester- I **Paper – II** **Unit – I**
1.1	**Chemical Kinetics: (8L)** Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, Integrated rate equation of first order and Second order reactions (with equal initial concentration of reactants) Determination of order of reaction by a) Integration method b) Graphical method c) Ostwald's isolation method d) Half time method, Effect of temperature on the rate of reaction, Concept of activation energy and its calculation from Arrhenius equation (derivation not expected). (Numerical problems expected wherever necessary).
1.2	**Liquid State: (7L)** **Surface tension:** Introduction, methods of determination of surface tension by drop number method **Viscosity:** Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer **Refractive index**: Introduction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer. **Liquid crystals**: Introduction, Classification and structure of thermotropic phases (Nematic, Smectic and Cholesteric phases), applications of liquid crystals. (Numerical problems expected wherever necessary).
	Unit II
2	**Comparative chemistry of MainGroupElements:(15L)**

	Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behavior of second period elements, allotropy, catenation, diagonal relationship. Comparative chemistry of oxides and hydroxides of group I and group II elements. Some important compounds- **$NaHCO_3$, Na_2CO_3, CaO, $CaCO_3$**; oxides of carbon, oxides of Sulphur and Nitrogen with respect to environmental aspects like greenhouse effect, photochemical smog and acid rain.
	Unit III
3	**Stereochemistry I: (15L)** Projection formulae: Flying Wedge projection, Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 - dichlorobutane) and their interconversions; **Geometrical isomerism in alkene and cycloalkanes**: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules. **Optical Isomerism:** Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Diastereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected). **Relative and absolute configuration**: D/L and R/S designations. **Conformational analysis of alkanes** (ethane, propane and n-butane); Relative stability with energy diagrams

Semester II
Paper I
Unit I

1.1	**Gaseous State (6L)** Kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (Qualitative discussion), Ideal gas laws, Deviation from ideal gas laws, Ideal and real gases, Reasons for deviation from ideal gas laws, Compressibility factor, Boyle's temperature, van der Waals equation of state, Critical phenomena, Relation between critical constants and van der Waals constants. (Numerical problems expected wherever necessary)
1.2	**Electrochemistry - I (4 L)** Conductance, specific conductance, equivalent conductance, molar conductance, Variation of molar conductance with concentration of strong and weak electrolyte. Reversible electrodes, Electrode potential, standard electrode potential, Galvanic cells, Conventions to represent the galvanic cells, Concept of emf of cell. (Numerical problems expected wherever necessary)
1.3	**Chemical Equilibria and Thermodynamic Parameters (5L)** Second law of thermodynamics, concept of entropy, Physical significance of entropy, Concept of free energy, Helmholtz and Gibbs free energy, Variation of free energy with temperature and pressure, Spontaneity and Physical significance of free energy. Re Reversible and irreversible reactions, equilibrium constants (Kc and Kp), relationship between Kc and Kp. Thermodynamic derivation of equilibrium constant (Numerical problems expected wherever necessary)
	Unit II

2	**Concept of Qualitative Analysis:(8 L)**
2.1	Testing of Gaseous Evolutes, Role of Papers impregnated with Reagents in qualitative analysis (with reference to papers impregnated with starchiodide, potassium dichromate, lead acetate, dimethylglyoxime and oxinereagents).
	Precipitation equilibria,Formation of precipitates like$AgCl$, $AgBr$, AgI and $BaSO_4$ effect of common ions, uncommon ions, oxidationstates, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations)
2.2	**Acid Base Theories: (7L)**
	Arrhenius, Lowry- Bronsted, Lewis, Solvent – Solute concept of acids and bases, Usanovich concept, Hard and Soft acids and bases, Applications of HSAB.
	Unit III
3	**Chemistry of Aliphatic Hydrocarbons**
3.1	**Carbon - Carbon sigma bonds: (3L)** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig reaction, free radical substitutions: Halogenation - relative reactivity and selectivity
3.2	**Carbon - Carbon pi bonds (12L):** **Formation of alkenes and alkynes by elimination reactions**: Mechanism of E1, E2, E1cb reaction. Saytzeff and Hofmann eliminations **Reactions of alkenes**: Electrophilic additions with mechanisms (Markownikoff / AntiMarkownikoff addition), Mechanism of oxymercuration - demercuration, hydroboration - oxidation, ozonolysis, reduction (catalytic and chemical), syn- and anti-dihydroxylation (oxidation), 1, 2- and 1, 4-addition reactions in conjugated dienes, Diels-Alder reaction. **Reaction of alkynes**: Acidity, Electrophilic and Nucleophilic additions with mechanisms. Hydration to form carbonyl compounds, Alkylation of terminal alkynes
	Semester II **Paper II** **Unit I**
1.1	**Ionic Equilibria: (7L)** Strong and weak electrolytes, degree of ionization, factors affecting degree of ionization,Ionization constant and ionic product of water, Ionization of weak acids and bases, Dissociation constants of mono-, di-, and tri-protic acids. pH scale, Buffer solutions, types of buffers, Derivation of Henderson equation for acidic and basic buffers, Buffer action, buffer capacity (Numerical problems expected, wherever necessary)
1.2	**Photochemistry (4L)** Laws of photochemistry, Quantum yield or efficiency, experimental determination of quantum yield, Reasons for low and high quantum yield, Primary and secondary processes. Photochemical reactions (with suitable examples), Photosensitizers and photosensitized reactions, Fluorescence, Phosphorescence and Chemiluminescence. (Numerical problems expected, wherever necessary)
1.3	**Molecular Spectroscopy: (4L)** Electromagnetic radiation, electromagnetic spectrum, Planck's equation, Interaction of electromagnetic radiation with matter; Absorption, Emission, Scattering, Electronic, Vibrational and Rotational transitions, Beer-Lamberts law.

	(Numerical problems expected, wherever necessary)
	Unit II
2.1	**Chemical Bond and Reactivity:(10 L)** Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for AB_n type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.
2.2	**Oxidation Reduction Chemistry: (5L)** Reductionpotentials, **Redox potentials: half reactions**; balancing redoxequations. **Applications of redoxchemistry**; Redox reagents in Volumetric analysis; a) I_2 b)$KMnO_4$
	Unit III
3.1	**Stereochemistry II: (5L)** **Cycloalkanes and Conformational Analysis: (5L)** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagram.
3.2	**Aromatic Hydrocarbons: (10L)** **Aromaticity:** Hückel's rule, anti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. **Electrophilic aromatic substitution:** halogenation, nitration, sulphonation and Friedel-Crafts alkylation/acylation with their mechanism, Directing effects of the groups

Reference Books:

Unit – I

1) Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2)
3) Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
4) Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
5) Keith J. Laidler& John H. Meiser, Physical Chemistry, 2nd Ed. (2004)
6) Puri B. R., Sharma L. R. &Pathania M. S. Principles of Physical Chemistry, Vishal Publishing Company, 2008
7) Ball, D. W. Physical Chemistry Thomson Press, India (2007).
8) Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
9) Engel, T. & Reid, P. *Physical Chemistry3rd Ed.*, Prentice-Hall (2012).
10) McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
11) Levine, I .N. *Physical Chemistry* 6th Ed.,Tata Mc Graw Hill (2010).

Unit II

1. Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
3. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970
4. Atkins, P.W. & Paula, J. Physical Chemistry, 10^{th} Ed., Oxford University Press, 2014. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India

Unit III

1. Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).2012
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
5. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994
6. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
7. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
8. Paula Y Bruice, Organic Chemistry, 7th Ed, Pearson education, Asia.2014
9. Graham Solomon, Fryhle, Dnyder, Organic Chemistry, Wiley publication. 12 th Ed,2016
10. Bahl and Bahl, Advanced Organic chemistry by S. Chand publication.2010
11. Peter Sykes. Guidebook to the mechanism in Organic chemistry ,6^{th}edition
12. D. Nasipuri.Stereochemistry of Organic Compounds,Principles and Applications, Second Edition

Chemistry lab.
Semester – I

Unit – I: Physical Chemistry

1) To prepare 0.1 N succinic acid and standardize the NaOH solution of different concentrations.
2) To determine the rate constant for the hydrolysis of ester using HCl as catalyst.
3) To determine enthalpy of dissolution of salt (KNO_3)
4) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature (Any two solutions).

Unit II: Inorganic Chemistry

1) Commercial analysis of (anytwo)
   a) Mineralacid
   b) Organicacid
   c) Salt of weak acid and strongbase.
2) Titration using double indicator: analysis of solution of $Na_2CO_3$and$NaHCO_3$

3) Gravimetric analysis
   a) To determine the percent purity of sample of $BaSO_4$containingNH_4Cl
   b) To determine the percent purity of ZnO containing$ZnCO_3$.

Unit III Organic Chemistry

1. Purification of organic compounds by recrystallization selecting suitable solvent (minimum 2 organic compounds to be given)
   (Learners are expected to report a) Solvent for recrystallization. b) Percentage Yield and the melting points of the purified compound.)

2. Basic principles of Organic compound characterization (minimum 4 Solid organic compounds)
   (Learners should perform Preliminary Tests, Solubility Test, obtain melting point and recrystallize the compound with given solvent)

Minimum 80 percent of practical must be completed in each term

Chemistry lab:
Semester - II

Unit – I: Physical Chemistry

1) To determine the amount of strong acid in the given solution by titrating against strong base conductometrically.
2) To determine the dissociation constant of weak acid (Ka) using Henderson's equation and the method of incomplete titration pH metrically.
3) To verify Beer-Lamberts law using $KMnO_4$ solution by colorimetric method.
4) To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.

Unit II Inorganic Chemistry

1) **Qualitative analysis: (5 mixtures to beanalyzed)**
   Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions(from amongst):

   Cations (from amongst): Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, K^+,NH_4^+

   Anions (from amongst):CO_3^{2-}, S^{2-}, SO^{2-}, NO_2^-, NO_3^-, Cl^-, Br^-, I^-, SO_4^{2-}, PO_4

(Scheme of analysis should avoid use of sulphide ion in any form for precipitation/ separation of cations.)

2) **Redox Titration:** To determine the percentage of copper(II) present in agiven sample by titration against a standard aqueous solution of sodium thiosulfate (iodometrytitration)

Unit III Organic Chemistry

1) **Characterization of organic compounds** containing C, H, (O), N, S, X elements

(6 solid/liquid Organic compounds)
(Preliminary Tests, Solubility/Miscibility Test, Detection of Elements, Detection of Functional group and determination of Physical constant)

Minimum 80 percent of practicals must be completed in each term

Reference Books

Unit I:Physical Chemistry

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
2) Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).
3) Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
4) Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed*.; McGraw-Hill: New York (2003).
5) Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Unit II: Inorganic Chemistry

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
2) Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6thEd.,* Pearson, 2009.

Unit III: Organic Chemistry

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
2) Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
3) Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
4) Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

University of Mumbai

No. AAMS_UGS/ICC/2023-24/25

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office Circular No. UG/230 of 2017-18 dated 27th August, 2017 relating to the revised syllabus as per the (CBCS) for the S.Y.B. Sc. Chemistry (Sem - III & IV).

They are hereby informed that the recommendations made by the Board of Deans at its meeting held on 27th June, 2023 **vide** item No. 6.1 (R) have been accepted by the Academic Council at its meeting held on 27th June, 2023 **vide** item No. 6.1 (R) and that in accordance therewith, the **revised syllabus of S.Y.B. Sc. (Chemistry) (CBCS) (Sem – III & IV)** has been brought into force with effect from the academic year 2023-24.

(The said circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
13th July, 2023

(Prof. Sunil Bhirud)
I/c. REGISTRAR

To

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.1(R) /27/06/2023

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies **Chemistry**,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Information & Communication Technology,
6) The Co-ordinator, MKCL.

Copy for information and necessary action :-

1. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
2. **College Teachers Approval Unit (CTA),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)**
5. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
6. **The Deputy Registrar, Executive Authorities Section (EA)**
   He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
7. **The Deputy Registrar, PRO, Fort, (Publication Section),**
8. **The Deputy Registrar, Special Cell,**
9. **The Deputy Registrar, Fort Administration Department (FAD) Record Section,**
10. **The Deputy Registrar, Vidyanagari Administration Department (VAD),**

Copy for information :-

1. **The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,**
   He is requested to upload the Circular University Website
2. **The Director of Department of Student Development (DSD),**
3. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**
4. **All Deputy Registrar, Examination House,**
5. **The Deputy Registrars, Finance & Accounts Section,**
6. **The Assistant Registrar, Administrative sub-Campus Thane,**
7. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
8. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
9. **P.A to Hon'ble Vice-Chancellor,**
10. **P.A to Pro-Vice-Chancellor,**
11. **P.A to Registrar,**
12. **P.A to All Deans of all Faculties,**
13. **P.A to Finance & Account Officers, (F & A.O),**
14. **P.A to Director, Board of Examinations and Evaluation,**
15. **P.A to Director, Innovation, Incubation and Linkages,**
16. **P.A to Director, Department of Lifelong Learning and Extension (DLLE),**
17. **The Receptionist,**
18. **The Telephone Operator,**

Copy with compliments for information to :-

19. **The Secretary, MUASA**
20. **The Secretary, BUCTU.**

AC – 27/06/2023
Item No. 6.1 (R)

UNIVERSITY OF MUMBAI

Revised Syllabus for
S.Y. B.Sc.

(Chemistry)

Semester: III & IV
(CBCS)

(With effect from the academic year 2023-24)

University of Mumbai

Syllabus for Approval

Sr. No.	Heading	Particulars
1	O: ____________ Title of Course	**S. Y. B. Sc. (Chemistry)**
2	O: ____________ Eligibility	F. Y. B. Sc. Passed from this university (or with ATKT in any two courses at the F. Y. B. Sc. Level) or equivalent qualification from other universities as may have been allowed by the relevant ordinances of this university
3	R: ____________ Passing Marks	40%
4	No. of years/Semesters:	Two
5	Level:	UG
6	Pattern:	Semester
7	Status:	Revised
8	To be implemented from Academic Year :	From Academic Year: 2023-24

Garje

Prof. Shivram S. Garje,
Dean,
Faculty of Science and Technology

UNIVERSITY OF MUMBAI

Essentials Elements of The Syllabus

1	**Title of Course**	Syllabus for two semester S. Y. B. Sc. course in chemistry
2	**Course Code**	USCH301, USCH302, USCH303 USCH401, USCH402, USCH404 USCHP1 to USCHP6
3	**Preamble**	Attached
4	**Objective**	• To infuse in the learner a spirit of inquiry into the fundamental aspects of the various core areas of Chemistry. • To make the learner proficient in analyzing the various observations and chemical phenomena presented to him during the course. • To make the learner capable of solving problems in the various units of this course • To give the learner an opportunity to get hands on experience of the various concepts and processes in the various branches of chemistry • To impart various skills of handling chemicals, reagents, apparatus, instruments and the care and safety aspects involved in such handling • To make the learner capable of analysing and interpreting results of the experiments he conducts or performs
5	**Eligibility**	Pass F. Y. B. Sc.
6	**Fee Structure**	As Per Guidelines issued from the University
7	**No. of Lectures**	9 lectures per week (three lectures per paper)

8	**No. of Practicals**	9 periods per week (three periods per paper)
9	**Duration of Course**	Two Semester
10	**Notional Hours**	72 hours per paper per semester Theory and 36 hours per paper per semester for laboratory sessions
11	**No of students per batch**	120 students per division (20 Students for laboratory sessions)
12	**Selection**	As per merit.
13	**Assessment**	End of semester examination of 75 marks per paper for theory, 25 marks Internal evaluation and 50 marks per paper for laboratory sessions
14	**Syllabus Detail**	Attached
15	**Title of the Unit**	As given in the Syllabus text
16	**Title of the Sub-unit**	As given in the syllabus text.
17	**Semester wise Theory**	As prescribed in the syllabus text
18	**Semester wise Practicals**	As prescribed in the syllabus text.
19	**Question Paper Pattern**	As prescribed by the Faculty of Science
20	**Scheme of evaluation of Project**	N.A.
21	**List of suggested reading**	--
22	**List of websites**	--
23	**List of You Tube videos**	--
24	**List of MOOCs**	--

REGULATIONS

1. Preamble and objectives of the Course :

In the first two semesters of the six semester graduation program of B. Sc.(Chemistry) the learner was introduced to some basic aspects in the various core branches of chemistry like Physical Chemistry, Organic chemistry and Inorganic chemistry. Concepts about the structure of atom, distribution of electrons, Thermodynamics, Formation of organic compounds and basic ideas in reactivity of molecules in general and organic compounds in particular were introduced to the learner. He was made inquisitive about why and how should atoms combine to give molecules or ions. The non-orbital approach to appreciating the shapes of polyatomic species in general and molecules in particular.

The story of chemistry is taken further in the coming two semesters of the second year of the B. Sc. (Chemistry) Program. However it is also realised that some students opting for the course on Chemistry may not continue with the subject subsequently as such the syllabus is designed to retain the interest of the serious learner of chemistry as well as be helpful to non-chemistry learners. With such students who would want to pursue other branches of science but would want to acquire a basic appreciation and experience of chemistry a separate paper (Paper-III) is designed. This paper along with the laboratory session unit that goes with it deals with the basics of chemical analysis, separating components from a given sample, basic concepts like pH, experimental techniques like Titrimetry, Gravimetry, using instruments to carry out analysis, the various techniques like chromatography, electrophoresis, Instrumentation in general is felt to be of interest to learners of various branches like physics, botany, zoology, and microbiology.

The major objectives of B.Sc. Chemistry course are

- To infuse in the learner a spirit of inquiry into the fundamental aspects of the various core areas of Chemistry.

- To make the learner proficient in analysing the various observations and chemical phenomena presented to him during the course.
- To make the learner capable of solving problems in the various units of this course
- To give the learner an opportunity to get hands on experience of the various concepts and processes in the various branches of chemistry
- To impart various skills of handling chemicals, reagents, apparatus, instruments and the care and safety aspects involved in such handling
- To make the learner capable of analyzing and interpreting results of the experiments he conducts or performs
- To make the learner capable of acquiring or pursuing a source of livelihood like jobs in chemical industry
- To arouse the interest to pursue higher levels of learning in chemistry,

2. Condition for Admission

A candidate who has passed the F.Y.B.Sc. of Mumbai University or an examination of some other university accepted by the syndicate as equivalent there to with Chemistry, Physics, Maths, Botany, Zoology or Life Science shall be eligible for admission into S.Y.B.Sc., course in Chemistry.

3. Duration of the Course: one year

4. Course of study:

Draft copy of the proposed revised syllabus for
Choice Based Credit System
S.Y.B.Sc. Chemistry
To be implemented from the Academic year 2023-2024

For the subject of chemistry there shall be three papers for 45 lectures each comprising of three units of 15 L each.

Semester-III

1. Paper-I (General Chemistry) Unit-I Physical Chemistry
   Unit-II Inorganic Chemistry
   Unit-III Organic Chemistry.
2. Paper-II (General Chemistry) Unit-I Physical Chemistry
   Unit-II Inorganic Chemistry
   Unit-III Organic Chemistry.
3. Paper III (Basics of Analytical Chemistry)

Semester-IV

1. Paper-I (General Chemistry) Unit-I Physical Chemistry
   Unit-II Inorganic Chemistry
   Unit-III Organic Chemistry.
2. Paper-II (General Chemistry) Unit-I Physical Chemistry
   Unit-II Inorganic Chemistry
   Unit-III Organic Chemistry.
3. Paper III (Basics of Analytical Chemistry)

Choice Based Credit System
S. Y. B. Sc.
Chemistry Syllabus
To be implemented from the Academic year 2023-2024

Course Content
Semester III

Course Code	Unit	Topics	Credits	L/Week
USCH301	I	Chemical Thermodynamics-II, Electrochemistry	2	1
	II	Chemical Bonding		1
	III	Reactions and reactivity of halogenated hydrocarbons, alcohols, phenols and epoxides		1
USCH302	I	Chemical Kinetics-II, Solutions, Polymer Chemistry-I	2	1
	II	Selected topics on p block elements		1
	III	Carbonyl Compounds		1
USCH303	I	Introduction to Analytical Chemistry and Statistical Treatment of analytical data-I	2	1
	II	Classical Methods of Analysis.		1
	III	Instrumental Methods-I		1
USCHP1		Chemistry Practicals I	1	3
USCHP2		Chemistry Practicals II	1	3
USCHP3		Chemistry Practicals III	1	3

Semester IV

Course Code	Unit	Topics	Credits	L/Week
USCH401	I	Electrochemistry-II, Phase Equilibria	2	1
	II	Comparative Chemistry of the transition metals & Coordination Chemistry		1
	III	Carboxylic acids and their derivatives, Sulphonic acids		1
USCH402	I	Solid state, Catalysis	2	1
	II	Ions in aqueous medium & Uses and Environmental Chemistry of Volatile Oxides and oxo-acids		1
	III	Amines, Diazonium salts, Heterocyclic compounds		1
USCH403	I	Methods of separation	2	1
	II	Instrumental Methods-II		1
	III	Statistical Treatment of analytical data --II		1
USCHP4		Chemistry Practicals I	1	3
USCHP5		Chemistry Practicals II	1	3
USCHP6		Chemistry Practicals III	1	3

Semester III
Paper I
Theory: 45 Lectures

Unit I: Physical Chemistry

1.1 Chemical Thermodynamics-II(8L)

1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature.

1.1.2 Gibbs-Helmholtz equation, van't Hoff reaction isotherm and van't Hoff reaction isochore.
(Numericals expected).

1.1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation.

1.1.4 Concept to fugacity and Activity.

1.2 Electrochemistry: (7L)

1.2.1 Electrolytes: Definition, Strong and Weak electrolytes and their conductance measurement, ions and electrical conductivity by ions.

1.2..2 Kohlrausch law of independent migration of ions.

1.2.3 Applications of conductance measurements: determination of degree of ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts, ionic product of water. (Numerical expected).

1.2.4 Transference number and its experimental determination using Moving boundary method. (Numericals expected).Factors affecting transference number.

Unit-II: Inorganic Chemistry

2. Chemical Bonding

2.1 Non-Directional Bonding (4L)

2.1.1 Ionic Bond: Conditions for the Formation of Ionic Bond.
Types of Ionic Crystals

2.1.3 Radius Ratio Rules

2.1.4 Born-Haber Cycle and its Application

2.2. Directional Bonding: Orbital Approach.(6L)

2.2.1 Covalent Bonding, The Valence Bond Theory- Introduction and basic tenets.

2.2.2 Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system.
2.2.3 Corrections applied to the system of two hydrogen atoms-Formation of H_2
2.2.4 Definition, concept of Homonuclear diatomic molecules only for He2 & Ne2 molecules.
2.2.5 Resonance and the Concept of Formal Charge; Rules for Resonance or Canonical Structures.
2.2.6 Bonding in Polyatomic Species: The Role of Hybridization. And types of hybrid orbitals-sp,sp^2,sp^3, sp^3d, sp^2d^2andsp^2d sp^3d^2.
2.2.7 Equivalent and Non-Equivalent hybrid orbitals

2.3 Molecular Orbital Theory (5L)

2.3.1.Comparing Atomic Orbitals and Molecular Orbitals.
2.3.2.Linear combination of atomic orbitals to give molecular orbitals LCAO-MO approach for diatomic homonuclear molecules).
2.3.3 Molecular orbital Theory and Bond Order and magnetic property: with reference toO_2,$O_2^+$$O_2^-$,$O_2^{2-}$ (Problemsandnumericalproblemsexpectedwhereverpossible)

Unit III: Organic Chemistry

3.1. Reactions and reactivity of halogenated hydrocarbons: [4L]

3.1.1.Alkyl halides: Nucleophilic substitution reactions: SN1, SN2 and SNi mechanisms with stereochemical aspects and factors affecting nucleophilic substitution reactions, nature of substrate, solvent, nucleophilic reagent and leaving group.

3.1.1. Aryl halides: Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (SNAr) addition-elimination mechanism and benzyne mechanism.

3.1.2.Organomagnesium and organolithium compounds: [3L]

Nomenclature, nature, type and reactivity of carbon-metal bond. Preparation using alkyl / aryl halide. Structure, stability and reactions with compounds containing acidic hydrogen, carbonyl compounds, CO_2, cyanides and epoxides.

3.2 Alcohols, phenols and epoxides: [8L]

3.2.1. Alcohols: Nomenclature, Preparation: Hydration of alkenes, hydrolysis of alkyl halides, reduction of aldehydes and ketones, using Grignard reagent. Properties: Hydrogen bonding, types and effect of hydrogen bonding on different properties. Acidity of alcohols, Reactions of alcohols

3.2.2.Phenols: Preparation, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols.

3.2.3.Epoxides: Nomenclature, methods of preparation and reactions of epoxides: reactivity, ring-opening reactions by nucleophiles (a) In acidic conditions: hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide. (b) In neutral or basic conditions: ammonia, amines, Grignard reagents, alkoxides

Semester III

Paper II

Unit I: Physical Chemistry

1.1 Chemical Kinetics-II (5L)

1.1.1 Introduction to reaction mechanism (concept of elementary steps, intermediates, and the overall reaction mechanism with an example of Thermal chain reactions: H_2. and Br_2. reaction.

1.1.2 Types of Complex Chemical reactions: Reversible or opposing, consecutive and parallel reactions
(No derivations, only examples expected),

1.2 Solutions: (6 L)

1.2.1 Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law–non-ideal solutions. Vapour pressure-composition and temperature -composition curves of ideal and non-ideal solutions. Azeotropes and Zeotropes definition and significance in solution behavior

1.2.2 Partial miscibility of liquids: Definition, Effect of Temperature, effect of impurity and intermolecular interactions on partial miscibility, Critical solution temperature;
Phenol-Water, Triethanolamine – Water and Nicotine – Water systems

1.2.3 Immiscibility of liquids- Nernst distribution law and its applications, solvent extraction..

1.3 Polymer Chemistry – I (4L)

1.3.1 Basic Terms: Macromolecule, monomer, repeat unit, Polymerisation, (addition and condensation polymerization) Degree of Polymerisation

1.3.2 Polymer structures linear, branched and cross-linked

1.3.3 Molecular weight of Polymers: Definition and formulae of Number average molecular weight, weight average molecular weight Z- average molecular weight, and viscosity average molecular weight.
(numerical expected)

Unit-II: Inorganic Chemistry

2. Selected topics on p-block elements (15L)

2.1 Chemistry of Boron Compounds

2.1.1 Electron deficient compounds–BH_3,BF_3,$BCl_3$with respect to Lewis acidity and applications.
2.1.2 Preparation of simple boranes like diborane and tetraborane.
2.1.3 Structure and bonding in diborane and tetraborane(2e-3cbonds)
2.1.4 Synthesis of Borax.

2.2 Chemistry of Silicon

2.2.1 Silicon compounds: Occurrence, Structure and Inertness of SiO_2
2.2.2 Preparation of structure of $SiCl_4$
2.2.3 Preparation of extra-pure Silicon

2.3 Chemistry of Nitrogen family

2.3.1 Trends in chemical reactivity - Formation of hydrides, halides, oxides with special reference to oxides of nitrogen.
2.3.2 Oxides of nitrogen with respect to preparation and structure of NO, NO_2,N_2O and N_2O_4.

Unit III: Organic Chemistry

3. Carbonyl Compounds: [15L]

3.1 Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds. Structure, reactivity of aldehydes and ketones and methods of preparation; Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, Rosenmund reduction and Gattermann – Koch formylation

3.2 General mechanism of nucleophilic addition, and acid-catalyzed nucleophilic addition reactions.

3.3 Reactions of aldehydes and ketones with $NaHSO_3$, HCN, RMgX, alcohol, amine, phenylhydrazine, 2,4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$.

3.4 Mechanisms of following reactions: Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt and Cannizzaro reaction.

3.5 Keto-enol tautomerism: Mechanism of acid and base catalyzed enolization

3.6 Active methylene compounds: Acetylacetone, ethyl acetoacetate diethyl malonate, stabilized enols. Alkylation of Acetylacetone and ethyl acetoacetate

Semester IV
Paper I
Theory: 45 Lectures

Unit I: Physical Chemistry

1.1Electrochemistry-II: (8 L)

1.1.1 Electrochemical cells, Nernst equation and its importance in generating electricity through chemical reactions. Types of electrochemical cells - Reversible and irreversible cells (Definition, example, characteristics)
1.1.2 Types of electrodes, Standard electrode potential, Electrochemical series.
1.1.3 Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.
1.1.4 Calculation of equilibrium constant and pH measurement using Hydrogen electrode and quinhydrone electrode, from EMF data.
1.1.5 Application of electrochemistry in the field of –'Hydrogen Clean energy' and the role of Batteries in clean energy storage.
(Numericals to be solved wherever necessary)

1.2 Phase Equilibria: (7L)

1.2.1 Introduction to Phase equilibria, Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule.
1.2.2 Derivation of Clausius – Clapeyron equation and its importance in phase equilibria.
1.2.3 Phase diagrams of one-component systems (water and sulphur).
1.2.4 Two-component systems involving eutectics – Condensed Phase rule, Definition of eutectic Phase diagram of Lead-Silver system.
1.2.5 Application of Phase equilibria in
ii). Industry – metallurgy
iii). Energy and environmental engineering
iiii). Food and beverage industry
iiv). Pharmaceutical industry.

Unit-II: Inorganic Chemistry

2.1 Comparative Chemistry of the transition metals (9L)

2.1.1 Position in the periodic table; Natural occurrence principal ores and minerals;
2.1.2 Significance of special stability of d^0, d^5 and d^{10} leading to variable oxidation states; Unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium, and chromium.)
2.1.3 Origin of color for transition metals and their compounds: such as reflectivity, surface coatings, particle size, packing density for metals and nature of d-orbitals, number of electrons in the d-orbitals, geometry, and ability for charge transfer).
2.1.4 Magnetic properties of transition metal compounds: Origin of magnetism-spin and orbital motion of electrons; equation for spin only and spin-orbital magnetism in terms of Bohr magnetons (No derivation of relevant equations expected); Reasons for quenching of orbital moments.

2.1.5 Qualitative tests for transition metal ions: General considerations indevising tests (with reference to Chromium, Manganese, Iron, Cobalt Nickel and Copper)

2.2 Coordination Chemistry: (6L)

2.2.1 Introduction to Chemistry of Coordination Compounds

i. Historical perspectives : Early ideas on coordination compounds

ii. Basic terms and nomenclature.

iii. Types of ligands

iv. Isomerism: General Types with special reference to stereo isomerism of coordination compounds (C.N=6)

v. Evidence for the formation of coordination compounds.

2.2.2 Theories of coordination compounds

i. Werner's Theory of coordination compounds,

ii. Effective atomic number rule.

iii. Eighteen electron Rule

2.2.3 Nature of the Metal-Ligand Bond:

i. Valence Bond Theory; Hybridisation of the central metal orbitals-sp^3d^2/d^2sp^3

ii. Inner and outer orbital complexes of .(suitable examples of Mn(II)Fe(II), Fe(III), Co(II)/Co(III), Ni(II), Cu(II) Zn(II) complexes with ligands like aqua, ammonia $CN^-$and halides may be used)

iii. Limitations of V.B.T

2.2.4 Application of coordination compounds.

Unit III: Organic Chemistry

3.1 Carboxylic Acids and their Derivatives :(11 L)

3.1.1. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids.

3.1.2. Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles.

3.1.3. Reactions: Acidity, salt formation, decarboxylation, Reduction of carboxylic acids with $LiAlH_4$, diborane, Hell-Volhard-Zelinsky reaction, Conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides and their relative reactivity.

3.1.4. Mechanism of nucleophilic acyl substitution and acid-catalyzed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution.

3.1.5. Mechanism of Claisen condensation and Dieckmann condensation

3.2 Sulphonic acids: [4L]

Nomenclature, preparation of aromatic sulphonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene, Reactions: Acidity of arene sulfonic acid, Comparative acidity of carboxylic acid and sulfonic acids. Salt formation, desulphonation. Reaction with alcohol, phosphorous pentachloride, IPSO substitution

Semester IV
Paper II

Unit I: Physical Chemistry

Solid State: (7L)

1.1.1 laws of Crystallography and Types of Crystals

1.1.2 Characteristics of simple cubic, face-centered cubic and body-centered cubic systems, interplanar distance in a cubic lattice (only expression for ratio of interplanar distances are expected)

1.1.3 Use of X-rays in the study of crystal structure, Bragg's equation (derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected)

Catalysis: (8 L)

1.2.1 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation

1.2.2 Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH.

1.2.3 Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)

1.2.4 Nanoparticles as catalyst – basic concepts, their importance in chemical reactions, properties and their application in energy conversion(fuel cells and solar cells) Challenges associated with nanoparticles as catalyst.

Unit-II: Inorganic Chemistry
2. Ions in aqueous medium
2.1 Acidity of Cations and Basicity of Anions (8L)

i. Hydration of Cations; Hydrolysis of Cations predicting degree of hydrolysis of Cations-effect of Charge and Radius.
ii. Classification of cations on the basis of acidity category – Non-acidic, Moderately acidic, strongly acidic, very strongly acidic with pKa values range and examples
iii. Hydration of Anions; Effect of Charge and Radius; Hydration of anions-concept, diagram classification on the basis of basicity

2.2 Uses and Environmental Chemistry of volatile Oxides and oxo-acids (7L)

i. Physical properties of concentrated oxo-acids like sulfuric, Nitric and Phosphoric acid
ii. Uses and environmental aspects of these acids.

Unit III: Organic Chemistry

3.1Nitrogen containing compounds (7L)
3.1.1 Amines:(4L)

Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Zn-acetic acid, reduction of nitriles, ammonolysis of halides, reductive amination, Hoffmann bromamide reaction Reactions- Salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation (HEM), Hofmann-elimination reaction, reaction with nitrous acid, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation

3.1.2 Diazonium Salts:(3L)

Preparation and their reactions/synthetic application - Sandmeyer reaction, Gattermann reaction, Gomberg reaction, Replacement of diazo group by -H,-OH. Azo coupling with phenols, naphthols and aromatic amines, reduction of diazonium salt to aryl hydrazine and hydroazobenzene

3.2 Heterocyclic Compounds: (8L)

- **3.2.1.** Classification, nomenclature of 5- and 6-membered rings containing one heteroatom
- **3.2.2.** Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis)
- **3.2.3.** Reactivity of furan, pyrrole and thiophene towards electrophilic substitution reactions on the basis of stability of intermediate and of pyridine on the basis of electron distribution. Reactivity of pyridine towards nucleophilic substitution on the basis of electron distribution.
- **3.2.4.** Reactions of furan, pyrrole and thiophene: halogenation, nitration, sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, Ring opening. Pyrrole: Acidity and basicity of pyrrole. Comparison of basicity of pyrrole and pyrrolidine.
- **3.2.5.** Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine (with and without catalyst), reduction and action of sodamide (Chichibabin reaction)

Semester III
Chemistry Practicals:

Unit I: Physical Chemistry

1. To verify Ostwald's dilution law for weak acid conductometrically.
2. To determine dissociation constant of weak acid conductometrically.
3. To determine the critical solution temperature (CST) of phenol - Water System.
4. Determination of energy of activation of acid-catalyzed hydrolysis of methyl acetate.
5. To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentrations of the reactants
6. To determine solubility of sparingly soluble salts (any two) conductometrically.

Unit II: Inorganic Chemistry

1. Identification of cations in a given mixture and Analytically separating them [From a mixture containing not more than two of the following: Pb(II), Ba(II), Ca(II), Sr (II), Cu(II), Cd(II), Mg(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II) Al(III), Cr(III)]
2. Crystallisation of potassium iodate and to estimate its purity before and after the separation.
3. Estimation of total hardness
4. Investigation of the raction between Copper supfate and Sodium Hydroxide (Standard EDTA solution to be provided to the learner).

Unit III: Organic Chemistry

Short organic preparation and their purification: Use 0.5-1.0g of the organic compound. Purify the product by recrystallization. Report theoretical yield, percentage yield and melting point of the purified product.

Preparation of:

1. Cyclohexanone oxime from cyclohexanone.
2. Glucosazone from dextrose or fructose
3. Tribromoaniline from aniline.
4. β-Naphthylbenzoate
5. m-Dinitrobenzene from nitrobenzene
6. Phthalic anhydride from phthalic acid by sublimation
7. Acetanilide from aniline
8. p-Bromoacetanilide from acetanilide
9. Iodoform from acetone

(Any eight preparations)

Semester IV
Chemistry Practicals:

Unit I: Physical Chemistry

1. To determine standard EMF and the standard free energy change of Daniel cell potentiometrically.
2. To determine the amount of HCl in the given sample potentiometrically.
3. Compare the strengths of HCl and H_2SO_4 by studying kinetics of acid hydrolysis of methyl acetate.
6. Industrial visit report.

Unit II: Inorganic Chemistry

1. Inorganic preparation – Nickel dimethyl glyoxime using microscale method.
2. Complex cation – *Tris* (ethylene diamine) nickel (II) thiosulphate.
3. Complex anion – Sodium Hexanitrocobaltate (III) The aim of this experiment is to understand the preparation of a soluble cation (sodium)and a large anion hexanitrocobaltate (III) and its use to precipitate a large cation (potassium)
4. Inorganic salt – Calcium or magnesium oxalate using PFHS technique

Unit III: Organic Chemistry
Qualitative Analysis of bi-functional organic compounds on the basis of

1. **Prelimenary examination**
2. **Solubility profile**
3. **Detection of elements C, H, (O), N, S, X.**
4. **Detection of functional groups**
5. **Determination of physical constants (M.P/B.P)**

Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysisto be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halides.
Students are expected to write balanced chemical reactions wherever necessary. (Minimum 6 compounds to be analyzed)

Reference Books for Practicals:

Unit I:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)

Unit II:

1. *Practical Inorganic Chemistry* by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)

Unit III:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
4. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

Reference Books:

Unit I:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry CengageLearning India Pvt.Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co., NewYork (1985).
6. K.L.Kapoor A textbook of Physical Chemistry3rd Ed. vol.1,2Macmillan Publishing Co., NewDelhi(2001)

Unit II:

1. *Practical Inorganic Chemistry* by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)

2. Inorganic Chemistry – Gary Wulfsberg, Viva Book, First Indian Edition 2002
3. Quantitative Analysis – R.A.Day, A.L. Underwood, sixth edition
4. Vogel’s Textbook of quantitative chemical analysis – J Mendham, R C Denny, J D Barnes, M Thomas, B Sivasankar
5. Bruce H. Mahan, University Chemistry, Narosa publishing house pg. 611 to 683.
6. R. Gopalan , Universities Press India Pvt.Ltd. Inorganic Chemistry for Undergraduates.
7. Chemistry of Transition Elements Pg.- 608 – 679 .
8. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS, The group III elements Pg. 359-648.
9. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999) page 325-446.
10. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
11. CNR Rao edited, University General Chemistry, 513-578.
12. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
13. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, page no. 435-463.
14. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
15. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).
16. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry, page 416-628.
17. Bruce H. Mahan, University Chemistry, Narosa publishing house.
18. R. Gopalan , Universities Press India Pvt.Ltd. Inorganic Chemistry for Undergraduates.
19. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS
20. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999)
21. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
22. CNR Rao edited, University General Chemistry
23. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,

24. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry
25. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
26. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).
27. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry

Unit III:

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).2012
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Comprehensive Organic Chemistry- The synthesis and reactions of Organic Compounds, Derek barton ,W. David Ollis.
8. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
9. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
10. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005

Semester III

Paper III

Basics in analytical Chemistry

Theory: 45 Lectures

The Role of Analytical Chemistry in various fields including non-chemistry fields such as Environmental Science, Pharmacy, Medicine, Life Sciences, Petrochemicals, Arts (like Painting) Forensic sciences and so on can never be underestimated. This course is expected to introduce the learner to this interesting field of Analytical Chemistry.

It is expected to provide the learner an overview of this very important branch of chemistry. After successful completion of this course the learner is expected to be familiar with the question of what is analysis, why it is required and the methods, techniques, procedures and protocols that may be used or required in the course of a given problem of analysis. The learner is also expected to appreciate the role of an Analytical Chemist and a Chemical Analyst.

Correctness or acceptability of the results of a given analysis and how to deal with wrong or erroneous results: when to reject them and when and how to retain them to be meaningful and/or acceptable are some other attributes expected as outcomes of learning this paper As such it is felt that this paper will be a subject of choice and interest for learners preferring a specialization in Chemistry as well as to those who may have interests in other science fields as Physics, Botany, Zoology, Microbiology, Geochemistry and so on.

Goal:

To introduce the learner to an area of learning that is vital for the inherent nature of the subject itself but also is important and irreplaceable irrespective of the long-term interest of specialization or subject of interest of the learner.

Unit I-Introduction to Analytical Chemistry and Statistical Treatment of analytical data-[15L]

Scope/Objectives:

Learners should be able to

1. Selecta method of analysis
2. Decide how to identify a sample and prepare it for analysis
3. Select a procedure for analysis
4. Identify sources of possible errors in the results obtained.
   [Numerical problems wherever possible, expected]

1.1. Role of Analytical Chemistry [04 L]

1.1.1. Language of analytical chemistry: important terms and their significance in Analytical Chemistry.

1.1.2. Purpose of Chemical Analysis; Analysis Based on
(i) the nature of information required:(Proximate, Partial, Trace, Complete Analysis) and
(ii) On the size of the sample used (Macro, semi-micro and microanalysis)

1.1.3. Classical and Non-Classical Methods of Analysis; their types and Importance.

1.2. Significance of Sampling in Analytical Chemistry [05 L]

1.2.1. Terms involved in Sampling

1.2.2. Purpose of Sampling

1.2.3. Difficulties encountered in sampling

1.2.4. Types of Sampling
i) Random Sampling
ii) Systematic Sampling

1.2.5. Theories of Sampling

1.3. Results of Analysis [06 L]

1.3.1. Errors in Analysis and their types
i) Determinate Errors
ii) Indeterminate Errors

1.3.2 Methods of minimizing Determinate errors in analysis
i) Calibration of apparatus
ii) Carrying out Control determination
iii) Carrying out Blank determination

1.3.3 Concept of Precision and Accuracy in Analysis and evaluation involved in the study of Precision and accuracy
i) Mean, Median, Mode, Absolute deviation, Average deviation, Relative average deviation, standard deviation, variance and coefficient of variation
ii) Absolute error and Relative error
[Numerical problems on precision and accuracy expected]

References:

1. Instrumental Analysis by Douglas A. Skoog, F. James Holler, Stanley R.Crouch
2. Instrumental methods of analysis by Willard, H.H.; Merritt, L.L. Jr.;Dean,J.A.; Settle,7th Edition
3. FundamentalofAnalyticalChemistrybyDouglasA.Skoog,West,F.JamesHoller,S.R. Crouch
4. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education

Unit II- Classical Methods of Analysis [15L]

Objectives:

The main objectives of this unit is to

- Introduce classical methods of chemical analysis.
- Appreciate the various terms and types of titrimetric analysis.
- Ability to select proper titrimetric method
- Appreciate the usefulness of the gravimetric method of analysis
- Identify a suitable gravimetric method
- Perform the required calculations involved in the analysis by titrimetry as well as gravimetry.

2. Classical Methods of Analysis. [15 L]

2.1. Titrimetric Methods [04 L]

- 2.1.1. Terms involved in Titrimetric methods of analysis. Comparing volumetry and Titrimetry
- 2.1.2. The Conditions suitable for titrimetry
- 2.1.3. Types of titrimetry
  - i) Neutralisation (Acidimetry, alkalimetry)
  - ii) Redox (Iodometry, Iodimetry,)
  - iii) Precipitation
  - iv) Complexometric titrations
- 2.1.4. Tools of Titrimetry: Graduated glassware and Calibration

2.2. Standard solutions[02L]

- 2.1.1 Primary and Secondary standards in Titrimetry
- 2.1.2 Calculations based on preparation of primary and secondary standards

2.2 Neutralization Titration [03 L]

- 2.2.1 Concept of pH and its importance in Neutralization Titrations
- 2.2.2 Endpoint and Equivalence point of Neutralization titrations
- 2.2.3 Determination of End point by using Indicators causing colour change
- 2.2.4 Selection of indicators – Ostwald's theory of indicators

2.3 Gravimetric analysis [06L]

- 2.3.1 Introduction and Principle of Gravimetric analysis
- 2.3.2 Types of Gravimetric Methods
  - i) Volatilisation gravimetry
  - ii) Precipitation gravimetry
- 2.3.3 Precipitation Gravimetry:
  - i) Steps involved in precipitation gravimetric analysis
  - ii) Factors affecting precipitation
  - iii) Concept of Nucleation (Homogenous and Heterogeneous) and crystal growth
  - iv) Impurities involved in precipitates
    - i) Simultaneous precipitation
    - ii) Post precipitation
    - iii) Co-precipitation
- 2.3.4 Digestion and its importance
- 2.3.5 Filtration, Washing, Drying and Ignition of Precipitate.
- 2.3.6 Applications of Gravimetric Analysis:
  - i) Determination of sulfur from organic compounds;
  - ii) Estimation of Nickel in Cu-Ni alloy using dimethyl glyoxime

References:

1) Skoog etal. “Fundamentals of Analytical Chemistry" Cengage Learning, Eight Edition, chapter13, 14 and 15
2) Day and Underwood, “Quantitative analysis" prentice hall 1991, chapter 3
3) S.M. Khopkar, “Basic Concepts of Analytical Chemistry”, IInd Edition New Age International Publisher
4) Gary D. Christan, “Analytical Chemistry”, VIth Edition, Wiley Students Edition, Chapter No. 8, 9, 10
5) Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch
6) Modern Analytical Chemistry, David Harvey (page numbers 232-265)

Unit III: Instrumental Methods-I [15 L]

Objectives:

On completing the learning of this unit the learner is expected to

- Know the various instrumental methods of analysis
- Advantages of using instruments to make measurements
- The various observable properties of a given analyte and the stimulus best suited for its analysis
- Know about a generalized diagram of an analytical instrument
- Select a suitable instrumental method for analysis
- Appreciate the basic terms in spectrometry
- Use the relationship between absorbance (and its variations) and concentration of the analyte.
- Chose a suitable method for photometric titrations.

3 Basic Concepts in Instrumental Methods [03 L]

3.1 Relation between the Analyte, Stimulus and measurement of change in the observable property.

3.2 Block Diagram of an Analytical Instrument.

3.3 Types of Analytical Instrumental Methods based on

i. Optical interactions (eg. Spectrometry: UV-Visible, Polarimetry)
ii. Electrochemical interactions (eg. Potentiometry, Conductometry,)
iii. Thermal interactions (eg. Thermogravimetry)

3.4 Spectrometry [12 L]

3.4.1 Interaction of electromagnetic radiation with matter: Absorption and Emission spectroscopy

3.4.2 Basic Terms: Radiant Power, Absorbance, Transmittance, Monochromatic light, Polychromatic light, Wavelength of maximum absorbance, Absorptivity and Molar Absorbtivity

3.4.3 Statement and derivation of Beer’s Law and Lambert’s Law, Combined Mathematical Expression of Beer Lambert’s Law,

3.4.4 Validity and Deviations from Beer-Lambert’s Law *(Numerical problems based on Beer-Lambert’s Law)*

3.4.5 Block Diagrams for Single beam and double beam Colorimeter (Principle, Construction and working (Details of Components expected, i.e. source, Sample holder, Filter, Detectors)

3.4.6 Block Diagrams for Single beam and double beam Spectrophotometer (Principle, Construction and working (Details of Components expected i.e, source, Sample holder, Monochromator, Detectors)

References:
1. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal, Shm K. Anand pp2.107-2.148
2. Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Edition pp143-172.
3. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle 7th Edition pp 118-181.

Semester III Chemistry

Practicals: Paper III

Basics in Analytical Chemistry

1. Tools of Analytical Chemistry-I:

a) Analytical glass wares like burettes, pipettes, Standard flasks, Separating funnels.
b) Weighing tools such as two pan balance and mono pan balance, digital balances:
c) Incineration devices: Burners, Electrical Incinerators, Muffle Furnace,
d) Drying Devices: Hot Air Oven, microwave oven, Desiccators, Vacuum desiccators
e) Monochromators, Filters, Sample holders, Prisms, Diffraction Gratings, Photoemissive cells, Photomultiplier tubes

(The learner should draw diagrams and write-ups providing uses, care and maintenance of the items mentioned in (a)and principle, construction and uses of items(b)to (e)in his journal.

2. Gravimetric estimation of Nickel (II) as Ni-DMG and calculation of % error.(The learner is expected to know the role of the various reagents/chemicals used in the estimation, the various steps involved. They should write the complete and Balanced chemical reaction for the formation of the $Ni(DMG)_2$ complex.

3. Colorimetric Determination of Copper Ions in a given Solution by using calibration curve method and calculation of % error.
(The learner is expected to learn the relation between concentration and Absorbance, to draw a calibration curve, use the slope of the calibration curve and compare it with the calculated slope. They are also expected to state the error estimate of their results).

4. Determination of buffer capacity of acid buffer and basic buffer.
(The learner is expected to learn the use pH meter, standardization of pH meter, use of Henderson's equation and calculation of buffer capacity)

5. Estimation of Aspirin

6. Gravimetric estimation of barium ions using K_2CrO_4 as precipitant. Calculation of % error.
(The learner is expected to learn the skills of using the counterpoise technique used in this gravimetric estimation; Using counterpoise method whatman No.42 for filtration. In such a case no incineration or use of silica crucible is required. They are also expected to state the error estimate of their results)

Semester IV

Paper III : Basics in Analytical Chemistry -II

Theory:45 Lectures

Unit–I –Methods of separation[15L]

Objectives

The learner is expected to understand

- The importance of separation in sample treatment
- Various methods of separations
- How to select a method of separation of an analyte from the matrix
- How a solute gets distributed between two immiscible phases
- Principle of solvent extraction and various terms involved therein
- Effect of various parameters on solvent extraction of a solute
- Classification of Chromatographic methods
- Paper and thin layer chromatography and using them in practice.

1. Separation Techniques in Analytical Chemistry **[02L]**

1.1. An Introduction to Analytical Separations and its importance in analysis.

1.2. Estimation of an analyte without affecting separation.

1.3. Types of separation methods

1.3.1. Based on Solubilities (Precipitation, Filtration Crystallisation)

1.3.2. Based on Gravity-Centrifugation

1.3.3. Based on volatility-Distillation;

1.3.4. Based on Electrical effects-Electrophoresis

1.3.5. Based on retention capacity of a Stationary Phase -Chromatography;

1.3.6. Based on distribution in two immiscible phases-Solvent Extraction;

1.3.7. Based on capacity to exchange with a resin-Ion Exchange;

1.4. Study of types of separation methods

1.4.1 Electrophoresis: [02 L]

Principles, Basic Instrumentation, Working and Application in separation of biomolecules like enzymes and DNA.

1.4.2 Solvent extraction [06L]

i) Introduction, Nernst distribution Law, Distribution Ratio, Partition Coefficient and Separation factor.

ii) Conditions of extraction: Equilibration time, Solvent volumes, temperature, pH.

iii) Single-step and multistep extraction, Percentage extraction for single step and multistep extraction.

iv) Batch and continuous extraction

1.5 Chromatography: [05L]

1.5.1 Introduction to Chromatography

1.5.2 Classification of chromatographic methods based on stationary and mobile phase

1.5.3 Paper Chromatography

i) Principle

ii) Technique

iii) Applications in separation of cations.

1.5.4 Thin layer Chromatography

i) Principle

ii) Technique

iii) Applications with special reference to

a) Determination of the purity of a given solute

b) Study of the progress of a given reaction.

References:

1. D.A. Skoog, D.M. West, F.J. Holler and CX.R. Crouch – Fundamentals of Analytical Chemistry, 8th edition
2. G. H. Morrison and H. Freiser, Solvent extraction in analytical chemistry
3. P.G. Swell and B. Clarke, Chromatographic separations, Analytical chemistry by open Learning, John Wiley and sons, 1987
4. Modern Analytical Chemistry, David Harvey (page numbers 596-606)
5. Modern Analytical Chemistry, David Harvey (page numbers 215-217)

Unit–II-Instrumental Methods-II [15 L]

Objectives

On completing this unit, the learner is

- Expected to appreciate the nature of interaction between applied electrical potential and the concentration of the analyte.
- The nature of chemical reactions that influence potential of a given cell.
- Familiar with the various types of electrodes or half cells.
- Appreciate the nature, need and importance of pH
- Expected to know the applications of the various instrumental methods dealt with in this unit.

2. Instruments based on the electrochemical properties of the analytes

2.1. Potentiometry: [05 L]

2.1.1. Principle.

2.1.2. Role of Reference and indicator electrodes

2.1.3. Applications in Neutralization reactions with reference to the titration of Strong acid against Strong Base (using quinhydrone electrode)

2.1.4. Graphical methods for detection of endpoints

i) Graph of EMF against Volume of titrant added

ii) First derivative graph

2.2. pH metry: [04 L]

2.2.1. Principle

2.2.2. Construction, working and maintenance of Combined Glass electrode

2.2.3. Application

i) In Titrimetry (Strong acid-Strong Base)

ii) Biological and Environmental analysis.

2.3. Conductometry: [06 L]

2.3.1. Principle

2.3.2. Conductivity cell: Construction

2.3.3. Applications in Neutralization Titrimetry with respect to

i. Strong Acid-Strong Base

ii. Strong Acid-Weak Base

iii. Strong Base-weak Acid

iv. Weak Acid- Weak Base.

2.3.4. Advantages and limitations of conductometric titrations.

References:

1) Principles of Instrumental Analysis, D. A. Skoog, 3rd edition, Saunders College publishing. Chapters:20, 23Page Nos: 600 -605, 631, 704 - 711.
2) Vogel's Textbook of quantitative inorganic analysis, 4thedition, ELBS / Longman. Chapters: XIV, XV Page nos:566 - 601, 615– 625.
3) Instrumental method of analysis, B.K. Sharma, Goel publishing house. Miscellaneous methods: Chapters:1,3,4 Page Nos: 1-14, 21 - 57.

Unit III-Statistical Treatment of analytical data—II [15L]

Objectives: On completing this unit the learner is expected to understand

i) The use of statistical methods in chemical analysis.
ii) Therandomnessofsucherrorsanditsdistributionaroundacorrectoracceptableresult
iii) Computation of Confidence limits and confidence interval
iv) Test for rejection of doubtful result
v) Method to draw best fitting straight line

3.1. Distribution of random errors: [03L]

3.1.1. Gaussian distribution curve.
3.1.2. Equation and salient features of Gaussian distribution curve

3.2. Concept of Confidence limits and confidence interval and its computation using [04 L]

(i) Population standard deviation
(ii) Student's test
(iii) Range

3.3. Criteria for rejection of doubtful result [03 L]

(i) 2.5 d rule
(ii) 4.0 d rule
(iii) Q test

3.4. Test of Significance [03 L]

(i) Null hypothesis
(ii) F-test (variance ratio test)

3.5. Graphical representation of data and obtaining best fitting straight line [02L]

(i) For line passing through origin
(ii) For line not passing through origin

Note: Numerical problems on 3.2 to 3.5 are expected

References:

1. Modern Analytical Chemistry, David Harvey (page numbers 53-84)
2. Fundamentals of analytical chemistry –Skoog and West

Semester IV

Chemistry Practicals:

Paper III Elective (Basics in Analytical Chemistry)

1. Tools of Analytical Chemistry-II
   a. Filtration Flasks, Funnels, Separating Funnels, Distillation apparatus, Vacuum Distillation assembly, Centrifuge machine, Electrophoresis apparatus.
   b. Development chamber for chromatography
   c. Electrodes like Reference Electrodes and Indicator Electrodes (with respect to care and maintenance.)
   d. Conductivity cell (with respect to care and maintenance.)
   e. Combined Glass electrode (with respect to care and maintenance.)
   f. Types of Salt Bridges and preparation of anyone or use of a salt bridge, its effect on the potential of a given electrode/cell

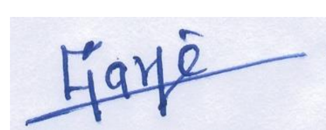
(The learner should draw diagrams and write-ups providing uses of the items mentioned in (a and b) and Principle, Construction care and Uses of items (c) to (f) in his journal.)

2. Paper chromatography: Separation of cations like Fe (III), Ni (II) and Cu (II) in a sample.
3. Separation of a solute between two immiscible solvents to determine the distribution ratio and/or extraction efficiency. (Solutes could be as their aqueous solutions and the organic solvent ethyl acetate) Suggested solute for the distribution study: Fe (III) in aqueous solutions. (The learner is expected to learn the technique of solvent extraction by using a separating funnel, method to estimate the concentrations of the solute distributed in the two immiscible phases, determination of the extraction efficiency)
4. Estimation of concentration of Iron from a given sample calorimetrically by using 1,10 phenanthroline.(The learner is expected to learn the handling of the colorimeter).
5. Estimation of Fe (II) in the given solution by titrating against $K_2Cr_2O_7$ potentiometrically and calculation of % error. (The learner is expected to learn the handling of the potentiometer, use of Platinum electrode and reference electrode like SCE. They will learn to determine endpoint by plotting a graph. They are also expected to state the error estimate of their results).
6. Gravimetric estimation of Sulfate as $BaSO_4$ and calculation of % error. (The learner is expected to write a balanced chemical reaction, need for digestion of the precipitate and the skill required to carry out the incineration and to estimate the% error.)
   (The learner is expected to write a balanced chemical reaction, need for digestion of the precipitate and the skill required to carry out the incineration and to estimate the % error.)

REFERENCES:

For paper III

1. D.A. Skoog, D.M. West, F.J. Holler, and S.R. Crouch, Analytical Chemistry: An Introduction,7th ed., Chapter 15, pp. 345-381.
2. A.I. Vogel."Text book of Quantitative Inorganic Analysis", Longman, London (1961).
3. R.V. Dilts."Analytical Chemistry. Methods of Separation", van Nostrand, N.Y.(1974).
4. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B. BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogoi.



Prof. Shivram S. Garje,
Dean,
Faculty of Science and Technology

UNIVERSITY OF MUMBAI

No. UG/ 156 of 2016-17

CIRCULAR:-

A reference is invited to the Syllabi relating to the B.Sc. degree course , **vide** this office Circular No. UG/98 of 2015-16, dated 13th October, 2016 and the Principals of affiliated Colleges in Science are hereby informed that the recommendation made by the Ad-hoc Board of Studies in Chemistry at its meeting held on 7th July, 2016 has been accepted by the Academic Council meeting held on 14th July, 2016 **vide** item No. 4.13 and that in accordance therewith, the revised syllabus as per the Choice Based Credit System for T.Y. B.Sc. programme in Chemistry (Sem. V & VI), which are available on the University's web site (www.mu.ac.in) and that the same has been brought into force with effect from the academic year 2016-17.

(Dr.M.A.Khan)
REGISTRAR

MUMBAI – 400 032
16 November, 2016

To,

The Principals of the affiliated Colleges in Science.

A.C/4.13/14.07.2016

****

No. UG/ 156-A of 2016 MUMBAI-400 032 16 November, 2016

Copy forwarded with Compliments for information to:-

1) The Co-ordinator, Faculties of Science,
2) The Chairman, Board of Studies in Chemistry,
3) The Professor-cum-Director, Institute of Distance & Open Learning (IDOL)
4) The Director, Board of College and University Development,
5) The Co-Ordinator, University Computerization Centre,
6) The Controller of Examinations.

(Dr.M.A.Khan)
REGISTRAR

PTO..

UNIVERSITY OF MUMBAI

Syllabus for sem V & VI
Program: B.Sc.
Course: CHEMISTRY

(Credit Based Semester and Grading System with effect from the academic year 2016–2017)

T.Y.B.Sc.

CHEMISTRY

Credit Based Semester and Grading System

To be implemented from the Academic year 2016-2017

SEMESTER V

Theory

Course	UNIT	TOPICS	Credits	L / Week
USCH501	**I**	**1.1 Colligative Properties of Dilute Solutions (8L)** **1.1.1** Dilute solution, colligate properties, Raoult's law, relative lowering of vapour pressure. **1.1.2** Elevation in boiling point of a solution, thermodynamic derivation relating elevation in the boiling point of a solution and the molar mass of the non-volatile solute. **1.1.3** Depression in freezing point of a solution, thermodynamic derivation relating the depression in the freezing point of a solution and the molar mass of the non-volatile solute. **1.1.4** Osmotic pressure, van't Hoff's equation for osmotic pressure, (derivation is expected) and determination of molar mass of the solute. Abnormal molar masses of solutes and van't Hoff factor (calculation of Degree of Association and Degree of Dissociation.) **1.2 Phase Rule (7L)** **1.2.1** Gibb's phase rule and terms involved in the equation. **1.2.2** Application of phase rule to ONE component systems (i) water system, (ii) sulphur system **1.2.3** Application of phase rule to TWO component systems, condensed systems, condensed phase rule, eutectic systems (Lead-Silver system), desilverisation of lead. **1.2.4** Introduction to three component system, explanation of phase diagram for three liquids forming one immiscible pair.	**2.5**	**1**

	II	**2.1 Surface Chemistry & Catalysis (9L)** **2.1.1 Adsorption:** Physical and Chemical Adsorption, types of adsorption isotherms **.** Langmuir's adsorption isotherm (Postulates and derivation expected). B.E.T. equation for multilayer adsorption, (derivation not expected). significance of the terms involved in the equation is expected.),determination of surface area of an adsorbent using B.E.T. equation. Numericals on surface area determination are expected. **2.1.2 Catalysis:** Homogeneous and heterogeneous catalysis, catalytic activity and selectivity, promoters, inhibitors, catalyst poisoning and deactivation, **2.1.3 Acid-Base catalysis**, mechanism and kinetics of acid-base catalyzed reactions, effect of pH on acid-base catalyzed reactions. Mechanism and kinetics of enzyme catalyzed reaction (Michaelis-Menten equation). **2.2 Colloids (6L)** **2.2.1** Introduction to colloidal state of matter. **2.2.2** Origin of charge on colloidal particles. Concept of electrical double layer, zeta potential, Helmholtz and Stern model, Electro-kinetic phenomena:1.Electrophoresis, 2.Electrophoresis , 3. Streaming potential 4. Sedimentation potential . **2.2.3** Colloidal electrolytes. **2.2.4** Donnan Membrane Equilibrium. **2.2.5** Surfactants, micelle formation, applications of surfactants in detergents, food industry, in pesticide formulations.		
	III	**3.1 Electrochemistry – Electrochemical cells (15L)** **3.1.1** Lewis concept of Activity and Activity coefficient, Mean ionic activity and mean ionic activity coefficient γ_{+-} of an electrolyte, expression for activities of electrolytes of different valence type, ionic strength		

		3.1.2 Classification of cells: 1.chemical cells without transference 2.Concentration cells with and without transference (derivations of expression for concentration cell EMF are expected) Origin of liquid-liquid junction potential and its elimination using a salt bridge. **3.1.3** Applications of EMF .measurements in the determination of **1.** pH of a solution using quinhydrone and glass electrode. **2** solubility and solubility product of sparingly soluble salts using chemical cell and concentration cell method **3**. determination of liquid-liquid junction potential .		
	IV	**4.1 Introduction to Polymers (8L)** **4.1.1 Basic terms** : macromolecule, monomer, repeat unit, degree of polymerization. **4.1.2. Classification of polymers** based on (i) source, (ii) structure, (iii) thermal response, (iv) physical properties. **4.1.3. Molar masses of polymers**: 1. Number average molar mass, 2.Weight average molar mass, 3. Viscosity average molar mass, monodispersity, polydispersity. **4.1.4. Methods of determining molar masses of polymers** : 1. Ultrcentrifuge method (Limiting velocity method only). Viscosity method (Mark-Houwink equation). **4.1.5. Introduction to light emmiting polymers** (characteristics, method of preparation and it's application are expected). **4.2 Crystalline State (7L)** **4.2.1. Laws of Crystallography** **4.2.2**. Characteristics of simple cubic, face centered and body centered cubic system, inter planar distance in cubic lattices (only expressions for ratios of inter planar distances are expected). **4.2.3.** Use of X- rays in the study of crystal structure, Bragg's equation (derivation expected), X- ray diffraction method of studying crystal lattices, structure of NaCl and KCl,		**1**

		determination of Avagadro number. **4.2.4.** Elementary idea of defects in crystals- Frenkel defect and Schottky defect.		
USCH502	**I**	**1. Chemical Bonding And Solid State Chemistry (15L)** **1.1 Molecular Symmetry (7L)** **1.1.1** Introduction and Importance. **1.1.2** Symmetry elements and symmetry operations. **1.1.3** Concept of a Point Group with illustrations using the following point gro ups: (i) $C_{\alpha v}$ (HCl), (ii) $D_{\alpha h}$ (H_2), (iii) C2v (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans – trichloroethylene), and (vi) D_{3h} (BCl_3). **1.2 Molecular Orbital Theory for Polyatomic Species (5L)** **1.2.1** Simple triatomic species: H_3^+ and H_3 (correlation between bond angle and Molecular orbitals). Term such as Walsh correlation diagram, Symmetry Adapted Linear Combinations (SALCs), Ligand Group orbitals (LGOs), transformation of atomic orbitals into appropriate symmetry types, expected to be discussed **1.3 (3L)** Other molecules (considering only σ-bonding): i) BeH_2, ii) H_2O, Explanation of terms viz.crystal lattice, lattice points, unit cells and lattice constants.	**2.5**	**1**

	II	**2. Solid Materials (15L)** **2.1 Structures of Solids (10L)** **2.1.1** Importance of solid state chemistry. **2.1.2** Classification of solids on the basis of bonding. **2.1.3** Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). Point defects with respect to Frenkel and Schottky defects expected. **2.1.4** Structure metallic solids. **2.1.5** Tetrahedral and octahedral interstitial voids in ccp lattice, tetrahedral holes,limiting radius ratios for different coordination numbers and their significance, calculation of limiting radius ratio for coordination number 4. **2.1.7** Structures of sodium chloride and cesium chloride. **2.2 Superconductivity (05L)** **2.2.1** Superconductivity, Meissner effect. **2.2.2** Different superconducting materials viz,convential superconductors, organic superconductors, alkali metal fullerides (A_3C_{60}) and high temperature Superconductors. **2.2.3** Applications of superconducting materials.		1
	III	**3. Chemistry of elements (15L)** **3.1 Inner transition elements (3L)** **3.1.1** Introduction: position of f-block elements and comparison between lanthanides and actinides **3.1.2** The shapes of *f*-orbitals. **3.1 Lanthanides Series (10L)** **3.2.1** Chemistry of lanthanides with reference to (i) lanthanide contraction, (ii) Oxidation states (iii) magnetic and spectral properties, **3.2.2** Occurrence, extraction and separation of lanthanides by Solvent extraction. **3.2.3** Applications of lanthanides.		1

		3.3 Actinides Series (2L) **3.3.1 Chemistry** of Uranium and with reference to occurrence, extraction (solvent extraction method), **3.3.2** Properties and applications.		
	IV	**4. Solution Chemistry** **4.1 Acid-base Chemistry in Aqueous Medium (8L)** **4.1.1 Acidity** of mono- and polyatomic cations. **4.1.2** Basicity of mono- and polyatomic anions (discussion for 4.1.1 as well as 4.1.2 to Include Latimer equation and predominance diagrams). **4.2 Chemistry in Non-aqueous Solvents (7L)** **4.2.1** Classification of solvents and importance of non-aqueous solvents. **4.2.2** Characteristics and study of liquid ammonia, dinitrogen tetraoxide and acetic acid as non-aqueous solvents with respect to (i) acid-base reactions and (ii) redox reactions.		**1**
USCH503	**I**	**1.1. Mechanism of Organic Reactions (15L)** 1.1.1 Thermodynamic and Kinetic control of organic reactions: Concept with mechanisms of the following reactions: addition of HX to butadiene; sulfonation of naphthalene. Nucleophilicity/ electrophilicity vs Basicity/acidity. 1.1.2 Mechanism of elimination reactions, with stereochemistry: E1 and E2 reactions: regioselectivity (Saytzeff and Hofmann rules). 1.1.3 Mechanism of reactions of carbonyl compounds with nucleophiles: 1.1.3.1 Formation of acetals/ketals from aldehydes and ketones. 1.1.3.2 Reaction of aldehydes and ketones with primary and secondary amines. 1.1.3.3 Acyl nucleophilic substitution (tetrahedral mechanism): Acid catalysed esterification of Carboxylic acids and base promoted hydrolysis of esters. 1.1.4 Mechanism of rearrangements with examples and stereochemistry wherever applicable. 1.1.4.1 Migration to electron deficient carbon: Pinacol,	**2.5**	**1**

		Benzylic acid. 1.1.4.2 Migration to electron deficient nitrogen: Beckmann, Hofmann. 1.1.5 Mechanism of the following reactons with synthetic application: Claisen condensation, Michael addition.		
	II	**2. Stereochemistry (15L)** 2.1.1 Molecular chirality and element of symmetry: Mirror Plane symmetry (inversion centre), rotation-reflection (alternating) axis, Chirality of compounds without stereogenic centre: cummulenes, spirans and biphenyls. 2.1.2 Stability ofcycloalkanes: Strains in cycloalkanes-angle,eclipising, transannular (3 to 8 membered). Conformations of cyclohexane, mono- and di- alkyl cyclohexanes and their relative stabilities. 2.1.3 Stereo selectivity and Stereo specificity: Idea of enantioselectivity (ee) and diastereoselectivity (de).Topicity-enantiotopic and diastereotopic atoms, groups and faces. **Stereochemistry of-** (1) Substitution reactions- S_N1, S_N2, S_Ni (reaction of alcohol with thionyl chloride). (2) E_2-anti-elimination-Base induced dehydrohalogenation of 1-bromo-1,2- diphenylpropane. (3) Addition reactions to olefins-i) catalytic hydrogenation ii) bromination (electrophilic anti addition) (iii)syn-hydroxylation (molecular addition) with OsO_4 and $KMnO_4$.		**1**
	III	**3.1 Carbohydrates (10L)** 3.1.1 Introduction: Classification, Sources, Reducing and non-reducing sugars DL notation. 3.1.2 Structures of monosaccharides: Fischer projection (4-6 carbon monosaccharides and Haworth formula-Furanose and pyranose forms of pentoses and hexoses. Interconversion :open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with stereochemistry of D-glucose and D-fructose. Stability of chair forms of D-		**1**

		glucose. 3.1.3 Determination of open chain configuration- of D-glucose assuming the configuration of D-arabinose; and of D-fructose assuming the configuration of D-glucose. 3.1.4 Anomers and epimers of monosaccharides. Enantiomers and diastereomers of glucose. Mutarotation (with mechanism) in D-glucose. 3.1.5 Chain lengthening and shortening reaction: Modified kiliani-fischer synthesis. Wohl method. 3.1.6 Reactions of D-glucose and D-fructose: (a) osazone formation (b) reduction- H_2/Ni, $NaBH_4$ c)oxidation-bromine water, HNO_3, HIO_4. D) interconversion of D-glucose and D-fructose e) acetylation f) methylation [e and f with cyclic pyranose form]. 3.1.7 Commercial importance of carbohydrates in pharmaceutical, paper,food and Textile industries. **3.2. IUPAC Nomenclature (5L)** IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/ functional groups): **3.2.1** (a)Bicyclic compounds- spiro-,fused, and bridged (upto 11carbon atoms)-saturated and unsaturated compounds. **3.2.2** (b) Biphenyls. **3.2.3** (c) Cummulenes upto 3 double bonds (d) Monocyclic (5 and 6 membered) aromatic and non-aromatic heterocyclic compounds containing a maximum of two hetero atoms among N,O,S. **3.1.1**Introduction:Classification, Sources, Reducing and non-reducing sugars DL notation. **3.1.2** Structures of monosaccharides: Fischer projection (4- 6 carbon monosaccharides and Haworth formula-Furanose and pyranose forms of pentoses and hexoses. Interconversion :open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with		

		stereochemistry of D-glucose and D-fructose. Stability of chair forms of D-glucose. **3.1.3** Determination of open chain configuration- of D-glucose assuming the configuration of D-arabinose; and of D-fructose assuming the configuration of D-glucose. **3.1.4** Anomers and epimers of monosaccharides. Enantiomers and diastereomers glucose. Mutarotation (with mechanism) in D-glucose. **3.1.5** Chain lengthening and shortening reaction: Modified kiliani-fischer synthesis. Wohl method. **3.1.6** Reactions of D-glucose and D-fructose: (a) osazone formation (b) reduction- H_2/Ni, $NaBH_4$ c)oxidation-bromine water, HNO_3, HIO_4. D) interconversion of D-glucose and D-fructose e) acetylation f) methylation [e and f with cyclic pyranose form]. **3.2. IUPAC Nomenclature (5L)** IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/functional groups): **3.2.1** (a)Bicyclic compounds- spiro-,fused, and bridged (upto 11carbon atoms)-saturated and unsaturated compounds. **3.2.2** (b) Biphenyls. **3.2.3** (c) Cummulenes upto 3 double bonds (d) Monocyclic (5 and 6 membered) aromatic and non-aromatic heterocyclic compounds containing a maximum of two hetero atoms among N,O,S.		
	IV	**4.1. Heterocyclic Chemistry (8L)** **4.1.1** Introduction: Electronic structure and aromaticity of furan, pyrrole,thiophene and pyridine. **4.1.2** Synthesis: Synthesis of furans, pyrroles, and thiophenes by Paal-Knor synthesis. Pyridines by Hantzsch synthesis and from 1,5-diketones. **4.1.3** Reactivity: Reactivity towards electrophilic substitution reactions- of furan, pyrrole and thiophene on basis		**1**

		of stability of intermediate; and of pyridine on the basis of electron distribution.Nucleophilic substitution reaction of pyridine on the basis of electron distribution. **4.1.4** Reactions of heterocycles: The following reactions of furan, pyrrole and thiophene: Halogenation , Nitration, Sulphonation, Vilsmeir formylation reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction. Ring opening of furan. Pyrrole: Acidity and basicity of pyrrole -Comparison of basicity of pyrrole and pyrrolidine, Acid catalyzed polymerization of pyrrole. Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine, with and without catalyst. Reduction.Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction).N-methylation of pyridine. Quaternization of piperdine, pyrrolidine and Hofmann elimination of the quaternary salts. **4.2. Organic Synthesis (7L)** **4.2.1** Introduction: Criteria for ideal organic synthesis. Yield and selectivity. Multi- component synthesis – with examples, Mannich reaction, Hanztsch synthesis of pyridines (without mechanism). **4.2.2** Illustrative synthesis of industrially important compounds: Ibuprofen (chiral synthesis), paracetamol (green synthesis), L-ascorbic acid (from D-glucose), norfloxacin, thyroxine, vanillin, methyl dihydrojasmonate (Hedione), Bifenox-I, pigment red 242, indigo, 2-hydroxy-3-amino-5-nitrobenzene sulphonic acid. **4.2.3** Newer methods of organic synthesis: Introduction to the use of the following in organic synthesis: Ultrasound, microwaves, PTC. **4.1.1** Introduction: aromaticity of furan,pyrrole,thiophene and pyridine. **4.1.2** Synthesis: Synthesis of furans, pyrroles, and thiophenes by Paal-Knor synthesis. Pyridines by Hantzsch		

		synthesis and from 1,5-diketones. **4.1.3** Reactivity: Reactivity towards electrophilic substitution reactions- of furan, pyrrole and thiophene on basis of stability of intermediate; and of pyridine on the basis of electron distribution. Nucleophilic substitution reaction of pyridine on the basis of electron distribution. **4.1.4** Reactions of heterocycles: The following reactions of furan, pyrrole and thiophene: Vilsmeir formylation reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction. Ring opening of furan. Pyrrole: Acidity and basicity of pyrrole-Comparison of basicity of pyrrole and pyrrolidine, Acid catalyzed polymerization of pyrrole. Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine, with and without catalyst. Reduction.Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction). N-methylation of pyridine.Quaternization of piperdine, pyrrolidine and Hofmann elimination of the quaternary salts. **4.2. Organic Synthesis (7L)** **4.2.1** Introduction: Criteria for ideal organic synthesis. Yield and selectivity. Multi- component synthesis – with examples, Mannich reaction, Hanztsch synthesis of pyridines (without mechanism). **4.2.2** Illustrative synthesis of industrially important compounds: Ibuprofen (chiral synthesis), paracetamol (green synthesis), L-ascorbic acid (from D-glucose), norfloxacin, nalidixic acid, vanillin, methyl dihydrojasmonate (Hedione), Bifenox-I, pigment red 242, 2-hydroxy-3-amino-5-nitrobenzene sulphonic acid. **4.2.3** Newer methods of organic synthesis: Introduction to the use of the following in organic synthesis: Ultrasound, microwaves, PTC.		

USCH504	I	**1. Treatment of analytical data-I and sampling (15 L)** **1.1 Treatment of Analytical Data (7L)** Types of errors, determinate and indeterminate errors, minimization of errors, constant and proportionate errors, accuracy and precision, measures of dispersion and central tendency: mean, median, average deviation, relative average deviation, standard deviation, variance, coefficient of variation.[Numerical problems expected] **1.2 Sampling (8L)** Terms involved, importance of sampling, sampling techniques, sampling of gases, ambient and stack sampling, equipment used, sampling of homogeneous and heterogeneous liquids, sampling of static and flowing liquids, methods and equipments used, sampling of solids, importance of particle size and sample size, samples used, need for the reduction in the sample size, methods of reduction in sample size, collection, preservation and dissolution of the sample.	2.5	1
	II	**2. Titrimetric analysis-I and UV-Visible spectroscopy. (15L)** **2.1 Acid-base Titrations (5L)** Construction of titration curves and choice of indicators in the titration of [1] strong acid and strong base, [2] strong acid and weak base, [3] weak acid and strong base, [4] weak acid and weak base. **2.2 Precipitation titrations (4L)** Argentimetric titrations, construction of the titration curve, Volhard's method, Mohr's method, adsorption indicators, theory and applications. **2.3 U.V. Visible Spectroscopy (4L)** Photometers and spectrophotometers, Instrumentation in the case of single and double beam spectrophotometers, Qualitative and quantitative analysis, calibration cure method.		1

	III	**3. Methods of separation-I (15L)** **3.1 Solvent Extraction (8L)** Partition coefficient and distribution ratio, extraction efficiency, separation factor, role of complexing agents in solvent extraction, chelation, ion pair formation, solvation, types of solvent extraction: batch, continuous. [Numerical problems expected] **3.2 Chromatography (2L)** Introduction to chromatographic techniques, classification of chromatographic techniques. **3.3 Planar Chromatography (5L)** Principle, techniques and applications of [1] Paper chromatography [2] Thin layer chromatography		**1**
	IV	**4. Optical methods (15L)** **4.1 Atomic Spectroscopy (7L)** Absorption and emission spectra, energy level diagrams, process involved in atomization, flame photometry, flame atomizer, types of burners, monochromators and detectors, atomic absorption spectroscopy; flame and electrothermal atomizer, sources, instrumentation, quantitative applications of atomic absorption and flame photometry, calibration curve method, standard addition and internal standard method. **4.2 Molecular Fluorescence and Phosphorescence Spectroscopy (4L)** Theory, instrumentation and applications **4.3 Turbidimetry and Nephelometry (4L)** Scattering of light, effect of concentration, particle size and wavelength on light scattering, instrumentation and applications.		**1**

Practicals

USCHP05	**Practicals of Course USCH501** **<u>Physical Practicals</u>** **Chemical Kinetics –** To determine the order between $K_2S_2O_8$ & KI by fractional change method. **Viscosity** – To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement. **OR** To determine the radius of a glycerol molecule by viscosity measurement. **Potentiometry** – 1. To determine the amount of Fe(II) in the given solution by titration with a standard $K_2Cr_2O_7$ solution and hence to find the formal redox potential of Fe^{3+}/Fe^{2+} 2. To determine the solubility product and solubility of AgCl potentiometrically using chemical cell. **OR** 3. To determine the solubility product and solubility of AgCl potentiometrically using concentration cell. **Colorimetry –** To determine the amount of Fe(III) present in the given solution by using salicylic acid by colorimetric titration.(static method) (=525 nm) **pH –Metry –** To determine acidic and basic dissociation constants of amino acid hence to calculate isoelectric point. **Course USCH502** **<u>Inorganic Practicals</u>** **Inorganic preparations** 1. Potassium diaquo bis-(oxalate)cuprate (II)$K_2[Cu(C_2O_4)_2.(H_2O]$	**3**	**8**

	2. $CuCl_2$-2DMSO 3. Bis(ethylene diamine)iron(II)sulphate[$C_2H_4(NH_2)_2FeSO_4.4H_2O$]. 4. Skill based Qualitative preparation of Chromium (II)acetate $Cr(OAc)_2$ so that the following outcomes are achieved: • Setting up reactor for Cr(II) ions • Identification of oxidation states of Chromium • Preparation of chromium(II)acetate • Isolation of the product			

	Volumetric analysis 1. Determination of magnesium from the supplied commercial sample of Milk of magnesia tablet 2. Estimation of Nickel(II)complexometrically using murexide indicator (Students are expected to standardize supplied EDTA solution using $ZnSO_4.7H_20$)		
USCHP06	**Practicals of Course USCH503** **<u>Organic Practicals</u>** i. Separation of binary (solid-slid) mixture.(Weights and physical constant of both crude components of the mixture are to be reported. (Minimum 4 mixtures) ii. Identification of an organic compound of known chemical type. (Minimum 4 mixtures) Syllabus for Organic Chemistry Sem-VI **Organic preparations** i. Acetylation of hydroquinone. ii. Nitration of nitrobenzene. iii. Hydrolysis of ethyl benzoate. iv. Bromination of acetanilide. **Course USCH504** **<u>Analytical Practicals</u>** 1. Estimation of persulphate in the given sample by the method of back titration. 2. Determination of the calcium and the magnesium content of a dolomite sample. 3. Determination of glucose content of a honey sample by Wilstater's method. 4. Determination of the amount of fluoride in the given solution colorimetrically. 5. Determination of Vitamin C content of a given tablet by titration with sodium hydroxide pH metrically	**3**	**8**

T.Y.B.Sc.
Chemistry
Credit Based Semester and Grading System
To be implemented from the Academic year 2016-2017

SEMESTER VI
Theory

Course	UNIT		Credits	L / Week
USCH601	**I**	**1.1 Molecular Spectroscopy –I (15L)** **1.1.1** Dipole moment: Dipole moment, polarization of a bond, bond moment, dipole moment and molecular structure. **1.1.2 Rotational Spectrum:** Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of inter nuclear distance and isotopic shift. **1.1.3 Vibration (IR) spectrum:** Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum. **1.1.4 Vibration-Rotation spectrum of diatomic molecule v**ibrating rotor, energy levels, selection rule, nature of spectrum, R and P branches, anharmonic oscillator : energy levels, selection rule, fundamental band, overtones . Application of vibration-rotation spectrum in determining Force constant, determination and significance. Introduction to infrared spectra of simple molecules like H_2O and CO_2 **1.1.5 Raman Spectroscopy :** Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum , Stoke's lines,anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion.(example of CO_2molecule).	**2.5**	**1**
	II	**2.1 Basics of Quantum Chemistry (10L)** **2.1.1** Classical mechanics, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect. **2.1.2** Introduction to quantum mechanics,		**1**

		Planck's theory of quantization, wave particle duality, de-Broglie equation, Heisenberg's uncertainty principle. **2.1.3** Progressive and standing waves, boundary conditions, Schrodinger's time independent wave equation(derivation not expected)., interpretation and properties of wave function. **2.1.4** Postulates of quantum mechanics (following are to be considered),1. state function and it's significance2. Concept of operators : definition, addition, subtraction and multiplication of operators, commutative and non- commutative operators, linear operator, Hamiltonian operator, 3. Eigen function and eigen value, eigen value equation. **2.2 Applied Electrochemistry (5L)** **2.2.1** Polarization, concentration polarization and it's elimination **2.2.2** Decomposition potential, experimental determination of decomposition potential, factors affecting decomposition potential (nature of electrolyte, nature of electrodes and temperature) Tafel's equation for hydrogen overvoltage, Overvoltage, experimental determination of over-voltage, **2.2.3** Electroplating ---objectives and procedures		
	III	**3.1 Renewable Energy Sources (5L)** **3.1.1.** Lithium ion cell. **3.1.2**. Fuel cells; Choice of fuel and oxidant, Bacon's H_2 and O_2 fuel cell. **3.1.3**. Solar cells, solar energy, photovoltaic effect, semiconductors as solar energy converters, silicon solar cell **3.1.4**. Hydrogen : Fuel of the future, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium. **3.2 Nuclear Magnetic Resonance Spectroscopy (6L)** **3.2.1**. Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession, Relaxation processes in n.m.r. (spin-spin relaxation and spin-lattice relaxation). **3.2.2**. NMR Spectrometer, chemical shift, shielding and deshielding of protons, low resolution n.m.r. spectrum of methanol and ethanol.		**1**

		3.3 Chemical Kinetics (4 L) **3.3.1** Collision theory of reaction rates, application of collision theory to 1. uni-molecular reaction and 2. bimolecular reaction (Lindemann theory, derivation expected). Merits and drawbacks of collision theory. **3.3.2** Classification of reactions as slow, fast and ultra-fast. study of kinetics of fast reactions by Stop flow method.		
	IV	**4.1 Nuclear Chemistry** **4.1.1** Types of nuclear radiations and their characteristics, behaviour of ion pairs in electric field, detecton and measurement of nuclear radiations using G. M. Counter and Scintillation Counter. **4.1.2** Kinetics of radioactive decay, units of radioactivity (Curie, Bequerel, Rutherford) **4.1.3** Radioactive equilibrium (secular and transient), determination of radioactive constants for radio-elements having 1. moderate half life, 2. long half life 3.extremely long or short half life. **4.1.4** Use of radioisotpes as tracers in 1. chemical investigations- reaction mechanism, 2. age determination- dating by carbon-14 **4.1.5** Nuclear reactions – nuclear transmutation, artificial radioactivity Q-value of nuclear reaction, threshold energy. **4.1.6** Fissile and fertile material, nuclear fission, chain reaction, factor controlling fission process. (multiplication factor and critical size or mass of fissionable material)., nuclear power reactor and breeder reactor.		**1**
USCH602	**I**	**Coordination Chemistry (15L)** **1.1 Crystal Field Theory (CFT)** **1.1.1** Basic tenets of Crystal field theory and effect of crystal field on central metal valence orbitals. **1.1.2** Splitting of *d* orbitals in octahedral, tetrahedral and square planar complexes. **1.1.3** Crystal field splitting energy $(10\Delta_o)$ for octahedral complexes and factors affecting the magnitude of Δ_o. **1.1.4** Crystal field stabilization energy (CFSE), calculation of CFSE, for octahedral and tetrahedral complexes with	**2.5**	**1**

		d^1 to d^{10} metal ion configurations. **1.1.5** Effect of crystal field splitting on i) Ionic radius and ii) Lattice energy. **1.1.6** Theoretical failure of the CFT model. **1.1.7** Experimental evidence for co-valence in co-ordination compounds.(i) ESR spectrum of $[IrCl_6]^{2-}$ (ii) NMR spectrum of tris (acetyl acetanato) vanadium complex, (iii) Intensities of *d-d* transitions, and (iv) Nephelauxetic effect. Consequences of crystal field splitting on various properties such as ionic radii, hydration energy, lattice energy, enthalpies of formation, colour and magnetic properties. **1.2 Molecular Orbital Theory (MOT) of Coordination Complexes** **1.2.1** Application to octahedral complexes in case of (i) $[Ti(H_2O)]^{3+}$, (ii) Fluoro complexes of Fe(II) and Fe (III) and (iii) Cyano complexes of Fe(II) and Fe (III). **1.2.2** Effect of pi-bonding an ligand field splitting parameter in M→L and L→M interactions. **1.3 Electronic States and Terms for Polyelectronic Atoms** **1.3.1** Introduction: electronic configuration and electronic states, Term symbols, coupling of spin momenta (M_S),orbital momenta $(M_l)$and spin- orbit coupling or Russell-Saunders coupling. **1.3.2** Determination of Terms for p^2 electronic configuration (as in a carbon atom). **1.3.3** Terms and micro-states for transition metal atoms/ions.		
	II	**2. Properties of Coordination compounds (15L)** **2.1 Stability of Complexes (5L)** **2.1.1** Thermodynamic stability and kinetic stability of complexes with examples. **2.1.2** Stability constants: Stepwise and overall constants and their inter-relationship. **2.1.3** Factors affecting thermodynamic stability. **2.1.4** Potentiometric method of determination of stability constants with example of silver-ammonia complex. **2.2 Substitution Reactions in Octahedral Complexes (5L)**		**1**

2.2.1 Introduction, types of reactions in complexes.
2.2.2 Ligand substitution reactions: basic mechanisms.
2.2.3 Inert and labile complexes and

		electronic configurations and lability of complexes. **2.2.4** Acid hydrolysis, base hydrolysis and anation reactions. **2.3 Electronic Spectra (5L)** **2.3.1** Types of electronic transitions like intra –ligand transitions, charge transfer transitions and intra-metal transitions and (*d-d* or ligand field transitions for transition metals). **2.3.2** Rules for electronic transitions: Spin and Orbital or Laporte selection rules. Orgel Diagrams for D Terms (i.e,d^1 , d^4 and d^6 .d^9 electronic configurations) and its use in interpretation of visible electronic absorption spectra of these configurations.		
	III	**Organometallic Chemistry (15L)** **3.1 Organometallic Compounds of main group metals (6L)** **3.1.1** Introduction: General synthetic methods: (i) Oxidative addition, (ii) Metal-Metal exchange (Transmetallation), (iii) Carbanion-Halide exchange, (iv) Metal Hydrogen exchange and (v) Methylene insertion reactions. **3.1.2** Chemical rections: (i) Reactions with oxygen, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents and (iv) Complex formation reactions. **3.2 Organometallic compounds of transition metals (9L)** **3.2.1** Synthesis , structure, reactions and of ferrocene. **3.2.2** Bonding in ferrocene on the basis of VBT. **3.2.3** Bonding in Re and Mo halide complexes.		**1**
	IV	**Some Selected Topics (15L)** **4.1 Inorganic Polymers (3L)** 4.1.1Various methods of classification with examples. **4.1.2** Chemistry of borazine with reference to preparation , properties, structures, bonding and applications. **4.2 Characteristics and Treatment**		**1**

		of Liquid Effluent (06L) **4.2.2** Characterization of waste: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), aerobic and anaerobic processes. **4.2.3** Removing of solid contaminants, physical and chemical principles such as coagulation, flocculation and sedimentation. **4.2.4** Primary,secondary and tertiary of liquid effluents. **4.3 Nanomaterials(04L)** **4.3.2** Introduction and importance of nanomaterials. **4.3.3** Properties (Comparison between bulk and nanomaterials): (i) Optical properties, (ii) Electrical conductivity, and (iii) Mechanical properties. **4.3.4** Forms of nanomaterials: nanofilms, nanolayers, nanotubes, nanowires, and nanoparticles. **4.3.5** Chemical methods of preparation: (i) Colloidal route, and (ii) Sol-gel method. **4.5 Inorganic Pharmaceuticals (2L)** **4.4.2** Gastrointestinal agents viz., (i) antacids (aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) cathartics (magnesium sulphate and sodium phosphate). Topical agents viz., (i) protectives and adsorbents (talc, calamine), (ii) antimicrobial agents (potassium permanganate, tincture iodine, boric acid) and astringents (alum).		
USCH603	**I**	**1.1 Spectroscopy** (15L) 1.1.1 Introduction : Electromagnetic spectrum, units of wavelength and frequency. 1.1.2 UV- Visible Spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum, concept of Chromophore, auxochrome,bathochromic shift,Hypsochromic shift hyperchromic	**2.5**	**1**

		effect and chromophore-auxochrome interactions. 1.1.3 IR Spectrocopy: Basic theory, nature of IR spectrum, selection rule , fingerprint region. 1.1.4 PMR Spectroscopy: Basic theory of NMR, nature of PMR spectrum, chemical shift (∂ unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, CΞC, C=O and benzene ring). Spin- spin coupling and coupling constant. Proton exchange-application of deuterium exchange ,Application of PMR in structure determination. 1.1.5 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to UV-VIS, IR,PMR: (1)alkanes (2)alkenes and polyenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) carboxylic acids (9) esters (10)amines (11) amides (broad regions characteristic of different groups are expected). 1.1.6 Mass Spectrometry: Basic theory.Nature of mass spectrum. General rules of fragmentation. Importance of -molecular ion peak, isotopic peaks, basepeak, Nitrogen rule.Illustrative fragmentation of alkanes and aliphatic carbonyl compounds (No Mclafferty rearrangement). 1.1.7 Problems of structure elucidation of simple organic compounds using individual or combined use of the above spectroscopic technique are expected.(index of hydrogen deficiency should be the first step in solving the problems).		
	II	**2.1 Polymers (11L)** 2.1.1 Introduction: General idea of monomers, polymers, and polymerization, natural and synthetic polymers. Homoplymers and copolymers. Classification of polymers- Plastic, fibres, resins, elastomers. Thermoplastics and thermosets. Copolymers-alternating, block, random, graft. 2.1.2 Mechanism of free radical addition		**1**

		polymerization. 2.1.3 Elastomers: Natural and synthetic rubbers. Diene polymerization: 1,2- and 1,4- addition (cis and trans) polymerization of isoprene. 1,3-Butadiene-styrene copolymer. 2.1.4 Stereochemistry of polymers: Tacticity. Role of Ziegler-Natta catalyst (co- ordination polymerization) in directing the tacticity in polypropylene (no mechanism). 2.1.5 Preparation & use of polymers: (1) Addition polymers: (a) polyethylene (b)polypropylene (c) PVC (d) polystyrene (e) polyacrylonitrile (f) polyvinylalcohol (g) Teflon. (2) Condensation Polymers: (a) Polyesters (b) polyamides (c) polyurethans (d)phenol-formaldehyde resin (e) epoxy resin (f) polycarbonates. 2.1.6 Recyclable polymers. Biodegradable polymers and their uses. Biomedical use of polymers. 2.1.7 Additives to polymers: Plasticizers ,stabilizers and fillers.(The students are expected to identify monomers in a given polymer and draw the structure of a polymer from a given set of monomers). **2.2 Photochemistry** 2.2.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triple states, allowed and forbidden transitions, fate of excited molecules, photosensitization. 2.2.2 Photochemical reactions of olefins: photoisomerisation, photochemical rearrangement of 1,4-dienes (di π methane) 2.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages, Photo reduction (e.g. benzophenone to benzpinacol).		
	III	**3.1 Catalysts and Reagents (5L)** Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism). 3.1.1 **Catalysts** : Catalysts for hydrogenation: Raney Ni,Pt and PtO_2: C=C, CN, NO_2, aromatic ring; Pd/C: C=C, COCl→CHO (Rosenmund); Lindlar catalyst: alkynes; Wilkinson's catalyst for	**1**	

		stereo selective reduction of olefins. 3.1.2 **Reagents**: (1)$LiAlH_4$ and Red-Al: reduction of CO,COOR, CN, NO_2. (2) $NaBH_4$: reduction of CO (3) SeO_2: hydroxylation of allylic and benzylic positions,oxidation of CH_2, alpha to CO to CO.(5)mCPBA and R-OOH/H_2O_2 for epoxidation of C=C. (6) NBS: allylic and benzylic bromination of position alpha to CO. **3.2 Natural Products (10L)** 3.2.1 Introduction: Primary and secondary metabolites. Introduction to the following natural products with respect to the sources and classes. (Structures of the compounds specified below are expected). (a) Terpene: Isoprene and special isoprene rule.α-terpeniol, citral,camphor, α-pinene. (b) Alkaloids: nicotine,atropine. (c) Vitamins: Vitamins A and C. (d) Hormones: adrenaline, thyroxine. (e) Steroids: cholesterol, progesterone. 3.2.2 Structure determination of natural products: 3.2.2.1 Ozonolysis in terpenoids-Examples of open chain and monocyclic monoterpenes. 3.2.2.2 Hofmann exhaustive methylation and degradation in alkaloids – simple open chain and monocyclic amines.3.2.2.3 Structure determination of citral and nicotine through degradation studies. Total synthesis of degradation studies. Total synthesis of (i) Citral from 3-methylbutan-1-ol (ii) Nicotine from nicotinic acid. 3.2.4 Commercial importance of terpenoids and alkaloids: Synthesis of camphor from α-pinene, α and β ionones, geraniol and nerol from citral. 3.2.5		
	IV	**4.1 Organometallic Chemistry (5L)** 4.1.1 Intoduction: Carbon-metal bond- Nature, types reactivity. 4.1.2 **Organo magnesium Compounds**: Grignard reagent :Preparation, structure, and stability, Reaction with compounds containing acidic hydrogen,carbonyl compounds, cyanides and CO_2. 4.1.3 **Organolithium Compounds** : Preparation using alkyl/aryl halides. Reactions with compounds containing		**1**

		acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO_2. Lithium dialkyl cuprates: Preparation and reactions with aliphatic /aromatic/vinylic halides. 4.1.4 **Organozinc compounds**: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism). **4.2 Chemistry of some Important Biomolecules: (10L)** 4.2.1 α-Amino acids: Structure,configuration,Essential amino acids and their abbreviations, classification, Properties: pH dependency of ionic structure and isoelectric point. Methods of preparations: Strecker synthesis, amidomalonate synthesis, Erlenmeyer azalactone synthesis. 4.2.2 Polypeptides and Proteins: Polypeptides: Peptide bond. Nomenclature and representation of polypeptides. Merrifields solid phase peptide synthesis (example of di- and tri- peptides for nomenclature and synthesis). Proteins: Sources, types,functions,colloidal nature, separation based on isoelectric point, denaturation and functions. Partial and total hydrolysis. General idea of primary, secondary, tertiary and quartenary structures. 4.2.3 Nucleic acids: Selective hydrolysis of nucleic acids.Sugars and bases in nucleic acids. Stuctures of nucleosides an nucleotides in DNA and RNA. Structure of nucleic acids (DNA and RNA): Base pairing in nucleic acids. Importance of nucleic acids-self duplication, protein synthesis.		
USCH604	**I**	**Electroanalytical methods. (15L)** **1.1** D.C. Polaroghraphy (11L): Polarizable and nonpolarizable electrodes, basic principles, residual current, diffusion current, limiting current, dropping mercury electrode, supporting electrolyte half wave potential, derivation of the polarographic wave equation for a reversible reaction. Ilkovic equation, oxygen interference and its removal, maxima and maxima suppressors, polarographic cell, qualitative	**2.5**	**1**

		and quantitativeanalysis, calibration curve and standard addition method, applications. [Numerical problems expected] **1.2** Amperometric Titrations: Basic principles, rotating platinum electrode and nature of the titration curves, applications, advantages and limitations.		
	II	**Methods of separation-II (15L)** **2.1** Gas chromatography (6L): Gas liquid chromatography, basic principles retention time, retention volume, resolution, peak width theoretical plates. HETP, instrumentation, columns, detectors, applications. **2.2** High Performance Liquid Chromatography (4L): Instrumentation, types of elution, U.V. and I.R. detector and applications **2.3** Ion Exchange Chromatography (5L): Types of ion exchangers, mechanism of ion exchange, selectivity coefficients and separation factors, capacity and its determination, factors affecting the separation of ions, applications.		**1**
	III	**Treatment of analytical data-II and Titrimetric analysis-II (15L)** **3.1** Treatment of Analytical Data (6L): Distribution of random errors, Gaussian curve, students' t, confidence limits and confidence interval, criteria for rejection of result: 2.5d rule,4.0 rule and Q test, F teset, testing for significance, null hypothesis, method of averages, least squares method. Numerical problems expected] **3.2** Complexometric Titrations (5L): General introduction, EDTA titrations, advantages and limitations of EDTA as the titrant, absolute and conditional formation constants of metal EDTA complexes, construction of titration curves, types of EDTA titrations,methods of increasing the selectivity of EDTA as a titrant, metallochromic indicators, theory and applications. **3.3** Redox Titrations (4L): General introduction, theory of redox indicators, criterion for choosing an indicator for a redox titration, construction of the titration curves in the case of (1) Fe (II) Vs. Ce(IV)		**1**

		(2) Fe (II) Vs. dichromate, use of diphenyl amine and ferroin as redox indicators.		
	IV	**Concepts in Quality and miscellaneous methods (15L)** **4.1** Total quality management (5L) : concept of quality, quality control, quality assurance total quality management, ISO series, Good laboratory practices **4.2** Mass Spectrometry (2L): Basic principles, introduction of components only **4.3** Thermal Methods (5L): Classification of thermal methods, thermogravimetric analysis,basic principles, instrumentation factors affecting the TG curve, applications **4.4** Introduction to Radio Analytical Techniques (3L): Classification of the techniques, introduction to neutron activation analysis and its applications.		**1**

Practicals

USCHP07	**Practicals of Course USCH601** **<u>Physical Practicals</u>** **Chemical Kinetics –** To determine the energy of activation for the acid catalysed hydrolysis of methyl acetate. **Partition coefficient** To determine the equilibrium constant for the reactionKI + I_2 KI_3 by partition method. (Partion coefficient of I_2 between CCl_4 and water is to be given) **Potentiometry –** 1. To determine the strength of the given strong acid (HCl) by potentiometric titration using quinhydrone electrode (Calculation of pH from E_{cell} and the plot of (a) $\frac{\Delta E}{\Delta V}$ against V (b) pH against V graphs are expected). **OR** To determine pKa value of the given weak monobasic acid (CH_3COOH) by e.m.f. measurements. 2. To determine E_{cal} at room temperature	**3**	**8**

	and using this value, determine standard reduction potential of Ag/Ag^{+} electrode at room temperature. **Conductometry –** To determine the amount of dibasic acid (Oxalic acid) by conductometric titration against strong base. **OR** To determine the relative strength of monochloroacetic acid and acetic acid conductometrically. **Course USCH602** **<u>Inorganic Practicals</u>** **Inorganic preparations** 1. Mercury tetrathiocyanato Cobaltate (II) $Hg[Co(SCN)_4]$ 2. Magnesium oxinate$[Mg(Ox)_2]$ 3. Tris-acetyl acetonato iron(III) $[Fe(AcAc)_3]$ 4. Tetrammine copper(II) sulphate. $[Cu(NH_3)_4]SO_4.H_2O$ **Inorganic estimations/ Analysis** 1. Estimation of copper iodometrically using sodium thiosulphate. (Students are expected to standardize supplied sodium thiosulphate solution using potassium dichromate) 2. Estimation of lead by complexomety using EDTA solution. (Students are expected to standardize the supplied EDTA solution. Suggested standard for standardization: $ZnSO_4.7H_2O$)		
USCHP08	**Practicals of Course USCH603** **<u>Organic Practicals</u>** **Binary Mixture Separation** Seperation of mixture containing (VL + NVL) & (S + VL) components. **Organic Preparations** 1. Aniline/p-toluidine → N-Acetyl derivative 2. Salicylic acid/nitrobenzene/ Acetanilide → Nitro derivative	**3**	**8**

3. β- naphthol → Methyl Ether derivative (Using dimethyl sulphate)
4. Acetanilide → p-bromoacetanilide derivative
5. Aniline/ p-toluidine → Schiff base with benzaldehyde
6. Hydroquinone/beta naphthol → Acetyl derivative
7. Methyl salicylate/ethyl benzoate → Acid derivative (Hydrolysis)
8. Benzaldehyde/p-nitrobenzaldehyde → Acid (Oxidation)

Course USCH604

Analytical Practicals

1. Determination of chemical oxygen demand of a water sample.
2. Determination of percentage purity of a sample of common salt using a cation exchanger.
3. Determination of potassium content of a commercial salt sample by flame photometry.
4. Determination of acetic acid content of a vinegar sample by potentiometric titration with sodium hydroxide using quinhydrone.
5. Determination of Cr (VI) in the given solution as dichromate by the method of least squares, spectrophotometrically

Reference List for Paper-I (Physical Chemistry)

1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkota.
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rd edition , John Wiley & Sons, Inc [part 1]
4. Physical Chemistry, G. Castellan, 3rd edition, 5th Reprint, 1995 Narosa Publishing House.
5. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer
6. Visible & U.V. Spectroscopy, Analytical Chemsitry by Open Learning R. Demny and R. Sinclair M 1991 John Wiley & Sons
7. Classical Methods , Vol 1 Analytical Chemistry by Open Learning D. Cooper & C. Devan,1991 John Wiley & Sons
8. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
9. The Elements of Physical Chemistry, P.W. Atkins, 2nd Edition, Oxford Universtity Press Oxford
10. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.

References for Paper-II.(Inorganic Chemistry).

1. D. Banerjea, *Coordination chemistry*, Tata McGraw Hill, New Delhi, (1993).
2. D. F. Shriver and P. W. Atkins, *Inorganic chemistry*, 3rd Ed., Oxford University Press, (1999).
3. K. F. Purcell and J. C. Kotz, *Inorganic chemistry*, Saunders, Hongkong, (1977).
4. N. N. Greenwood and E. Earnshaw, *Chemistry of elements*,Pergamon Press, Singapore, (1989).
5. W. L. Jolly, *Modern inorganic chemistry*, 2nd Ed. McGraw Hill Book Co., (1991).
6. B. E. Douglas and H. McDaniel, *Concepts and models in inorganic chemistry*, 3rd Ed., John Wiley & Sons, Inc., New York, (1994).
7. G. N. Mukherjee and A. Das, *Elements of bioinorganic chemistry*, Dhuri and Sons, Calcutta, (1988).
8. R. W. Hay, *Bioinorganic chemistry*, Ellis Harwood, England, (1984).

9. R. C. Mehrotra and A. Singh, *Organometallic chemistry: A unified approach*, Wiley Eastern, New Delhi, (1991).
10. For synthesis of iron ethylenediamine sulphate refer Practical Inorganic Chemistry by G. Marr and B. W. Rockett,Van Nostrand Reinhold Company London1972. P 34.
11. For preparation of $CuCl_2$.2DMSO Refer Microscale Inorganic Chemistry by Z. Szafran, Ronald M. Pike and Mono M. Singh. Pub. John Wiley and Sons1991.p.218.

References For Paper-III (Organic Chemistry)

1. Organic Chemistry, Francis A Carey, Pearson Education, 6th Edition, Special Indian Edition 2008
2. Organic Chemistry, R.T. Morrison and R.N. Boyd, 6th Edition, Pearson Edition
3. Organic Chemistry, T.W.G. Solomon and C.B. Fryhle, 8th Edition, John Wiley & Sons, 2004
4. A guide to mechanism in Organic Chemistry, 6th Edition, Peter Sykes, Pearson Education
5. Fundamentals of Organic Chemistry , G. Marc Loudon, 4th Edition Oxford
6. Organic Chemistry, L.G. Wade Jr and M.S. Singh, 6th Edition,2008
7. Organic Chemistry Baula Y. Bruice, Pearson Edition, 2008
8. Organic Chemistry,J.G. Smith, 2nd Editionm Special Indian Edition, Tata McGraw Hill
9. Organic Chemistry, S.H. Pine, McGraw Hill Kogakusha Ltd.
10. Stereochemistry, P.S. Kalsi, New Age International Ltd. 4th Edition,2006

Reference List for Paper-IV (Analytical Chemistry)

1. D. Harvey, Modern Analytical Chemistry, The McGraw-Hill Pub. 1st Edition (2000)
2. H.S. Ray, R Sridhar and K.P. Abraham, Extraction of Nonferrous Metals, AffiliatedEast-West Press Pvt. Ltd. New Delhi (1985) reprint 2007.
3. G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney , Vogel's Textbook of Qunatitative Chemical Analysis, Fifth edition, ELBS Publication (1996)
4. D.A. Skoog D.M. West and F.J. Holler, Fundametals of Analytical Chemistry, 7thEdition (printed in India in 2001) ISBN Publication.
5. Analytical Chemistry, J.G. Dick,1973 Tata McGraw Hill Publishing Co. Ltd. New Delhi.
6. Quantitative analysis, Dey & Underwood, Prentice Hall of India, Pvt. Ltd.

New Delhi

7. Fundamentals of Analytical Chemistry, Skoog etal 8th edition, Saunders college publishing.

AC – -------------
ItemNo. ……..

University of Mumbai

M.Sc. Organic Chemistry Semester I & II
CHOICE BASED (REVISED SYLLABUS) As Per NEP 2020
With Effect From The Academic Year
2023–2024

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr.No	Heading	Particulars
1	**Heading**	**Particulars**
2	Title of the Course	**M.Sc. Organic Chemistry**
3	Eligibility for Admission	B.Sc. Chemistry or equivalent qualification from other universities as may have been allowed by the relevant ordinances of this university
4	Passing Marks	40%
5	Ordinances / Regulations (if any)	
6	No. of Years / Semesters	Two
7	Level	PG
8	Pattern	Semester
9	Status	Revised

Date: Signature

Chairman
BoS in Chemistry

Dean,
Science and Technology

University of Mumbai

Credit Distribution Structure for Two Years

(M.Sc. in Organic Chemistry)

Year	Level	Sem	Major: Mandatory	Major: Electives	RM	OJT/ FP	RP	Cum. Cr.	Degree
1	6.0	Sem I	3×4+ 2=14	4	4	--	--	22	PG Diploma (after 3 Years Degree)
			Inorganic Chemistry-I (CHEM 502)	**Credits 4 (2+2)** **Course 1 :** Physical Chemistry-I + Chemistry Practicals (Physical Chemistry and Inorganic Chemistry) (CHEM 50111) **(OR)** **Credits 4 (2+2)** **Course 2 :** Physical Chemistry-II + Chemistry Practicals (Physical Chemistry and Inorganic Chemistry) (CHEM 50112)	Research Methodology (CHEM 506)				
			Organic Chemistry-I (CHEM 503)						
			Analytical Chemistry-I (CHEM 505)						
			Chemistry Practical-I (Organic Chemistry and Analytical Chemistry) (PRCHEMOA 504)						
		Sem II	3*4+ 2=14	4	--	4 CHEM 512	--	22	PG Degree (after 3 Years Degree)
			Inorganic Chemistry-II (CHEM 508)	**Credits 4 (2+2)** **Course 1 :** Physical Chemistry-III + Chemistry Practicals (Physical Chemistry and Inorganic Chemistry) (CHEM 50711) **(OR)** **Credits 4 (2+2)** **Course 2 :** Physical Chemistry-IV + Chemistry Practicals (Physical Chemistry and Inorganic Chemistry) (CHEM 50712)					
			Organic Chemistry - II (CHEM 509)						
			Analytical Chemistry - II (CHEM 510)						
			Chemistry Practical-II (Organic Chemistry and Analytical Chemistry) (PRCHEMOA 511)						
Cum. Cr. For PG Diploma			28	8	4	4		44	
Exit Option: PG Diploma (44 credits) after Three Year UG Degree									

M.Sc. Organic Chemistry

PROGRAM OUTLINE

YEAR		COURSE CODE	COURSE TITLE	CREDITS	Page Number
M.Sc. Sem-I	Mandatory Course-I	CHEM 502	Inorganic Chemistry-I	04	6
	Mandatory Course-II	CHEM 503	Organic Chemistry-I	04	11
	Mandatory Course-III	CHEM 505	Analytical Chemistry-I	04	15
	Mandatory Course Practical	PRCHEMOA 504	Chemistry Practical-I (Organic and Analytical Chemistry)	02	20
	Elective 1	CHEM 50111	Physical Chemistry-I and Chemistry Practical (Physical and Inorganic Chemistry)	04	22
	Elective 2	CHEM 50112	Physical Chemistry-II and Chemistry Practical (Physical and Inorganic Chemistry)	04	28
	RM	CHEM 506	Research Methodology	04	34
M.Sc. Sem-II	Mandatory Course-I	CHEM 508	Inorganic Chemistry-II	04	36
	Mandatory Course-II	CHEM 509	Organic Chemistry-II	04	40
	Mandatory Course-III	CHEM 510	Analytical Chemistry-II	04	44
	Mandatory Course Practical	PRCHEMOA 511	Chemistry Practical-II (Organic and Analytical Chemistry)	02	48
	Elective 1	CHEM 50711	Physical Chemistry-III and Chemistry Practical (Physical and Inorganic Chemistry)	04	50
	Elective 2	CHEM 50712	Physical Chemistry-IV and Chemistry Practical (Physical and Inorganic Chemistry)	04	56
	OJT/FP	CHEM 512	Industrial Training/Field Project	04	62
			Proposed Examination Pattern		63

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, scrutinize and accomplish a solution to problems encountered in the field of research and analysis.

2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry.

5. Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

6. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

7. Exhibit professional work ethics and norms of scientific development.

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td colspan="3">SEMESTER: I</td></tr>
<tr><td colspan="3">Course:Paper-I</td><td colspan="3">Course Code: (CHEM502)
Course Title:- Inorganic Chemistry-I</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>04</td><td>NA</td><td>–</td><td>04</td><td>50</td><td>50</td></tr>
</table>

Learning Objectives:

Inorganic Chemistry

1. To develop the ability to correlate fundamental theories of spatial orientations of molecules based on wave mechanics with advancedconceptsin chemical bonding ,symmetry of molecular systems and Structural aspects of inorganic solids.
2. To gain theoretical knowledge of cutting edge topics such as solid state lasers and contemporary Methods of preparation of nanomaterial's .
3. To learn about diverse tools available for characterization of coordination compounds in order to enhance competency while applying for practical purpose

Course Outcomes:

1. The learner will know the important fundamental concept of Group Theory, which helps them in understanding the properties and bonding in polyatomic molecules.
2. The learner get the knowledge about the various techniques used for Characterization coordination compounds.
3. The learners develops the skill in interpretation of the spectra.
4. Thelearnerswill get comprehensive idea about established instrumental techniques and Significant characterization tools available to study inorganic complexes having wide applications in industries.

Course Code : (CHEM 502)

Course Title:-Inorganic Chemistry-I

Unit – I

Unit I Chemical Bonding: [15 L]

1.1 Recapitulation of hybridization Derivation of wave functions for sp, sp2, sp3 orbital hybridization types considering only sigma bonding.

1.2 Discussion of involvement of d orbitals in various types of hybridizations. Concept of resonance, resonance energy derivation expected. Formal charge with examples.

1.3 Molecular Orbital Theory for diatomic species of First transition Series.

1.4 Molecular Orbital Theory for Polyatomic species considering σ bonding for SF6, CO2, B2H6, I3 - molecular species.

1.5 Weak forces of attraction: Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.

Unit II

Molecular Symmetry and Group Theory: [15L]

2.1. Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules.

2.2. Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups.

2.3.a) Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C2v, C3v and C2h, structure of character tables.

b) Determination of symmetry species for translations and rotations.

c) Mulliken"s notations for irreducible representations.

d) Reduction of reducible representations using reduction formula.

2.4. Applications of Group Theory Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in ABn (NH3, CH4) molecule.

Unit III

Materials Chemistry and Nanomaterials: [15 L]

3.1 Solid State Chemistry -

3.1.1. Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones.

3.1.2. Structures of Compounds of the type: AB [nickel arsenide (NiAs)], AB2 [fluorite (CaF2) and anti-fluorite structures, rutile (TiO2)

3.1.3. Solid state lasers: Introduction, Types, Working & Applications

3.2 Nanomaterials-

3.2.1 Preparative methods, Chemical methods, solvothermal, combustion synthesis, microwave, coprecipitation, Langmuir-Blodgett(LB) method, biological methods, synthesis using microorganism.

3.2.2 Applications in the field of semiconductors, solar cells.

Unit IV

Characterization of Coordination compounds [15L]

4.1. Methods of Characterization: thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods.

4.2. Introduction to Orgel& Tanabe Sugano Diagram, Terms, Splitting of terms in Octahedral weak field, Calculation of electron parameters Δ, β, C and Nephlauxetic ratio with suitable examples.

4.3. Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectrophotometric methods.

References:

Unit I

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5. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
6. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
7. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.
8. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004.
9. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
10. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
11. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.
12. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

Unit II

1. F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989.
2. H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996.
3. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
4. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2nd Edition, New Age International Publishers, New Delhi, 2009.
5. A. SalahuddinKunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2012.
6. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House. 2014.
7. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.

Unit III

1. Solid State Chemistry Introduction, Lesley E. Smart, Elaine A. Moore, ISBN 0- 203-49635-3, Taylor & Francis Group, LLC.
2. Nanomaterials &Nanochemistry, 2007, Catherine Brechignac, Philippe Houdy, Marcel Lahmani, ISBN 978-3-540-72992-1 Springer Berlin Heidelberg New York.
3. Nanomaterials Chemistry, Recent Developments and New Directions C.N.R. Rao, A. Muller, and A.K. Cheetham, ISBN 978-3-527-31664-9, 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.
4. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, Marcel Dekker Inc. New York.
5. The Chemistry of Nanomaterials, CNR Rao, Muller Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.
6. Semiconductor Nanomaterials, Challa S.S.R. Kumar, ISBN: 978-3-527-32166-7, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010.
7. Peter Atkins and Julio de Paula, Atkin‟s*Physical Chemistry*, 7th Edn., Oxford University Press, 2002.
8. An introduction to Lasers Theory and Applications by M.N. Avadhanulu,P.S.Hemne, S.Chand publication.
9. Advances in solid state lasers development and Applications by M. Grishin
10. Solid state Lasers- A Graduate Text by Walter Koechner,Michael Bass, Springer.
11. Rare earth materials-properties & applications by A.R. Jha, CRC Press

Unit IV

1. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.
2. D. Banerjea ,Coordination Chemistry
3. Geary Coordination reviews 4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006.
5. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999,
6. B. Douglas, D. McDaniel and J. Alexander. Concepts and Models of Inorganic Chemistry(3rd edn.), John Wiley & Sons (1994).

PROGRAM(s): M.Sc.-I	SEMESTER: I				
Course: Paper-II	**Course Code: (CHEM 503)** **Course Title:- Organic Chemistry-I**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**NA**	–	**04**	**50**	**50**

Learning Objectives:

1.To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction Mechanism, stereochemistry, different reactions and reagents.

2. To apply the basic knowledge of Organic chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

3. Accomplish a solution to problems encountered in the field of research.

Course Outcomes:

After completing the course students will be able to:

1) predict the reactivity of organic compound from its structure.
2) understand different methods used for determination of Organic Reaction Mechanism
3) understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
4) acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
5) develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
6) identify the nomenclature of various stereochemical phenomena
7) organize the techniques of aromatic nucleophilic substitution reactions for synthesizing/transforming molecules.
8) understand the concept of aromaticity and to know the nature of bonds, electronic effects and other properties of molecules.
9) understand the preparation of important oxidizing reagent and predict the selectivity of the reagents in organic reactions.
10) explain the preparation and uses of important reducing reagents in various organic transformation reaction.

Course Code : (CHEM 503)

Course Title:-Organic Chemistry-I

Unit I

Physical Organic Chemistry: (15L)

1.1. Thermodynamic and kinetic requirements of a reaction: rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, Reactivity *vs* selectivity, Curtin-Hammett Principle, Microscopic reversibility, Kinetic *vs* thermodynamic control of organic reactions.

1.2. Determining mechanism of a reaction: Product analysis, kinetic studies, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect). Detection and trapping of intermediates, crossover experiments and stereochemical evidence.

1.3. Acids and Bases: Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity and solvation. Comparative study of acidity and basicity of organic compounds on the basis of pKa values, Leveling effect and non-aqueous solvents. Acid and base catalysis – general and specific catalysis with examples.

Unit-II

Stereochemistry: (15 L)

2.1. Concept of Chirality: Recognition of symmetry elements.

2.2. Molecules with tri- and tetra-coordinate centers: Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities.

2.3. Molecules with two or more chiral centers: Constitutionally unsymmetrical molecules: erythro-threo and syn-anti systems of nomenclature. Interconversion of Fischer, Sawhorse, Newman and Flying wedge projections. Constitutionally symmetrical molecules with odd and even number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudoasymmetriccentres. R-S nomenclature for chiral centres in acyclic and cyclic compounds.

2.4. Axial and planar chirality: Principles of axial and planar chirality. Stereochemical features and configurational descriptors (R,S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spirans, biaryls (buttressing effect) (including BINOLs and BINAPs), ansa compounds, cyclophanes, trans-cyclooctenes.

2.5. Prochirality: Chiral and prochiralcentres; prochiral axis and prochiral plane. Homotopic, heterotopic (enantiotopic and diastereotopic) ligands and faces.Identification using substitution and symmetry criteria.Nomenclature of stereoheterotopic ligands and faces. Symbols for stereoheterotopic ligands in molecules with i) one or more prochiralcentres ii) a chiral as well as a prochiralcentre, iii) a prochiral axis iv) a prochiral plane v) pro-pseudoasymmetriccentre. Symbols for enantiotopic and diastereotopic face.

Unit III

Nucleophilic substitution reactions and Aromaticity (15L)

3.1. Nucleophilic substitution reactions: (9 L)

3.1.1 Aliphatic nucleophilic substitution: S_N1, S_N2, S_N^i reactions, mixed S_N1 and S_N2 and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, σ and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1'' and S_N2'' reactions. S_N at sp^2 (vinylic) carbon.

3.1.2 Aromatic nucleophilic substitution: S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution.

3.1.3 Ester hydrolysis: Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples.

3.2. Aromaticity: (6 L)

3.2.1. Huckel's (4n+2) and 4n rules, structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity.

3.2.2. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C_{60}).

Unit-IV

Oxidation and Reduction: (15L)

4.1. Oxidation: General mechanism, selectivity, and important applications of the following:

4.1.1. Dehydrogenation: Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ).

4.1.2. Oxidation of alcohols to aldehydes and ketones: Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin's reagent), PCC (Corey's reagent) and PDC (Cornforth reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Corey-Kim oxidation - advantages over Swern and limitations; and Pfitzner-Moffatt oxidation-DCC and DMSO and Oppenauer oxidation.

4.1.3. Oxidation involving C-C bonds cleavage: Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$.

4.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH_2 to CO by SeO_2, oxidation of arylmethanes by CrO_2Cl_2 (Etard oxidation).

4.1.5. Oxidation of aldehydes and ketones: with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation)

4.2. Reduction: General mechanism, selectivity, and important applications of the following reducing reagents:

4.2.1. Reduction of CO to CH_2 in aldehydes and ketones-Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification.

4.2.2. Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane, 9-BBN, $Na(OAc)_3BH$, aluminium reagents ($LiAlH_4$, DIBAL-H, Red Al, L and K- selectrides).

4.2.3. N_2H_2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzschdihydropyridine).

4.2.4. Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 mediated reduction of aromatic compounds (Birch reduction) and Alkynes.

Reference Books.

1. Physical Organic Chemistry, NeilIsaacs
2. Modern Physical Organic Chemistry, Eric V. Anslynand Dennis A.Dougherty
3. Comprehensive Organic chemistry, Barton and Ollis,Vol1
4. Organic Chemistry, J. Claydens, N. Greeves, S.Warren and P. Wothers, Oxford University Press.
5. Advanced Organic Chemistry, F.A. Careyand R.J. Sundberg, Part A and B, Plenum Press.
6. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
7. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
8. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
9. March’s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
10. Advanced Organic Chemistry: Reactions and mechanism, B. Millerand R.Prasad, Pearson Education.
11. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner,AcademicPress.
12. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
13. Writing Reaction Mechanism inorganic chemistry, A.Miller, P.H.Solomons, Academic Press.
14. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
15. Mechanism in Organic Chemistry, Peter sykes, 6^{th} edition onwards.
16. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press.
17. Organic Synthesis, Jagdamba Singh, L. D. S. Yadav, Pragati Prakashan.
18. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press.
19. Organic reactions and their Mechanisms, P.S. Kalsi, New Age International Publishers.
20. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Nelson Thornes

PROGRAM(s): M.Sc.-I		**SEMESTER: I**			
Course: Paper-III		**Course Code: (CHEM 505)** **Course Title:- Analytical Chemistry-I**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**NA**	–	**04**	**50**	**50**

Learning Objectives:

1. To enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.
2. To apply the basic knowledge of quality systems, quality audit and quality managements,.
3. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.
4. To provide solutions to problems encountered in the field of analysis and research.

Course Outcomes:

After completion of this Course, the learner will be able to:

1. Understand various terms used in analytical chemistry.
2. Identify the different types of errors in analysis.
3. Sketch out the role and importance of total quality management, safety, accreditations and GLP in industries.
4. Understand the efficacy of automation in chemical analysis.
5. Design and specify applications of advanced analytical techniques in various fields.
6. Explore the applications of IR spectroscopy and thermal methods.
7. Perform basic calculations required in chemical analysis
8. Interpret the experimental results of analytical techniques. transformation reaction.

Course Code : (CHEM 505)

Course Title:- Analytical Chemistry-I

Unit - I

1.1 Language of Analytical Chemistry [8 L]

1.1.1 Analytical perspective [3 L]

Analytical approach.common analytical problems. Terms involved in analytical chemistry - Analysis, Analyte, Matrix, Determination, Measurement, Techniques, Methods, Procedures and protocol.

1.1.2 An overview of analytical methods [3 L]

Analytical methods - Types, classification and selection. Quantitative method of Analysis- Calibration method, Method of Standard addition, Internal standard method. Performance Characteristics of analytical method- Accuracy, Precision, Selectivity, Sensitivity, Detection limit (LOD,LOQ,LOL) ,Dynamic range and Robustness and Ruggedness.

1.1.3 Errors [2 L]

Types of errors.Absolute error, Relative error, Constant error and Proportionate errors.Minimization of errors.

1.2 Quality in Analytical Chemistry [7L]

1.2.1 Total Quality Management- TQM [3L]

Definition, Principles, Importance and benefits. Philosophy of implementation of TQM - Process steps, Advantages and Limitations **i)** Kaizen -Six steps **ii)** Six Sigma approach **iii)** 5S and 5S audit check for laboratories.

1.2.2 Safety in laboratories [2L]

Basic concept of safety in laboratory- The Industrial Hygiene Principles.Personal protection equipment (PPE).Occupational Safety and Health Administration (OSHA).

1.2.3 Accreditations [2L]

Accreditation of laboratories, NABL**,** Indian Government standards (ISI, HALLMARK, AGMARK).- Meaning and significance.

Unit- II

2.1 Calculations based on Chemical Principles [15 L]

(The following topics are to be covered in the form of numerical problems only)

2.1.1 Concentration of a solution based on volume and mass units.
2.1.2 Calculations of ppm, ppb and dilution of the solutions, concept of mmol.
2.1.3 Stoichiometry of chemical reactions, concept of kg /mol, limiting reactant, theoretical and practical yield.
2.1.4 Solubility and solubility equilibria, effect of presence of common ion in solution.
2.1.5 Calculations of pH of acids, bases, acidic and basic buffers.
2.1.6 Concept of formation constants, stability and instability constants, stepwise formation constants.
2.1.7 Oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a solution of an oxidizing / reducing agent and its relationship with molarity).

Unit III -Optical Methods [15 L]

3.1 Infrared Absorption Spectroscopy [6 L]

3.1.1 Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument.

3.1.2 Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on "Finger print" and Quantitative analysis.

3.1.3 Advantages and Limitations of IR.

3.2 FT Technique [3 L]

3.2.1 Introduction of Fourier Transform.

3.2.2 Laser as a source of radiation, sample containers.

3.2.3 Detectors, Fiber optics.

3.2.4 FTIR and its advantages.

3.3 Molecular Ultraviolet and Visible Spectroscopy [6 L]

3.3.1 Factors affecting molecular absorption: pH, temperature, solvent and effect of substituents, types of transitions [emphasis on charge transfer absorption].

3.3.2 Applications of Ultraviolet and Visible spectroscopy:

i) On charge transfer absorption
ii) Simultaneous spectroscopy
iii) Derivative Spectroscopy

3.3.3 Dual spectrometry – Introduction, Principle, Instrumentation and Applications.

Unit - IV Instrumental methods-I [15L]

4.1 Thermal Methods: [9 L]

4.1.1 Introduction: Types of thermal methods, comparison between TGA and DTA.

4.1.2 Differential Scanning Calorimetry-Principle, comparison of DTA and DSC.

4.1.3 Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting DSC Curves.

4.1.4 Applications **-** Heat of reaction, Safety screening, Polymers, liquid crystals, Drug analysis.

4.2 Automation in chemical analysis: [6 L]

4.2.1 Need for automation, Objectives of automation.

4.2.2 An overview of automated instruments.

4.2.3 Process control analysis, flow injection analysis, discrete automated systems, automatic analysis based on multi-layered films, gas monitoring equipments.

4.2.4 Automatic titrators.

References

Unit I

1. Modern Analytical Chemistry ; David Harvey, McGraw-Hill,Higher Education,(2000)
2. Principles of Instrumental Analysis ; Skoog, Holler and Nieman, 5^{th} Edition, Ch: 1
3. Fundamentals of Analytical Chemistry, Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9^{th} Edition, 2004, Ch: 5.
4. Undergraduate Instrumental Analysis ; J W Robinson, Marcel Dekker, 6^{th} edition Ch:1.
5. ISO 9000 Quality Systems Handbook; David Hoyle. 4^{th} edition (Chapter: 3 & 4) (Free download).
6. Quality in the Analytical Laboratory ; Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 &Ch: 7.
7. Quality Management; Donna C S Summers, Prentice-Hall of India, Ch:3.
8. Quality in Totality: A Manager"s Guide To TQM and ISO 9000, Parag Diwan, Deep & Deep Publications, 1st Edition, 2000.
9. Quality Control and Total Quality Management - ; P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.
10. Industrial Hygiene and Chemical Safety, ; M H Fulekar, Ch:9, Ch:11 & Ch:15.
11. Safety and Hazards Management in Chemical Industries ; M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19.
12. World Health Organization (2009) Handbook: Good Laboratory Practice (GLP)
13. OECD Principles of Good Laboratory Practice (as revised in 1997)". OECD Environmental Health and Safety Publications. OECD. **1**. 1998
14. "A systematic approach for evaluating the quality of experimental toxicological and eco-toxicological data".;Klimisch, HJ; Andreae, M; Tillmann, U (1997). doi:10.1006/rtph.1996.1076. PMID 9056496.

Unit II

1. 3000 solved problems in chemistry, Schaums Solved problem series, ; David E. Goldbers, Mc Graw Hill international Editions, Chapter 11,15,16,21,22

Unit III

1. Principles of Instrumental Analysis, ; D. A. Skoog, F. J. Holler, T. A. Nieman, 5^{th} Edition, Harcourt Asia Publisher. Chapter 6, 7,8, 13, 14, 16,17

2. Instrumental Methods of Analysis,; H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, 6 th Edition, CBS Publisher. Chapter 2.

3. Introduction to Instrumental Analysis, ; R. D. Braun , McGraw Hill Publisher. Chapter 5, 8, 12

4. Instrumental Methods of Chemical Analysis, ; G. W. Ewing, 5 th Edition, McGraw Hill Publisher, Chapter 3.

5. The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding,; M. Ito, J. Mol. Spectrosc. 4 (1960) 106-124.

6. The effect of temperature on the visible absorption band of iodine in several solvents; A. J. Somnessa, Spectrochim. Acta. Part A: Molecular Spectroscopy, 33 (1977) 525-528.

7. Infrared Spectroscopy- Materials Science, Engineering and Technology. Z. M. Khoshhesab (2012). Prof. TheophanidesTheophile (Ed.). ISBN: 978-953- 51-0537-4, InTech,(open access)

Unit IV

1. Introduction to instrumental methods of analysis; Robert D. Braun, Mc. Graw Hill (1987): Chapter 27,28
2. Thermal Analysis-theory and applications; R. T. Sane, Ghadge, Quest Publications
3. Instrumental methods of analysis; Willard, Merrit, Dean:7 th Edition, Chapter 25, 26
4. Instrumental Analysis, ; Skoog, Holler and Nieman, 5 th Edition, Chapter 31,33
5. Vogel's Quantitative Chemical Analysis,; 6 th Edition, Chapter 12
6. Analytical Chemistry - Open Learning: Thermal Methods; James W. Dodd, W. James and Kenneth H. Tonge

PROGRAM(s): M.Sc.-I		SEMESTER: I			
Course: Practical		**Course Code:** PRCHEMOA504 **Course Title:- Chemistry Practical-I (Organic Chemistry and Analytical Chemistry)**			
Teaching Scheme				**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 25)**	**Semester End Examination (Marks- 25)**
NA	**04**	**NA**	**02**	**50**	**50**

Learning points:

1. Planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt.
2. Purify the product by crystallization. Formation and purity of the product should be checked by TLC
3. Report mass and melting point of the purified product.
4. To gain knowledge and hands on experience in instrumental and non-instrumental analysis.
5. To introduce the concept of non-aqueous titrations.
6. To study technique of ion exchange and efficiency of the ion exchanger.
7. To develop scientific temper and research-based skills.

Course Outcomes:

After completion of this Course, the learner will be able to

1. Carry out one step preparation in laboratory with basic understanding of stoichiometry
2. Evaluate the process and outcomes of an experiment quantitatively and qualitatively
3. Check purity of product using thin layer chromatography
4. handle and get familiar with SOP's of instruments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
5. understand the concept of non-aqueous titrations and apply it in analysis of samples.
6. apply the theory of redox reactions to experimental systems.
7. separate the component of interest from the matrix.
8. develop scientific temperament and research-based skills accomplish to encountered in the field of research

Course Code: PRCHEMOA 504

Organic Chemistry Practicals

One step preparations (1.0 g scale)

1. Bromobenzene to p-nitrobromobenzene
2. Anthracene to anthraquinone
3. Benzoin to benzil
4. Anthracene to Anthracene maleic anhydride adduct
5. 2-Naphthol to BINOL
6. p-Benzoquinone to 1,2,4-triacetoxybenzene
7. Ethyl acetoacetate to 3-methyl-phenylpyrazol-5-one
8. *o*-Phenylenediamine to 2-methylbenzimidazole
9. *o*-Phenylenediamine to 2,3-diphenylqunooxaline
10. Urea and benzil to 5,5-diphenylhydantoin

(Minimum 08 experiments are expected)

Analytical Chemistry Practicals

Instrumental Experiments

1. To determine percentage purity of sodium carbonate in washing soda pH metrically.
2. To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV)potentiometrically.
3. To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titration with perchloric acid in a non-aqueous medium using glass calomel system potentiometrically.
4. To determine the amount of nitrite present in the given water sample colorimetrically.

Non-Instrumental Experiments

1.To carry out assay of the sodium chloride injection by Volhard's method.

2.To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.

3.To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.

4.To determine number of nitro groups in the given compound using$TiCl_3$.

References:

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by ; A. I. Vogels, 3rd Ed. ELBS (1964)
2. Vogel's textbook of quantitative chemical analysis, Mendham, Denny, Barnes, Thomas, Pearson education, Sixth Ed.
3. Standard methods of chemical analysis ; F. J. Welcher, 1975
4. Standard methods of chemical analysis :Instrumental methods of Analysis ; F. J. Welcher , vol. 3, 1966
5. "Standard methods of Chemical Analysis"; W. W. Scott, Vol. I, Van Nostrand Company, Inc.,1939.
6."Spectrophotometric Determination of Traces of Metals"; E.B.Sandell and H.Onishi, ,Part II,4th Ed. ,A Wiley Interscience Publication, New York,1978

Course Code: (CHEM 50111)
Course Title:- Physical Chemistry Elective- I

PROGRAM(s): M.Sc.-I	SEMESTER: I				
Course: Elective:I	Course Code: (CHEM50111) Course Title:- Physical Chemistry-I				
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-25)	Semester End Examination (Marks-25)
02	NA	--	02	50	50

Learning Objectives:

Physical Chemistry

1. To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction kinetics, molecular dynamics and chemical thermodynamics.
2. To apply the basic knowledge of Physical chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.
3. Accomplish a solution to problems encountered in the field of research.

Course Outcomes:

1. The learners will apply the advanced thermodynamics, Maxwell equation and its applications to ideal gasses.
2. The learners will implement the applications of chemical thermodynamics to real gases, solutions, surfaces and their energetics.
3. The learners will understand the applications of operators and Schrodinger equation in the field of quantum Chemistry.
4. The learners will try to accomplish a solution to problems encountered in the field of research.

Elective: I Physical Chemistry-I

Unit - I

Thermodynamics-I [15]

1.1.State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; it‟s significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. **[8L]**
1.2.Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy. **[7L]** [Ref 2 and 1,10,11,12 17]

Unit II

Quantum Chemistry: [15L]

2.1.Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics.
2.2.Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions.
2.3.Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrodinger‟s Time independent wave equation from Schrodinger‟s time dependent wave equation.
2.4.Application of quantum mechanics to the following systems:
a) Free particle, wave function and energy of a free particle.
b) Particle in a one, two and three dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels.
c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.
[Ref 7, 8 and 9]

References: (Elective:I and II)

1. Peter Atkins and Julio de Paula, Atkin‟s*Physical Chemistry*, 7thEdn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rdEdn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5thEdn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rdEdn.,Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2ndEdn., McMillan and Co. Ltd., London, 1962
7. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
8. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
9. R.K. Prasad, *QuantumChemistry*, 2ndEdn., New Age International Publishers, 2000.
10. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
11. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
12. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
13. Ira N. Levine, *Quantum Chemistry*, 5thEdn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
14. Thomas Engel and Philip Reid, Physical Chemistry, 3rdEdn., Pearson Education Limited 2013.
15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1stEdn., 1992.
16. ***Bockris***, John O'M., ***Reddy***, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
17. Physical Chemistry by Gurtu and Gurtu.
18. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.
19. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2ndEdn

Elective Practical I

PROGRAM(s): M.Sc.-I			SEMESTER: I		
Course: Practical			Course Code: CHEM50111 Course Title:- Physical and Inorganic Chemistry Practical-I		
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial(Hours perweek)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
02	NA	–	02	25	25

Learning Objectives:

Physical Chemistry

1. To Gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2. To understand advance concept of thermodynamics and chemical kinetics in the chemical reactions.
3. To develop scientific temper and research based skills accomplish to encountered in the field of research.
4. To usage of subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions.
5. Learner will train the handling of equipments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
6. Learner will develop scientific temper and research based skills accomplish to encountered in the field of research.

Inorganic Chemistry

1. To apply basic concepts of separation and estimation of metals ions from constituent ores/alloys effectively using chemical analysis
2. To gain knowledge of employing instrumental techniques for quantitative analysis.
3. The learner can able to analyze structure, reactivity and reaction mechanisms of coordination compounds.
4. It explains various methods, concepts, highlights on effect of environment on human beings.
5. Will able to understand Commercial applications of novel materials in synthesis of compounds.

Chemistry Practical-I

Course Code: CHEM 50111

Non – Instrumental:

1.To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic/salicylic acid) from solubility measurement at three different temperature.
2.To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.
3.To investigate the reaction between acetone and iodine.
4.Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?

Instrumental:

1.To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.
2.To study the effect of substituent on the dissociation constant of acetic acid conductometrically.
3.To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
4.To verify Ostwald"s dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.

References:

1. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
2. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.
3. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Inorganic Chemistry Practical
Course Code: CHEM 50111

Ores and Alloys

1) Analysis of Devarda‟s alloy

2) Analysis of Cu – Ni alloy

3) Analysis of Limestone.

4) Analysis of Tin Solder alloy

Instrumentation

1) Estimation of Fe (III)solution using Ce (IV) ions Potentiometrically
2) Estimation of Copper using Iodometric method Potentiometrically
3) Estimation of Na_2CO_3 in washing soda by pH metry
4) Estimation of Cl- ion in NaCl/KCl by Conductometry.

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhuri& Sons Pvt Ltd

2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly

3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

Elective: II Physical Chemistry-II

PROGRAM(s): M.Sc.-I	**SEMESTER: I**				
Course: Elective-II	**Course Code: (CHEM50112)** **Course Title:- Physical Chemistry-II**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 25)**	**Semester End Examination (Marks- 25)**
02	**NA**	–	**02**	**50**	**50**

Learning Objectives:

Physical Chemistry

1. 1.To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction kinetics, molecular dynamics and chemical thermodynamics.
2. To apply the basic knowledge of Physical chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.
3. Accomplish a solution to problems encountered in the field of research.

Course Outcomes :

1. The learners evaluate the different theories of chemical kinetics and effect of temperature on reaction rates.
2. The learners will understand the applications of chain reactions in the field of Polymer Chemistry.
3. The learners will evaluate the resting membrane potential by using the concept of bio electrochemistry.
4. The learners will try to accomplish a solution to problems encountered in the field of research.

Course Code: (CHEM 50112)
Elective : II Physical Chemistry-II

Unit I

Chemical Kinetics and Molecular Dynamics-I [15L]

1.1.Composite Reactions:

Recapitulation: Rate laws, Differential rate equations Consecutive reactions, Steady state Approximation, rate determining steps, Microscopic Reversibility and Detailed Balanced Chain reactions-chain initiation processes. Some inorganic mechanisms: formation and decomposition of phosgene, decomposition of ozone, Reaction between Hydrogen and Bromine and some general examples Organic Decompositions: Decomposition of ethane, decomposition of acetaldehyde Gas phase combustion: Reaction between hydrogen and oxygen, Semenov – Hinshelwood and Thompson mechanism, Explosion limits and factors affecting explosion limits.

1.2.Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain length and estimation of average no .of monomer units in the polymer produced by chain polymerization.

1.3.Reaction in Gas Phase

Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory.

[Ref. 2 and 15, 17, 18]

Unit II

Electrochemistry [15L]

Recapitulation – basics of electrochemistry.

2.1. Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and its extension to higher concentration (derivations are expected).

2.2. Electrolytic conductance and ionic interaction, relaxation effect,.Debye-Hückel-Onsager equation (derivation expected). Validity of this equation for aqueous and non- aqueous solution, deviations from Onsager equation, Debye - Falkenhagen effect (dispersion of conductance at high frequencies), Wien effect.

2.3. Batteries: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells]

2.4. Bio-electrochemistry: Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, adsorption of proteins onto metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes, electrochemical enzyme-catalysed oxidation of styrene. Goldmann equation. (derivations are expected)

[Ref: 14 and 16, 17, 18]

[Note: Numerical and theoretical problems from each unit are expected]

References: (Elective:I and II)

1. Peter Atkins and Julio de Paula, Atkin‟s*Physical Chemistry*, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rd Edn.,Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2nd Edn., McMillan and Co. Ltd., London, 1962
7. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
8. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
9. R.K. Prasad, *QuantumChemistry*, 2nd Edn., New Age International Publishers, 2000.
10. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
11. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
12. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
13. Ira N. Levine, *Quantum Chemistry*, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
16. ***Bockris***, John O'M., ***Reddy***, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
17. Physical Chemistry by Gurtu and Gurtu.
18. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.
19. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2nd Edn

Elective Practical II

PROGRAM(s): M.Sc.-I				SEMESTER: I	
Course: Practical				Course Code: CHEM50112 Course Title:- Physical and Inorganic Chemistry Practical-I	
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
02	NA	–	02	25	25

Learning Objectives:

Physical Chemistry

1. To Gain knowledge of the advanced concepts
2. To understand advance concept of thermodynamics and chemical kinetics in the chemical reactions.
3. To develop scientific temper and research based skills accomplish to encounter in the field of research.
4. To usage of subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions.
5. Learner will train the handling of equipments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
6. Learner will develop scientific temper and research based skills accomplish to encountered in the field of research.

Inorganic Chemistry

1. To apply basic concepts of separation and estimation of metals ions from constituent ores/alloys effectively using chemical analysis
2. To gain knowledge of employing instrumental techniques for quantitative analysis.
3. The learner can able to analyze structure, reactivity and reaction mechanisms of coordination compounds.
4. It explains various methods, concepts, highlights on effect of environment on human beings.
5. Will able to understand Commercial applications of novel materials in synthesis of compounds.

Elective Practical-II

Course Code: CHEM 50112

Physical Chemistry

Non – Instrumental:

1.To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic/salicylic acid) from solubility measurement at three different temperature.
2.To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.
3.To investigate the reaction between acetone and iodine.
4.Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable?

Instrumental:

1.To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.
2.To study the effect of substituent on the dissociation constant of acetic acid conductometrically.
3.To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.
4.To verify Ostwald‟s dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.

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5. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.
6. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Elective Practical II

Course Code: CHEM 50112

Inorganic Chemistry

Ores and Alloys

1) Analysis of Devarda‟s alloy

2) Analysis of Cu – Ni alloy

3) Analysis of Limestone.

4) Analysis of Tin Solder alloy

Instrumentation

5) Estimation of Fe (III)solution using Ce (IV) ions Potentiometrically
6) Estimation of Copper using Iodometric method Potentiometrically
7) Estimation of Na_2CO_3 in washing soda by pH metry
8) Estimation of Cl- ion in NaCl/KCl by Conductometry.

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd

2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly

3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

Research Methodology

PROGRAM(s): M.Sc-I		SEMESTER: I			
Course code: CHEM506		**Course Title:- Research Methodology**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**–**	**–**	**04**	**50**	**50**

Learning Objectives:

1. To create awareness and understanding the terms like intellectual property, patents, copyright, Industrial designs, trademarks, geographical indications etc.
2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements.
3. To explore cheminformatics to facilitate molecular modeling and structure elucidations.
4. To apply the knowledge gained about various chemistry principles, techniques and tools in drug designing, target identification and validation, lead finding and optimization..

Course Outcomes:

At the end of the Course,

1. To enable the student to be able to extract information from journals and digital resources.
2. Understanding tools to analyse the data, writing and presenting scientific papers.
3. Safe working procedure And ethical handling of chemicals.
4. Describe research, identification of research problems, and preparation of proposals.
5. Practice ethics in all the domains of research.
6. Analyze the results using mathematical and statistical tools.

Research Methodology

Unit I Literature Survey

1.1 Print:

Primary, Secondary and Tertiary sources. Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

1.2 Digital:

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.

1.3 Information Technology and Library Resources:

The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.

Unit II DATA ANALYSIS

The Investigative Approach: Making and recording Measurements, SI units and their use, Scientific methods and design of experiments. Analysis and Presentation of Data: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.

Unit III METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS

Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation. Writing Scientific Papers: Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.

Unit IV CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Reference books:-

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 2 nd Ed., Prentice Hall, Harlow.

2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press.

3. Topping, J., (1984) Errors of Observation and their Treatment 4 th Ed., Chapman Hill, London.

4. Harris, D. C. (2007) Quantative Chemical Analysis 6 th Ed., Freeman Chapters 3-5

5. Levie, R. De. (2001) How to use Excel in Analytical Chemistry and in general scientific data analysis Cambridge Universty Press.

6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.

7. OSU Safety manual 1.01

PROGRAM(s): M.Sc.-I				SEMESTER: II	
Course:Paper-I				Course Code: (CHEM508) Course Title:- Inorganic Chemistry-II	
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	NA	–	04	50	50

Learning Objectives:

1. The course aims at the detailed mechanistic study of various inorganic complexes.
2. The course aims at the detailed interception of bonding concepts in organometallic and bioinorganic chemistry.
3. The course also aims at a detailed understanding of bio inorganic chemistry of metals.
4. The course also aims to study the preparation of different inorganic complexes.

Course Outcomes: The learners will be able to study rates of reactions and the factors affecting them and understand the different techniques used to study the rate of the reaction.

1. The learners will be able to learn ligand substitution reactions of Octahedral and Square planar complexes, Trans effect and factors affecting these substitution reactions.

2. The learners will be able to understand the 18 e^- and 16 e^- electron square planar complexes by studying different examples. They will also learn the preparation and properties of a few selected compounds including sandwich compounds of Fe, Cr

3. The learners will understand the structure and bonding of a few inorganic compounds like Ziese’s salt, ferrocene and bis(arene)chromium(0)

4. The learners will understand the occurrence and effect of toxic metals like Pb, As, Cu, Cd, and Hg on the environment, the different diseases caused by poisoning of metals and the impact these metals have on the living organism.

5. The learners will be familiar with the role of Inorganic chemistry in Biological systems, understand the structure of various biological oxygen carriers and molecules involved in electron storage and transport.

Course Code: (CHEM 508)

Course Title:-Inorganic Chemistry-II

Unit I

Inorganic Reaction Mechanism: [15 L]

1.1 Rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction (Direct chemical analysis, spectrophotometric method, electrochemical and flow methods).

1.2 Ligand substitution reactions of:

a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopic

labelling method)

b) Square planar complexes, trans-effect, its theories and applications. Mechanism

and factors affecting these substitution reactions.

1.3 Redox reactions: inner and outer sphere mechanisms, complimentary and non-complimentary reactions.

1.4 Isomerization and racemization reactions

Unit II

Organometallic Chemistry of Transition metals: [15 L]

2.1. Eighteen electron rule & electron counting with examples, sixteen electron Square Planar complexes.

2.2. Preparation and properties of the following compounds

(a) Alkyl and aryl derivatives of Pd and Pt complexes

(b) Carbenes and carbynes of Cr, Mo and W

(c) Alkene derivatives of Pd and Pt

(d) Alkyne derivatives of Pd and Pt

(e) Allyl derivatives of nickel

(f) Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo.

2.3 Structure and bonding on the basis of VBT and MOT in the following organometallic compounds:

Zeise"s salt, bis(triphenylphosphine)diphenylacetylene platinum (0) $[Pt(PPh_3)_2(HC\equiv CPh)_2]$, diallylnickel(diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl (η^2-butadiene) iron(0).

Unit III

Environmental Chemistry: [15 L]

3.1. Conception of Heavy Metals: Critical discussion on heavy metals

3.2. Toxicity of metallic species: a) Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment.

b) Itai-itai disease for Cadmium toxicity,

c) Arsenic Poisoning in the Indo-Bangladesh region.

3.3. Interaction of radiation in context with the environment: Sources and biological implication of radioactive materials. Effect of low-level radiation on cells- Its applications in diagnosis and treatment, Effect of radiation on cell proliferation and cancer.

Unit IV

Bioinorganic Chemistry: [15 L]

4.1. Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and differences in mechanism of oxygen binding, Differences between hemoglobin and myoglobin: Cooperativity of oxygen binding in hemoglobin and Hill equation, pH dependence of oxygen affinity in hemoglobin and myoglobin and its implications.

4.2. Activation of oxygen in biological system with examples of mono-oxygenases

4.3. Copper containing enzymes- superoxide dismutase,

4.4. Nitrogen fixation-nitrogenase, hydrogenases

4.5. Metal ion transport and storage: Ionophores, transferrin, ferritin and metallothionins

4.6. Medicinal applications of cis-platin and related compounds

References

Unit I

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.
2. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.
3. W. H. Malik, G. D./Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.
4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002
6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house,
7. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
8. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
9. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001.
10. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd Ed., Oxford University Press 2008.

Unit II

1. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.
2. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000.
3. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.
4. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
5. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.

Unit III

1. Environmental Chemistry 5th edition, Colin Baird Michael Cann, W. H. Freeman and Company, New York, 2012.
2. Environmental Chemistry 7th edition, Stanley E. Manahan, CRC Press Publishers,
3. Environmental Contaminants, Daniel A. Vallero, ISBN: 0-12-710057-1, Elsevier Inc., 2004.
4. Environmental Science 13th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-495-56016-2, Brooks/Cole, Cengage Learning, 2010.
5. Fundamentals of Environmental and Toxicological Chemistry 4th edition, Stanley E. Manahan, ISBN: 978-1-4665-5317-0, CRC Press Taylor & Francis Group, 2013.
6. Living in the Environment 17th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-538-49414-X, Brooks/Cole, Cengage Learning, 2011
7. Poisoning and Toxicology Handbook, Jerrold B. Leikin, Frank P. Paloucek, ISBN: 1-4200-4479-6, Informa Healthcare USA, Inc.
8. Casarett and Doull‟s Toxicology- The Basic Science of Poisons 6th edition, McGraw-Hill, 2001.

Unit IV

1. R. W. Hay, *Bioinorganic Chemistry,* Ellis Harwood, England, 1984.
2. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998.
3. J. A. Cowan, *Inorganic Biochemistry-An introduction,* VCH Publication, 1993.
4. S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry,* University Science Publications, Mill Valley, Caligronic, 1994.
5. G.N. Mukherjee and A. Das, Elements of Bioinorganic Chemistry, Dhuri& Sons, Calcutta, 1988.
6.J.Chem. Educ. (Special issue), Nov, 1985.

7. E.Frienden, J.Chem. Educ., 1985, 62.
8. Robert R.Crechton, Biological Inorganic Chemistry – An Introduction, Elsevier
9. J. R. Frausto da Silva and R. J. P. Williams *The Biological Chemistry of the Elements*, Clarendon Press, Oxford, 1991.
10. JM. D. Yudkin and R. E. Offord *A Guidebook to Biochemistry*, Cambridge University Press, 1980.

PROGRAM(s): M.Sc.-I	SEMESTER: II				
Course: Paper-II	**Course Code: (CHEM 509)** **Course Title:- Organic Chemistry-II**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**NA**	–	**04**	**50**	**50**

Learning Objectives:

1.To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction Mechanism, molecular orbital theory, different rearrangement reactions and spectroscopic techniques.

2. To apply the basic knowledge of Organic chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

3. Accomplish a solution to problems encountered in the field of research.

Course Learning Outcomes.

After completing the course students will be able to:

1) Recognise the type of mechanism & intermediates involved in the given organic reaction and to prove mechanism for the reaction.
2) Identify the ways to modify aliphatic and aromatic compounds via Nucleophilc substitution reactions.
3) Predict the mechanism and stereochemistry of important organic reactions.
4) Understand and write the mechanism of rearrangement reactions with stereochemistry and its applications.
5) Understand the HOMO-LUMO concept and it significance in organic chemistry.
6) Understand the basic principle and concepts in UV and IR spectroscopy
7) Understand the basic concepts of ^{1}H, ^{13}C NMR, and mass spectroscopy.
8) Understand how ^{1}H, ^{13}C NMR and Mass spectroscopy are important for the structure determination of organic compounds.

Course Code: (CHEM 509)

Course Title:-Organic Chemistry-II

Unit-I

1.1. Alkylation of Nucleophilic Carbon Intermediates: (7 L)

1.1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates.

1.1.2. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation.

1.1.3. Alkylation of aldehydes, ketones, esters, amides and nitriles.

1.1.4. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines.

1.1.5. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction).

1.2. Reaction of carbon nucleophiles with carbonyl groups: (8 L)

1.2.1. Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction and Robinson annulation.

1.2.2. Addition reactions with amines and iminium ions; Mannich reaction.

1.2.3. Amine catalyzed condensation reaction: Knoevenagel reaction.

1.2.4. Acylation of carbanions.

Unit-II

2.1. Introduction to Molecular Orbital Theory for Organic Chemistry: (7L)

2.1.1. Molecular orbitals: Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allyl cation, anion and radical. Concept of nodal planes and energies of π-MOs

2.1.2. Introduction to FMOs: HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra as well as chemical reactions. MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde.A brief description of MOs of nucleophiles and electrophiles.Concept of 'donor-acceptor' interactions in nucleophilic addition reactions on formaldehyde.Connection of this HOMO-LUMO interaction with 'curved arrows' used in reaction mechanisms.The concept of hardness and softness and its application to electrophiles and nucleophiles.Examples of hard and soft nucleophiles/ electrophiles.Identification of hard and soft reactive sites on the basis of MOs.

2.1.3. Application of FMO concepts in (a) S_N2 reaction, (b) Lewis acid base adducts (BF_3-NH_3 complex), (c) ethylene dimerization to Cyclobutane, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with allyl anion (f) addition of hydride to formaldehyde.

2.2. Applications of UV and IR spectroscopy: (8L)

2.2.1. Ultraviolet spectroscopy: Recapitulation, UV spectra of dienes, conjugated polyenes (cyclic and acyclic), carbonyl and unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents).

2.2.2. Infrared spectroscopy: Fundamental, overtone and combination bands, vibrational coupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds.

Unit III

Reactions and Rearrangements: (15L)

Mechanisms, stereochemistry (if applicable) and applications of the following:

3.1. Reactions: Baylis-Hillman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction.

3.2. Concerted rearrangements: Hofmann, Curtius, Lossen, Schmidt, Wolff, Boulton-Katritzky.

3.3. Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein.

3.4. Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Baker-Venkataraman.

Unit-IV

^{1}H and ^{13}C NMR spectroscopy and Mass spectrometry (15L)

4.1. Proton magnetic resonance spectroscopy: Principle, Chemical shift, Factors affecting on chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal,Karplusequation, long range coupling (allylic and aromatic).

4.2. ^{13}C NMR spectroscopy: Theory and comparison with proton NMR, proton coupled and decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons.

4.3. Mass spectrometry: Basic Principle, Molecular ion peak, base peak, isotopic abundance, metastable ions. Nitrogen rule, Determination of molecular formula of organic compounds based on isotopic abundance and HRMS.Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect.

4.4. Structure determination involving individual or combined use of the above spectral techniques.

References:

1. Organic Chemistry, J.Claydens, N.Greeves, S.Warrenand P.Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no.713-769,and B, Plenum Press.
3. March’s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael, B.Smith, Jerry March, Wiley.
4. Organic Chemistry, R.T.Morrison, R.N.Boydand S.K.Bhattacharjee, Pearson Publication (7thEdition)
5. Advanced Organic Chemistry: Reactions and mechanism, B.Millerand R.Prasad, Pearson Education.
6. Advanced Organic Chemistry: Reaction mechanisms, R.Bruckner,AcademicPress.
7. Understanding Organic Reaction Mechanisms, AdamsJacobs, Cambridge University Press.
8. Writing Reaction Mechanism in organic chemistry A. Miller, P. H. Solomons, Academic Press.
9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, NelsonThornes.
10. Advanced Organic Chemistry:Reactions and mechanism, L.G.Wade,Jr.,Maya Shankar Singh, Pearson Education.
11. Mechanism in OrganicChemistry, eter Sykes,6th
12. Molecular OrbitalandOrganic chemical reactions, Ian Fleming Reference Edition, Wiley
13. Introduction to Spectroscopy, DonaldL.Pavia, GaryM.Lampman, GeorgeS.Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R.Silverstein, G.C Basslerand T.C.Morrill, John Wiley and Sons.
15. Organic Spectroscopy,WilliamKemp,W.H.Freeman&Company.
16. Organic Spectroscopy-PrinciplesandApplications,Jagmohan,NarosaPublication.
17. Organic Spectroscopy,V.R.Dani,TataMcGrawHillPublishingCo.
18. Spectroscopy of Organic Compounds, P.S.Kalsi, New Age International Ltd.
19. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K.Parashar, Alpha Science International, 2011.
20. Name Reactions, Jie Jack Li, Springer
21. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K Parasher, Alpha Science International, 2011.
22. Reactions, Rearrangements and Reagents by S.N. Sanyal.
23. Name Reactions, Jie Jack Li, Springer.
24. Name reactions and Reagents in Organic Synthesis, Bradford P. Mundy, M.G. Ellerd and F.G. Favaloro, John Wiley & Sons.
25. Organic reactions and their Mechanisms, P.S. Kalsi, New Age International Publishers.
26. Elementary Organic Spectroscopy By- Y R Sharma, (S. Chand Publications)

<table>
<tr><td colspan="2">PROGRAM(s): M.Sc.-I</td><td colspan="4">SEMESTER: II</td></tr>
<tr><td colspan="2">Course: Paper-III</td><td colspan="4">Course Code: (CHEM 510)
Course Title:- Analytical Chemistry-II</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>04</td><td>NA</td><td>–</td><td>04</td><td>50</td><td>50</td></tr>
</table>

Course Objectives:

1. To gain knowledge of the chromatography techniques and its applications.
2. To understand application of X-ray spectroscopy for qualitative and quantitative analysis.
3. To introduce radio analytical techniques.
4. To apply the surface analytical techniques for system.
5. To study advantages and applications of electroanalytical methods.

Course outcomes: -

After completion of this Course, the learner will be

1. able to compare the advantages/disadvantages of SEM, STM and TEM.
2. able to develop different techniques to separate the components of mixture.
3. conversant with basic principles and theories of mass spectrometry.
4. able to apply the electroanalytical methods to sample under consideration.
5. able to elaborate on electrogravimetry and coulometry techniques.

Course Code: (CHEM 510)

Course Title :- Analytical Chemistry-II

Unit I -Chromatography [15 L]

1.1 Basic concepts and theories of chromatography: **[5 L]**

- **1.1.1** Introduction and Classification of chromatographic methods.
- **1.1.2** Concept of plate and rate theories in chromatography, efficiency, resolution, selectivity and separation capability.
- **1.1.3** Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions**.**

1.2 Gas Chromatography: **[5 L]**

- **1.2.1** Instrumentation –sample injection systems (split/split less), column types (solid/ liquid stationary phases), column switching techniques, temperature programming.
- **1.2.2** Requirements of an ideal detector and types of detectors in GLC and GSC.
- **1.2.3** Applications -Qualitative and quantitative analysis**.**

1.3 High Performance Liquid Chromatography (HPLC):[5 L]

- **1.3.1** Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns).
- **1.3.2** Diode array type and fluorescence detector.
- **1.3.3** Applications of HPLC.

Unit II - Instrumental methods - II [15L]

2.1 X-ray spectroscopy: **[6 L]**

Principle, instrumentation, applications, advantages and limitations of

- **2.1.1** X-ray absorption spectroscopy. (XAS)
- **2.1.2** X-ray fluorescence spectroscopy (XRF)
- **2.1.3** X-ray diffraction spectroscopy. (XRD)

2.2 Mass spectrometry: **[6 L]**

2.2.1 Instrumentation -

i) Ion sources - electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources.

ii) Mass analyzers: Quadrupole, time of flight and ion trap.

2.2.2 Applications

2.3 Radio analytical Methods –[3 L]

2.3.1 Neutron Activation Analysis(NAA)- Introduction, Principle, Theory and Applications.

2.3.2 Advantages and Limitations of NAA.

Unit III- Instrumental methods - III [15L]

3.1 Surface Analytical Techniques – [9 L]

Principle, Instrumentation and Applications of:

3.1.1 Scanning Electron Microscopy (SEM)

3.1.2 Scanning Tunneling Microscopy (STM)

3.1.3 Transmission Electron Microscopy (TEM)

3.2 Atomic Spectroscopy [6 L]

3.2.1 Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications.

3.2.2 Advantages and Limitations of AAS

Unit IV -Electroanalytical Methods [15L]

4.1 Ion selective potentiometry and Polarography: [10 L]

(Numericals are Expected)

4.1.1 Ion selective electrodes: Applications of - solid state, precipitate, liquid – liquid, enzyme, gas sensing, bio-catalytic membrane and enzyme-based biosensors electrodes.

4.1.2 Polarography**:** Ilkovic equation, Cottrell equation, effect of complex formation on the polarographic waves.

4.2 Electrogravimetry: **[2 L]**

4.2.1 Introduction, Principle and Instrumentation.

4.2.2 Factors affecting the nature of the deposit.

4.2.3 Applications**.**

4.3 Coulometry: [3 L]

4.3.1 Introduction, Principle and Instrumentation.

4.3.2 Coulometry at controlled potential and controlled current.

References:

Unit I

1. Instrumental Analysis, Skoog, Holler and Crouch, 7th edition
2. HPLC Practical and Industrial Applications; E.B.Sandell and H.Onishi 2 nd Ed., CRC Press

Unit II

1. Essentials of Nuclear Chemistry; H J Arnikar, New Age Publishers (2005)
2. Fundamentals of Radiochemistry; D. D. Sood A. V. R. Reddy and N. Ramamoorthy, , IANCAS 4th edition, 2010
3. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 12, 20

Unit III

1. Instrumental Analysis; Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition, (2003), ISBN-10: 8131505421, ISBN-13: 978-8131505427
2. Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM

   ; Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0- 387-26016- 7 (Online)
3. Modern techniques of surface science; D.P. Woodruff and T.A. Delchar, Cambridge Univ. Press, 1994.
4. Introduction to Scanning Tunneling Microscopy ; C. J. Chen, Oxford University Press, New York, 1993.
5. Transmission Electron Microscopy: A text book for Material Science; David B Williams and C., Barry Carter, Springer, 2009
6. Modern Spectroscopy,; J.M. Hollas, , John Wiley, New York, 3rd Edition (1996),
7. Principles of Instrumental Analysis; Skoog, Holler, Nieman, Harcourt College Publishers, 5th ed., 1998.
8. Instrumental Analysis; Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition (2003), ISBN10: 8131505421, ISBN-13: 978-8131505427

Unit IV

1. Principles of Instrumental Analysis – ; Skoog, Holler, Nieman, Harcourt College Publishers, 5th Edition, 1998. Chapters - 23, 24, 25.
2. Analytical Chemistry Principles – ; John H Kennnedy, Saunders College Publishing, 2nd edition, (1990).
3. Modern Analytical Chemistry; David Harvey; McGraw Hill Higher education publishers, (2000).
4. Vogel‟s Text book of quantitative chemical analysis; Pearson Education Limited, 6th edition, (2007).
5. Electrochemical Methods Fundamentals and Applications; Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).
6. Instrumental Methods of Analysis; Willard, Merrit, Dean and Settle, CBS publishers, 7th edition

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td colspan="3">SEMESTER: II</td></tr>
<tr><td colspan="3">Course: Practical</td><td colspan="3">Course Code: PRCHEMOA 511
Course Title:- Chemistry Practical-I
(Organic Chemistry and Analytical Chemistry)</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td colspan="2">Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>NA</td><td>04</td><td>NA</td><td>02</td><td>50</td><td>50</td></tr>
<tr><td colspan="6">Learning points:
1. To learn Organic mixture separations, purification methods and characterisation steps of organic compounds.
2. To gain knowledge and hands on experience in instrumental and non-instrumental analysis.
3. To introduce the concept of simultaneous determination in spectrophotometry.
4. To study technique of ion exchange and breakthrough capacity.
5. To develop scientific temper and research-based skills.</td></tr>
<tr><td colspan="6">Course Outcomes: After completion of this Course, the learner will be able to
1. learn determination of chemical types of different organic binary mixture
2. learn to separate solid organic binary mixtures on the basis of solubility.
3. learn to purify the separated organic compound by recrystallization technique
4. learn charachterization steps of organic compounds
5. handle and get familiar with SOP's of instruments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
6. understand the concept of complexometric titrations and factors enhancing selectivity of EDTA as a titrant.
7. apply the theory of FES to fertilizers analysis.
8. develop scientific temperament and research-based skills accomplish to encountered in the field of research</td></tr>
</table>

Organic Chemistry Practicals

Course Code: PRCHEMOA 511

Separation of Binary mixture using micro-scale technique

1. Separation of binary mixture using physical and chemical methods.
2. Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant.
3. Purification and determination of mass and physical constant of the second component.

   The following types are expected:

   (i) Water soluble/water insoluble solid and water insoluble solid,

   (ii) Non-volatile liquid-Non-volatile liquid (chemical separation)

   (iii)Water-insoluble solid-Non-volatile liquid.

   (Minimum two mixtures from each type and a total of eight mixtures are expected.)

Analytical Chemistry Practicals

Instrumental Experiments

1. To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.
2. Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.
3. To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.
4. To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.

Non-Instrumental Experiments

5. To determine the lead and tin content of a solder alloy by titration with EDTA.
6. To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).
7. To determine the break through capacity of a cation exchange resin.
8. Estimation of a mixture of Hydrochloric acid and boric acid by acid base titration.

References

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by ; A. I. Vogels, 3rd Ed. ELBS (1964)
2. Vogel's textbook of quantitative chemical analysis, Mendham, Denny, Barnes, Thomas, Pearson education, Sixth Ed.
3. Standard methods of chemical analysis ; F. J. Welcher, 1975
4. Standard methods of chemical analysis :Instrumental methods of Analysis ; F. J. Welcher , vol. 3, 1966
5. "Standard methods of Chemical Analysis"; W. W. Scott, Vol. I, Van Nostrand Company, Inc.,1939.
6.,"Spectrophotometric Determination of Traces of Metals"; E.B.Sandell and H.Onishi, ,Part II,4th Ed. ,A Wiley Interscience Publication, New York,1978

Course Code: (CHEM 50711)
Course Title:- Physical Chemistry Elective- I

PROGRAM(s): M.Sc.-I		**SEMESTER: II**			
Course: Elective:I		**Course Code: (CHEM50711)** **Course Title:- Physical Chemistry-I**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 25)**	**Semester End Examination (Marks- 25)**
02	**NA**	**--**	**02**	**50**	**50**

Learning Objectives:

1. To gain knowledge of the advanced concepts in quantum mechanics, applications of HMO theory, chemical kinetics and molecular dynamics.
2. To understand the advanced concepts in chemical thermodynamics and photochemistry.
3. To develop the skill to solve the problems encountered in the field of quantum and electrochemistry.

Course outcomes

1. To learn the concept of quantum chemistry and able to solve problems related to 1D box, 2D box, 3D box and to explain the role of operators in quantum chemistry.
2. To understand the use of Schrodinger wave equation in one and two electron systems along with applications of HMO.
3. To develop the skill to solve the problems based on chemical thermodynamics, molecular dynamics and quantum Chemistry.
4. To apply the concept of Jabolonski mechanism in photochemical reactions.

Elective: I Physical Chemistry-I

Unit IQuantum Chemistry II [15 L]

1.1 Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates,separation of the variables, the phi equation, wavefunction, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics.

1.2.Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the Radial (R), Zenith (theta) and Azimuthal (Phi) equations, solution of the equation, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots, points of maximum probability.

1.3.Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation.

1.4.Hückel Molecular Orbitals theory for ethylene, 1,3-butadiene, cyclobutadiene and benzene. ***(Derivation expected)*** [Ref 7, 8 and 9]

Unit: II Photochemistry 15 L

2.1 Absorption of light, laws of photochemistry, electronic structure of molecules, molecular orbital, electronically excited singlet states, designation based on multiplicity rule, construction of Jablonski diagram, electronic transition, Frank Condon principle, selection rules, intensity of absorption bands, nature of electronic spectra and primary process, photo-dissociation, pre-dissociation.

2.2Photo physical phenomena:

physical pathways of excited molecular system (radiative and non-radiative), prompt fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching: concentration quenching, collisional quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photo-excited donor and acceptor systems.

2.3. Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and applications in chemical analysis. Photochemical reactions, photo-oxidation, photoreduction, photo-dimerization, photoisomerization and photosensitized reactions. Photochemistry of environment: Greenhouse effect.

(Ref: 17 and 18)

References

1. Peter Atkins and Julio de Paula, Atkin‟s*Physical Chemistry*, 7thEdn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rdEdn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5thEdn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rdEdn.,Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2ndEdn., McMillan and Co. Ltd., London, 1962.
7. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
8. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
9. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
10. R.K. Prasad, *QuantumChemistry*, 2ndEdn., New Age International Publishers, 2000.
11. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
12. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
13. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
14. Ira N. Levine, *Quantum Chemistry*, 5thEdn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
15. Thomas Engel and Philip Reid, Physical Chemistry, 3rdEdn., Pearson Education Limited 2013.
16. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1stEdn., 1992.
17. C. H. DePuy, O. L. Chapman, Molecular reactions and photoChemistry, Prenticehall of India PVT.LTD.1988.
18. K. K. Rohatgi-Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher, 1978.
19. Principles of physical Chemistry , Marrown and Prutton 5th edition
20. Essentials of Physical Chemistry ,ArunBahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.
21. Introduction of Solids L.V Azaroff , Tata McGraw Hill .
22. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.
23. A Text book of physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd, 2011
24. New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.

Elective Practical I

PROGRAM(s): M.Sc.-I			SEMESTER: I		
Course: Practical			Course Code: CHEM50711 Course Title:- Physical and Inorganic Chemistry Practical-I		
TeachingScheme					EvaluationScheme
Lectures(Hoursper week)	Practical(Hoursper week)	Tutorial(Hoursper week)	Credit	ContinuousA ssessment(C A)	Semester EndExamination
02	NA	–	02	25	25

Learning Objectives:

Physical Chemistry

1.To gainknowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.

2.To develop scientific temper and research based skills accomplish to encountered in the field of research.

Inorganic Chemistry

1. The learners will be able to synthesize and characterize different inorganic coordination complexes.
2. The learners will be trained in calculating the equilibrium constant for Fe3-/SCN1- by slope intercept method and in determining the electrolytic nature of some inorganic compounds by conductance measurements.

Course Outcomes:-

1.To use the concept of quantum chemistry to interprete the shape and information about the orbitals like 1s, 2pz and 3dz2.

2. To apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions

3. Learner will train to handle the sophisticated instrument like digital potentiometer, conductivity meter, spectrophotometer.

Inorganic Chemistry

1. The learners will characterize different coordination compounds with the help of conductivity measurements, electronic and magnetic measurements and spectroscopic measurements.
2. Able to calculating the equilibrium constant for Fe3-/SCN1- by slope intercept method
3. Able to determine the electrolytic nature of some inorganic compounds by conductance measurements.

Elective Chemistry Practical-I

Course Code: CHEM 50711

Physical Chemistry

Non – instrumental:

1.Polar plots of atomic orbitals such as 1*s*, 2Pz and 3*dz2* orbitals by using angular part of hydrogen atom wave functions.

2.To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.

3.To study phase diagram of three component system water – chloroform/ toluene - acetic acid.

4.To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method.

Instrumental:

1.To determine the formula of silver ammonia complex by potentiometric method.

2.To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.

3.To determine Hammette constant of *m*- and *p*- amino benzoic acid/nitro benzoic acid by pH measurement.

4.To determine the Michaelis – Menten‟s constant value (Km) of the enzyme Beta Amylase spectrophotometrically.

References

1.Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.

2.Practical Physical Chemistry, A.M. James and F.E. Prichard, 3^{rd}Edn., Longman Group Ltd., 1974.

3.Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Elective Chemistry Practical-I

Course Code: CHEM 50711

Inorganic Chemistry

Inorganic Preparations (Synthesis and Characterization)

1) Bis-(tetramethylammonium) tetrachloroCuprate (II) $(Me_4 N)_2[CuCl_4]$

2) Bis-(tetramethylammonium) tetrachloroNickelate (II) $(Me_4 N)_2 [NiCl_4]$

3) Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$

4) HexaaamineNi(II) Sulfate $[Ni(NH_3)_6]SO_4$

5)Potassiumtrioxalato Chromate(III) $K_3[Cr(C_2O_4)_3]$

6) Tetramminemonocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$

Instrumentation

1) Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system

2) Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd

2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly

3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

Elective: II Physical Chemistry-II

PROGRAM(s): M.Sc.-I		**SEMESTER: II**			
Course: Elective:II		**Course Code: (CHEM50712)** **Course Title:- Physical Chemistry-II**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-25)**	**Semester End Examination (Marks-25)**
02	**NA**	**_**	**02**	**50**	**50**

Learning Objectives:

1.To gain knowledge of the advanced concepts in quantum mechanics, applications of HMO theory, chemical kinetics and molecular dynamics.
2.To understand the advanced concepts in chemical thermodynamics and photochemistry.
3.To develop the skill to solve the problems encountered in the field of quantum and electrochemistry.

Course outcomes:-

1.To develop the skill to solve the problems based on molecular dynamics and quantum Chemistry.

2. Learners will able to distinguish between competitive, Noncompetitive and Uncompetitive Inhibition in enzyme-catalysed reactions.

3.Learners will get knowledge of advanced chemical kinetics and molecular dynamics.

4.Leathers will able to use advanced concepts of chemical thermodynamics in chemical reactions.

Course Code: (CHEM50712)

Elective:II Physical Chemistry-II

Unit I

Chemical Thermodynamics II [15 L]

1.1.Fugacity of real gases, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity.Gibbs energy of mixing, entropy and enthalpy of mixing.

1.2.**Real solutions:** Chemical potential in non ideal solutions excess functions of non ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs DuhemMargules equation.

1.3.**Thermodynamics of surfaces**, Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected).

1.4.Bioenergetics : standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

[Ref 2 and 1,10,11,12]

Unit II

Chemical Kinetics and Molecular Reaction Dynamics-II [15 L]

2.1.**Elementary Reactions in Solution:-**Solvent Effects on reaction rates, Reactions between ions- influence of solvent Dielectric constant, influence of ionic strength, Linear free energy relationships Enzyme action

2.2.Kinetics of reactions catalyzed by enzymes -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses**.**

2.3.**Inhibition of Enzyme action**: Competitive, Noncompetitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes.

2.4.**Kinetics of reactions in the Solid State:-**Factors affecting reactions in solids **Rate laws for reactions in solid**: The parabolic rate law, The first order rate Law, the contracting sphere rate law,Contracting area rate law, some examples of kinetic studies.

(Ref: 7 and 2, 22)

References

1. Peter Atkins and Julio de Paula, Atkin‟s*Physical Chemistry*, 7thEdn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rdEdn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5thEdn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rdEdn.,Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2ndEdn., McMillan and Co. Ltd., London, 1962.
7. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
8. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
9. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
10. R.K. Prasad, *QuantumChemistry*, 2ndEdn., New Age International Publishers, 2000.
11. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
12. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
13. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
14. Ira N. Levine, *Quantum Chemistry*, 5thEdn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
15. Thomas Engel and Philip Reid, Physical Chemistry, 3rdEdn., Pearson Education Limited 2013.
16. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1stEdn., 1992.
17. C. H. DePuy, O. L. Chapman, Molecular reactions and photoChemistry, Prenticehall of India PVT.LTD.1988.
18. K. K. Rohatgi-Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher, 1978.
19. Principles of physical Chemistry , Marrown and Prutton 5th edition
20. Essentials of Physical Chemistry ,ArunBahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.
21. Introduction of Solids L.V Azaroff , Tata McGraw Hill .
22. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.
23. A Text book of physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd, 2011
24. New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.

Elective Practical II

PROGRAM(s): M.Sc.-I				SEMESTER: I	
Course: Practical				Course Code: CHEM50712 Course Title:- Physical and Inorganic Chemistry Practical-I	
TeachingScheme					EvaluationScheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA)	Semester End Examination
02	NA	–	02	25	25

Learning Objectives:

Physical Chemistry

1. To gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2. To develop scientific temper and research based skills accomplish to encountered in the field of research.

Inorganic Chemistry

1. The learners will be able to synthesize and characterize different inorganic coordination complexes.
2. The learners will be trained in calculating the equilibrium constant for Fe3-/SCN1- by slope intercept method and in determining the electrolytic nature of some inorganic compounds by conductance measurements.

Course Outcomes:-

1. To use the concept of quantum chemistry to interprete the shape and information about the orbitals like 1s, 2pz and 3dz2.
2. To apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions
3. Learner will train to handle the sophisticated instrument like digital potentiometer, conductivity meter, spectrophotometer.

Inorganic Chemistry

1. The learners will characterize different coordination compounds with the help of conductivity measurements, electronic and magnetic measurements and spectroscopic measurements.
2. Able to calculating the equilibrium constant for Fe3-/SCN1- by slope intercept method
3. Able to determine the electrolytic nature of some inorganic compounds by conductance measurements.

Elective Chemistry Practical-I

Course Code: CHEM 50712

Physical Chemistry

Non – instrumental:

1.Polar plots of atomic orbitals such as 1*s*, 2Pz and 3*dz2* orbitals by using angular part of hydrogen atom wave functions.

2.To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.

3.To study phase diagram of three component system water – chloroform/ toluene - acetic acid.

4.To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method.

Instrumental:

1.To determine the formula of silver ammonia complex by potentiometric method.

2.To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.

3.To determine Hammette constant of *m*- and *p*- amino benzoic acid/nitro benzoic acid by pH measurement.

4.To determine the Michaelis – Menten‟s constant value (Km) of the enzyme Beta Amylase spectrophotometrically.

References

1.Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.

2.Practical Physical Chemistry, A.M. James and F.E. Prichard, 3^{rd}Edn., Longman Group Ltd., 1974.

3.Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

Elective Chemistry Practical-I

Course Code: CHEM 50711

Inorganic Chemistry

Inorganic Preparations (Synthesis and Characterization)

1) Bis-(tetramethylammonium) tetrachloroCuprate (II) $(Me_4\,N)_2[CuCl_4]$

2) Bis-(tetramethylammonium) tetrachloroNickelate (II) $(Me_4\,N)_2\,[NiCl_4]$

3) Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$

4) HexaaamineNi(II) Sulfate $[Ni(NH_3)_6]SO_4$

5)Potassiumtrioxalato Chromate(III) $K_3[Cr(C_2O_4)_3]$

6) Tetramminemonocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$

Instrumentation

1) Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system

2) Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

Reference:

1. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur& Sons Pvt Ltd

2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly

3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc-I</td><td colspan="3">SEMESTER: II</td></tr>
<tr><td colspan="3">Course:Industrial Training/ Field Projects</td><td colspan="3">Course Code:CHEM512</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>NA</td><td>08</td><td>–</td><td>04</td><td>50</td><td>50</td></tr>
<tr><td colspan="6">Learning Objectives:
To provide students the opportunity to test their interest in a particular career before permanent commitments are made.
To develop skills in the application of theory to practical work situations. To develop skills and techniques directly applicable to their careers.</td></tr>
<tr><td colspan="6">Course Outcomes:
At the end of the Course,
Understand the Organizational Structure of a company.
Develop work habits and attitudes necessary for job success (technical competence, professional attitude, organization skills etc.)
Develop written communication and technical report writing skills.</td></tr>
</table>

PROPOSED MODALITIES OF ASSESSMENT

Theory Examination Pattern:

A. Internal Assessment- 50%- 50 Marks per paper

Sr.No.	Evaluation Type	Marks
1	**Written Objective/Short Answer Examination**	**25**
2	**Assignment/ Case study/ field visit report/ presentation/ project**	**25**
	Total	**50**

B. External Examination- 50%-

50 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:

a. There shall be 05 questions each of 10 marks on each unit.

b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern for 50 marks:

Question	Options	Marks	Questions Based on
Q.1	2 out of 4	10	Unit I
Q.2	2 out of 4	10	Unit II
Q.3	2 out of 4	10	Unit III
Q.4	2 out of 4	10	Unit IV
Q.5	5 out of 8	10	Units (I+II+III+IV)
	TOTAL	50	

Paper Pattern for 25 marks (Electives):

25 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of **one hour** duration.
2. Theory question paper pattern:

a. There shall be 02 questions each of 08 marks on each unit and one mix question for 09 marks

b. All questions shall be compulsory with internal choice within the questions.

Question	Options	Marks	Questions Based on
Q.1	2 out of 4	08	Unit I
Q.2	2 out of 4	08	Unit II
Q.3	3 out of 6	09	Units (I+II)
	TOTAL	25	

Semester End Practical Examination:

Particulars	Continuous assessment (CA)	Semester end external examination
Laboratory work	15	15
Viva	05	05
Journal	**05**	**05**
Total	**25**	**25**

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

AC – 07/07/2023
Item No. – 6.10 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A- P.G. Diploma in Physical Chemistry
B- M.Sc. (Physical Chemistry) (Two Year) } **2023-24**
C- M.Sc. (Physical Chemistry) (One Year) - **2027-28**

Syllabus for the

Semester – Sem I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1) **Introduction**
This program is designed to provide a comprehensive and in-depth understanding of the fascinating world of Physical chemistry. Through a rigorous academic curriculum and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. The M.Sc. (Physical Chemistry) course is structured to equip students with a strong theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of chemistry. Our esteemed faculty members are experts in their respective fields, with a passion for both teaching and research. They are committed to providing a nurturing learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences.
We envision our M.Sc. (Physical Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry. Whether your passion lies in research, industry, education, or beyond, our program aims to provide the knowledge and skills necessary to excel in your chosen path.

2) **Aims and Objectives**
The aims and objectives of M.Sc. (Physical Chemistry) course are designed to provide students with a well-rounded and advanced education in the field of Physical Chemistry. These goals focus on equipping students with a deep understanding of chemical principles, fostering research and analytical skills, and preparing them for successful careers in various sectors of the chemical sciences. The M.Sc. (Physical Chemistry) course aims to produce skilled and knowledgeable professionals who can contribute to scientific research, industrial innovation, and the betterment of society through their expertise in Physical chemistry.

3) **Learning Outcomes**
The learning outcomes of an M.Sc. (Physical Chemistry) course are designed to equip students with a comprehensive and advanced understanding of the field of chemistry. These learning outcomes reflect the knowledge, skills, and competencies that students are expected to gain upon successful completion of the program.

4) **Any other point (if any) :** The skills and knowledge acquired during this master's program will make the students well-equipped for diverse roles.

5) **Credit Structure of the M.Sc. (Physical Chemistry) (Sem I, II, III & IV) (Table as per परिशिष्ट-1 with sign of HOD and Dean)**

R __________

Post Graduate Program: M.Sc. (Physical Chemistry) परिशिष्ट-1

<table>
<tr><th rowspan="2">1</th><th rowspan="2">Level</th><th rowspan="2">Sem</th><th colspan="4">Major</th><th rowspan="2">RM</th><th rowspan="2">OJT/FP</th><th rowspan="2">RP</th><th rowspan="2">Cum. Cr.</th><th rowspan="2">Degree</th></tr>
<tr><th colspan="3">Mandatory</th><th>Electives</th></tr>
<tr><td rowspan="10">1</td><td rowspan="10">6.0</td><td rowspan="5">Sem I</td><td colspan="3">3*4+ 2=14</td><td>4</td><td>4</td><td rowspan="5"></td><td>-</td><td>22</td><td rowspan="5">PG Diploma (after 3 Years Degree)</td></tr>
<tr><td>Physical Chemistry-I (CHEM 501)</td><td>TH</td><td>4</td><td rowspan="4">Credits 4 (2+2)
Course 1:
Organic Chemistry-I
+
Chemistry Practicals (Organic Chemistry and Analytical Chemistry) (CHEM 50311)

(OR)

Credits 4 (2+2)
Course 2:
Organic Chemistry-II+
Chemistry Practicals (Organic Chemistry and Analytical Chemistry) (CHEM 50312)</td><td rowspan="4">Research Methodology (CHEM 506)</td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Inorganic Chemistry-I (CHEM 502)</td><td>TH</td><td>4</td></tr>
<tr><td>Analytical Chemistry-I (CHEM 505)</td><td>TH</td><td>4</td></tr>
<tr><td>Chemistry Practical-I (Physical Chemistry and Inorganic Chemistry) (PRCHEMPI 504)</td><td>PR</td><td>2</td></tr>
<tr><td rowspan="5">Sem II</td><td colspan="3">3*4+ 2=14</td><td>4</td><td rowspan="5">-</td><td rowspan="5">4
CHEM 512</td><td rowspan="5">-</td><td rowspan="5">22</td><td rowspan="5">PG Diploma (after 3 year degree)</td></tr>
<tr><td>Physical Chemistry-II (CHEM 507)</td><td>TH</td><td>4</td><td rowspan="4">Credits 4 (2+2)
Course 1:
Organic Chemistry-III
+
Chemistry Practicals (Organic Chemistry and Analytical Chemistry) (CHEM 50911)

(OR)

Credits 4 (2+2)
Course 2:
Organic Chemistry-IV
+
Chemistry Practicals (Organic Chemistry and Analytical Chemistry) (CHEM 50912)</td></tr>
<tr><td>Inorganic Chemistry-II (CHEM 508)</td><td>TH</td><td>4</td></tr>
<tr><td>Analytical Chemistry-II (CHEM 510)</td><td>TH</td><td>4</td></tr>
<tr><td>Chemistry Practical-II (Physical Chemistry and Inorganic Chemistry) (PRCHEMPI 511)</td><td>PR</td><td>2</td></tr>
</table>

Cum. Cr. For PG Diploma			28			8	4	4		44	
Exit Option: PG Diploma (44 credits) after Three Year UG Degree											

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum. Cr.	Degree
2	6.5	Sem III	3*4+ 2=14			4	-	-	4 Research Project (CHEM 606)	22	PG Degree (after 3 year UG)
			Paper –I Chemistry: Polymer, Surface and Photo (CHEM 601)	TH	4	Paper IV Advanced Instrumental Techniques-I + Physical Chemistry Practical-II (CHEM 60511) OR Paper IV Advanced Instrumental Techniques-II + Physical Chemistry Practical-II (CHEM 60512) OR Advanced Techniques in Physical Chemistry-I (CHEM 60513)					
			Paper II Nano Chemistry, Statistical Mechanics and Nuclear Chemistry (CHEM 602)	TH	4						
			Paper III Atomic and Molecular: Structure and Spectroscopy (CHEM 603)	TH	4						
			Physical Chemistry Practical- I (CHEM 604)	PR	2						
		Sem IV	3*4=12			4	-	-	6 Research Project (CHEM 611)	22	
			Paper I : Polymer, Green, Biophysical and Applied Chemistry (CHEM 607)	TH		Paper IV Intellectual Property and Cheminformatics (CHEM 61011) **(OR)** Advanced Techniques in					
			Paper II Material Science, Network and Irreversible Thermodynamics (CHEM 608)	TH	4						

			Paper III Symmetry and Spectroscopy (CHEM 609)	TH	4	Physical Chemistry-II (CHEM 61012)					
Cum. Cr. For 1 Yr PG Degree			26			8			10	44	
Cum. Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

HEAD
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MUMBAI

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Syllabus
M.Sc. (Physical Chemistry)
(Sem. I & II)

UNIVERSITY OF MUMBAI

Syllabus for M.Sc. (Physical Chemistry)
Semester I and II

Choice-Based Credit System
Under New Education Policy (NEP) 2020
(To be implemented from the academic year, 2023-2024)

PROGRAM OUTLINE 2023-2024

YEAR		COURSE CODE	COURSE TITLE	CREDITS	PAGE NO.
M.Sc. Sem-I	Mandatory Course-I	CHEM 501	Physical Chemistry-I	04	06
	Mandatory Course-II	CHEM 502	Inorganic Chemistry-I	04	11
	Mandatory Course-III	CHEM 505	Analytical Chemistry-I	04	16
	Mandatory Course Practical	PRCHEMPI 504	Chemistry Practical-I (Physical and Inorganic Chemistry)	02	22
	Elective 1	CHEM 50311	Organic Chemistry-I and Chemistry Practical (Organic and Analytical Chemistry)	04	25
	Elective 2	CHEM 50312	Organic Chemistry-II and Chemistry Practical (Organic and Analytical Chemistry)	04	29
	RM	CHEM 506	Research Methodology	04	36
M.Sc. Sem-II	Mandatory Course-I	CHEM 507	Physical Chemistry-II	04	39
	Mandatory Course-II	CHEM 508	Inorganic Chemistry-II	04	44
	Mandatory Course-III	CHEM 510	Analytical Chemistry-II	04	49

	Mandatory Course Practical	PRCHEMPI 511	Chemistry Practical-II (Physical and Inorganic Chemistry)	02	54
	Elective 1	CHEM 50911	Organic Chemistry-I and Chemistry Practical (Organic and Analytical Chemistry)	04	57
	Elective 2	CHEM 50912	Organic Chemistry-II and Chemistry Practical (Organic and Analytical Chemistry)	04	60
	OJT/FP	CHEM 512	Industrial Training/Field Project	04	66

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, scrutinize and accomplish a solution to problems encountered in the field of research and analysis.

2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the industry.

5. Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

6. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

7. Exhibit professional work ethics and norms of scientific development.

Semester – I

PROGRAM(s): M.Sc.-I	**SEMESTER: I**				
Course : Paper-I	**Course Code: (CHEM501)** **Course Title: - Physical Chemistry-I**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	NA	–	04	50%	50%

Learning Objectives:

1. To enable learners to have comprehensive knowledge and understanding of the advanced concepts in reaction kinetics, molecular dynamics and chemical thermodynamics.
2. To apply the basic knowledge of Physical chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.
3. Accomplish a solution to problems encountered in the field of research.

Course Outcomes:

1. The learners will apply the advanced thermodynamics, Maxwell equation and its applications to ideal gasses.
2. The learners evaluate the different theories of chemical kinetics and effect of temperature on reaction rates.
3. The learners will implement the applications of chemical thermodynamics to real gases, solutions, surfaces and their energetics.
4. The learners will understand the applications of operators and Schrodinger equation in the field of quantum Chemistry.
5. The learners will evaluate the resting membrane potential by using the concept of bio electrochemistry.
6. The learners will try to accomplish a solution to problems encountered in the field of research.

Semester – I

Paper I

Physical Chemistry-I

(CHEM 501)

Course code- CHEM 501	Unit	Course/Unit Title: Physical Chemistry-I	Credits 04/ [60 L]
	1	**Chemical Thermodynamics I**	**[15L]**
	1.1.	State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; its significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants.	**[8L]**
	1.2.	Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy [Ref 2 and 1,10,11,12 17]	**[7L]**
	2	**Quantum Chemistry II**	**[15L]**
	2.1.	Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics.	
	2.2	Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions.	
	2.3	Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrodinger's Time independent wave equation from Schrodinger's time dependent wave equation.	
	2.4	Application of quantum mechanics to the following systems:	

		a) Free particle, wave function and energy of a free particle. b) Particle in a one, two and three-dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula. [Ref 7, 8 and 9]	
	3	**Chemical Kinetics and Molecular Dynamics-I**	**[15L]**
	3.1	Composite Reactions: Recapitulation: Rate laws, Differential rate equations Consecutive reactions, Steady state Approximation, rate determining steps, Microscopic Reversibility and Detailed Balanced Chain reactions-chain initiation processes. Some inorganic mechanisms: formation and decomposition of phosgene, decomposition of ozone, Reaction between Hydrogen and Bromine and some general examples Organic Decompositions: Decomposition of ethane, decomposition of acetaldehyde Gas phase combustion: Reaction between hydrogen and oxygen, Semenov – Hinshelwood and Thompson mechanism, Explosion limits and factors affecting explosion limits.	
	3.2	Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain length and estimation of average no. of monomer units in the polymer produced by chain polymerization.	
	3.3	Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger-Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory. [Ref. 2 and 15, 17, 18]	
	4	**Electrochemistry**	**15L**
	4.1	Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and its extension to higher concentration (derivations are expected).	

	4.2	Electrolytic conductance and ionic interaction, relaxation effect, Debye-Hückel- Onsager equation (derivation expected). Validity of this equation for aqueous and non- aqueous solution, deviations from Onsager equation, Debye-Falkenhagen effect (dispersion of conductance at high frequencies), Wien effect.	
	4.3	Batteries: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells	
	4.2	Bio-electrochemistry: Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, adsorption of proteins onto metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes, electrochemical enzyme-catalysed oxidation of styrene. Goldmann equation. (derivations are expected) [Ref: 14 and 16, 17, 18]	

References:

1. Peter Atkins and Julio de Paula, Atkin‟s *Physical Chemistry*, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2nd Edn., McMillan and Co. Ltd., London, 1962
7. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
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9. R.K. Prasad, *Quantum Chemistry*, 2nd Edn., New Age International Publishers, 2000.
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12. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
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14. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
16. ***Bockris***, John O'M., ***Reddy***, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
17. Physical Chemistry by Gurtu and Gurtu.

18. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.
19. A Text book of Physical Chemistry by K L kapoor Vol 5 , 2^{nd} Edn

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td colspan="4">SEMESTER: I</td></tr>
<tr><td colspan="3">Course:
Paper-II</td><td colspan="4">Course Code: (CHEM 502)

Course Title: - Inorganic Chemistry-II</td></tr>
<tr><td colspan="6">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td colspan="2">Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>04</td><td>NA</td><td>–</td><td>04</td><td colspan="2">50%</td><td>50%</td></tr>
</table>

Learning Objectives:
Inorganic Chemistry

1. To develop the ability to correlate fundamental theories of spatial orientations of molecules based on wave mechanics with advanced concepts in chemical bonding, symmetry of molecular systems and Structural aspects of inorganic solids.
2. To gain theoretical knowledge of cutting-edge topics such as solid-state lasers and contemporary Methods of preparation of nanomaterials.
3. To learn about diverse tools available for characterization of coordination compounds in order to enhance competency while applying for practical purpose

Course Outcomes:

1. The learner will know the important fundamental concept of Group Theory, which helps them in understanding the properties and bonding in polyatomic molecules.
2. The learner get the knowledge about the various techniques used for Characterization coordination compounds.
3. The learners develops the skill in interpretation of the spectra.
4. The learners will get comprehensive idea about established instrumental techniques and significant characterization tools available to study inorganic complexes having wide a applications in industries.

Paper II Inorganic Chemistry-II

(CHEM 502)

Course code- CHEM 502	Unit	Course/Unit Title- Inorganic Chemistry-II	Credits: 4/60 ectures
	1	**Chemical Bonding**	**[15L]**
	1.1.	Recapitulation of hybridization Derivation of wave functions for sp, sp^2, sp^3 orbital hybridization types considering only sigma bonding.	
	1.2.	Discussion of involvement of d orbitals in various types of hybridizations. Concept of resonance, resonance energy derivation expected. Formal charge with examples.	
	1.3	Molecular Orbital Theory for diatomic species of First transition Series.	
	1.4	Molecular Orbital Theory for Polyatomic species considering σ bonding for SF_6, CO_2, B_2H_6, I_3^- molecular species.	
	1.5	Weak forces of attraction: Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.	
	2	**Molecular Symmetry and Group Theory:**	**[15L]**
	2.1.	Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules	
	2.2	Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups.	
	2.3	a) Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C2v, C3v and C2h, structure of character tables.	

		b) Determination of symmetry species for translations and rotations. c) Mulliken‟s notations for irreducible representations. d) Reduction of reducible representations using reduction formula	
	2.4	Applications of Group Theory Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in ABn (NH_3, CH_4) molecule.	
	3	**Materials Chemistry and Nanomaterials:**	**[15L]**
	3.1	Solid State Chemistry 3.1.1. Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones. 3.1.2. Structures of Compounds of the type: AB [nickel arsenide (NiAs)], AB_2 [fluorite (CaF_2) and anti-fluorite structures, rutile (TiO_2) 3.1.3. Solid state lasers: Introduction, Types, Working & Applications	
	3.2	**Nanomaterials** 3.2.1. Preparative methods: Chemical methods, Solvothermal, Combustion synthesis, Microwave, Co-precipitation, Langmuir Blodgett(L-B) method, Biological methods: Synthesis using microorganisms. 3.2.2. Applications in the field of semiconductors, solar cells	
	4	**Characterization of Coordination compounds**	**15L]**
	4.1	Methods of Characterisation: thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods.	
	4.2	Introduction to Orgel & Tanabe Sugano Diagram, Terms, Splitting of terms in Octahedral weak field, Calculation of electron parameters Δ, β, C and Nephlauxetic ratio with suitable examples.	

	4.3	Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectrophotometric methods.	

References:

Unit I

1. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
2. W. W. Porterfield, Inorganic Chemistry-A Unified Approach, 2nd Ed., Academic Press, 1993.
3. B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
4. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005.
5. J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
6. P. J. Durrant and B. Durrant, Introduction to Advanced Inorganic Chemistry, Oxford University Press, 1967.
7. R. L. Dekock and H.B.Gray, Chemical Structure and Bonding, The Benjamin Cummings Publishing Company, 1989.
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9. R. Sarkar, General and Inorganic Chemistry, Books & Allied (P) Ltd., 2001.
10. C. M. Day and J. Selbin, Theoretical Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 1985.
11. J. N. Murrell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1978.
12. G. A. Jeffrey, An Introduction to Hydrogen Bonding, Oxford University Press, Inc., 1997.

Unit II

1. F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989.
2. H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996.
3. R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
4. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2nd Edition, New Age International Publishers, New Delhi, 2009.
5. A. Salahuddin Kunju and G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning, 2012.
6. P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House. 2014.
7. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008.

Unit III

1. Solid State Chemistry Introduction, Lesley E. Smart, Elaine A. Moore, ISBN 0- 203-49635-3, Taylor & Francis Group, LLC.

2. Nanomaterials & Nanochemistry, 2007, Catherine Brechignac, Philippe Houdy, Marcel Lahmani, ISBN 978-3-540-72992-1 Springer Berlin Heidelberg New York.

3. Nanomaterials Chemistry, Recent Developments and New Directions C.N.R. Rao, A. Muller, and A.K. Cheetham, ISBN 978-3-527-31664-9, 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

4. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, Marcel Dekker Inc. New York.

5. The Chemistry of Nanomaterials, CNR Rao, Muller Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.

6. Semiconductor Nanomaterials, Challa S.S.R. Kumar, ISBN: 978-3-527-32166-7, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010.

7. Peter Atkins and Julio de Paula, Atkin‟s *Physical Chemistry*, 7th Edn., Oxford University Press, 2002.

8.An introduction to Lasers Theory and Applications by M.N. Avadhanulu,P.S.Hemne, S.Chand publication.

9. Advances in solid state lasers development and Applications by M. Grishin

10. Solid state Lasers- A Graduate Text by Walter Koechner,Michael Bass, Springer.

11. Rare earth materials-properties & applications by A.R. Jha, CRC Press

Unit IV

1. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.

2. D. Banerjea ,Coordination Chemistry

3. Geary Coordination reviews 4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006.

5. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999,

6. B. Douglas, D. McDaniel and J. Alexander. Concepts and Models of Inorganic Chemistry(3rd edn.), John Wiley & Sons (1994).

<table>
<tr><td colspan="4">PROGRAM(s): M.Sc.-I</td><td>SEMESTER: I</td></tr>
<tr><td colspan="4"></td><td>Course Code: (CHEM 505)
Course Title: -Analytical Chemistry-I</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 50)</td><td>Semester End Examination
(Marks- 50)</td></tr>
<tr><td>04</td><td>NA</td><td>04</td><td>50%</td><td>50%</td></tr>
</table>

Course Objectives:

1. To enable learners to have comprehensive knowledge, understanding of the types of instruments with operations and automated methods of analysis.

2. To apply the basic knowledge of quality systems, quality audit and quality managements.

3. To enable learners to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.

4. To provide solutions to problems encountered in the field of analysis and research.

Course Outcomes: After completion of this Course, the learner will be able to:

1. Understand various terms used in analytical chemistry.

2. Identify the different types of errors in analysis.

3. Sketch out the role and importance of total quality management, safety, accreditations and GLP in industries.

4. Understand the efficacy of automation in chemical analysis.

5. Design and specify applications of advanced analytical techniques in various fields.

6.Explore the applications of IR spectroscopy and thermal methods.

7. Perform basic calculations required in chemical analysis.

8. Interpret the experimental results of analytical techniques.

Course code- CHEM 505	**Unit**	**Course/Unit Title- Analytical Chemistry-I**	Credits 04/ 60 Lectures
	1	**Analytical Chemistry-I**	**[15L]**
	1.1.	**Language of Analytical Chemistry [8 L]** 1.1.1 Analytical perspective [3 L] Analytical approach. common analytical problems. Terms involved in analytical chemistry - Analysis, Analyte, Matrix, Determination, Measurement, Techniques, Methods, Procedures and protocol. 1.1.2 An overview of analytical methods [3 L] Analytical methods - Types, classification and selection. Quantitative method of Analysis- Calibration method, Method of Standard addition, Internal standard method. Performance Characteristics of analytical method- Accuracy, Precision, Selectivity, Sensitivity, Detection limit (LOD,LOQ,LOL) ,Dynamic range and Robustness and Ruggedness. 1.1.3 Errors [2 L] Types of errors. Absolute error, Relative error, Constant error and Proportionate errors. Minimization of errors.	**[8 L]**

	1.2	**Quality in Analytical Chemistry** 1.2.1 Total Quality Management- TQM [3L] Definition, Principles, Importance and benefits. Philosophy of implementation of TQM -Process steps, Advantages and Limitations **i)** Kaizen -Six steps **ii)** Six Sigma approach **iii)** 5S and 5S audit check for laboratories. 1.2.2 Safety in laboratories [2L] Basic concept of safety in laboratory- The Industrial Hygiene Principles. Personal protection equipment (PPE). Occupational Safety and Health Administration (OSHA). 1.2.3 Accreditations [2L] Accreditation of laboratories, NABL**,** Indian Government standards (ISI, HALLMARK, AGMARK).- Meaning and significance.	**[7L]**
	2.	**2.1 Calculations based on Chemical Principles [15L]** *(The following topics are to be covered in the form of numerical problems only)* 2.1.1 Concentration of a solution based on volume and mass units. 2.1.2 Calculations of ppm, ppb and dilution of the solutions, concept of mmol. 2.1.3 Stoichiometry of chemical reactions, concept of kg /mol, limiting reactant, theoretical and practical yield. 2.1.4 Solubility and solubility equilibria, effect of presence of common ion in solution. 2.1.5 Calculations of pH of acids, bases, acidic and basic buffers. 2.1.6 Concept of formation constants, stability and instability constants, stepwise formation constants. 2.1.7 Oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a	

		solution of an oxidizing / reducing agent and its relationship with molarity).	
	3	**Optical Methods**	**[15 L]**
	3.1	**Infrared Absorption Spectroscopy [6 L]** 3.1.1 Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument. 3.1.2 Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on “Finger print” and Quantitative analysis. 3.1.3 Advantages and Limitations of IR.	
	3.2	**FT Technique [3 L]** 3.2.1 Introduction of Fourier Transform**.** 3.2.2 Laser as a source of radiation, sample containers. 3.2.3 Detectors, Fiber optics. 3.2.4 FTIR and its advantages.	
	3.3	**Molecular Ultraviolet and Visible Spectroscopy** .1 Factors affecting molecular absorption: pH, temperature, solvent and effect of substituents, types of transitions [emphasis on charge transfer absorption]. .3.2 Applications of Ultraviolet and Visible spectroscopy: i) On charge transfer absorption ii) Simultaneous spectroscopy iii) Derivative Spectroscopy 3.3.3 Dual spectrometry – Introduction, Principle, Instrumentation and Applications**.**	
	4	**Instrumental methods-I**	
	4.1	**Thermal Methods: [9 L]** 4.1.1 Introduction: Types of thermal methods, comparison between TGA and DTA. 4.1.2 Differential Scanning Calorimetry-Principle, comparison of DTA and DSC.	

		4.1.3 Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting DSC Curves. 4.1.4 Applications - Heat of reaction, Safety screening, Polymers, liquid crystals, Drug analysis.	
	4.2	**Automation in chemical analysis: [6 L]** 4.2.1 Need for automation, Objectives of automation. 4.2.2 An overview of automated instruments. 4.2.3 Process control analysis, flow injection analysis, discrete automated system, automatic analysis based on multi-layered films, gas monitoring equipments. 4.2.4 Automatic titrators.	

References

Unit I

1. Modern Analytical Chemistry ; David Harvey, McGraw-Hill,Higher Education,(2000)
2. Principles of Instrumental Analysis ; Skoog, Holler and Nieman, 5th Edition, Ch: 1
3. Fundamentals of Analytical Chemistry, Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004, Ch: 5.
4. Undergraduate Instrumental Analysis ; J W Robinson, Marcel Dekker, 6th edition Ch:1.
5. ISO 9000 Quality Systems Handbook; David Hoyle. 4th edition (Chapter: 3 & 4) (Free download).
6. Quality in the Analytical Laboratory ; Elizabeth Pichard, Wiley India, Ch: 5, Ch: 6 &Ch: 7.
7. Quality Management; Donna C S Summers, Prentice-Hall of India, Ch:3.
8. Quality in Totality: A Manager‟s Guide To TQM and ISO 9000, Parag Diwan, Deep & Deep Publications, 1st Edition, 2000.
9. Quality Control and Total Quality Management - ; P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.
10. Industrial Hygiene and Chemical Safety, ; M H Fulekar, Ch:9, Ch:11 & Ch:15.
11. Safety and Hazards Management in Chemical Industries ; M N Vyas, Atlantic Publisher, Ch:4, Ch:5 & Ch:19.
12. World Health Organization (2009) Handbook: Good Laboratory Practice (GLP)
13. OECD Principles of Good Laboratory Practice (as revised in 1997)". OECD Environmental Health and Safety Publications. OECD. **1**. 1998
14. "A systematic approach for evaluating the quality of experimental toxicological and eco-toxicological data".; Klimisch, HJ; Andreae, M; Tillmann, U (1997). doi:10.1006/rtph.1996.1076. PMID 9056496.

Unit II

1. 3000 solved problems in chemistry, Schaums Solved problem series, ; David E. Goldbers, Mc Graw Hill international Editions, Chapter 11,15,16,21,22

Unit III

1. Principles of Instrumental Analysis, ; D. A. Skoog, F. J. Holler, T. A. Nieman, 5^{th} Edition, Harcourt Asia Publisher. Chapter 6, 7,8, 13, 14, 16,17
2. Instrumental Methods of Analysis,; H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, 6 th Edition, CBS Publisher. Chapter 2.
3. Introduction to Instrumental Analysis, ; R. D. Braun , McGraw Hill Publisher. Chapter 5, 8, 12
4. Instrumental Methods of Chemical Analysis, ; G. W. Ewing, 5 th Edition, McGraw Hill Publisher, Chapter 3.
5. The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding,; M. Ito, J. Mol. Spectrosc. 4 (1960) 106-124.
6. The effect of temperature on the visible absorption band of iodine in several solvents; A. J. Somnessa, Spectrochim. Acta. Part A: Molecular Spectroscopy, 33 (1977) 525-528.
7. Infrared Spectroscopy- Materials Science, Engineering and Technology. Z. M. Khoshhesab (2012). Prof. Theophanides Theophile (Ed.). ISBN: 978-953- 51-0537- 4, InTech,(open access)

Unit IV

1. Introduction to instrumental methods of analysis; Robert D. Braun, Mc. Graw Hill (1987): Chapter 27,28
2. Thermal Analysis-theory and applications; R. T. Sane, Ghadge, Quest Publications
3. Instrumental methods of analysis; Willard, Merrit, Dean:7 th Edition, Chapter 25, 26
4. Instrumental Analysis, ; Skoog, Holler and Nieman, 5 th Edition, Chapter 31,33
5. Vogel’s Quantitative Chemical Analysis,; 6 th Edition, Chapter 12
6. Analytical Chemistry - Open Learning: Thermal Methods; James W. Dodd, W. James and Kenneth H. Tonge.

<table>
<tr><td colspan="4">PROGRAM(s): M.Sc.-I</td><td colspan="2">SEMESTER: I</td></tr>
<tr><td colspan="4">Course: Practical</td><td colspan="2">Course Code: PRCHEMPI 504

Course Title: - Chemistry Practical-I
(Physical and Inorganic Chemistry)</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td colspan="2">Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 25)</td><td>Semester End Examina
(Marks- 25)</td></tr>
<tr><td>NA</td><td>04</td><td>NA</td><td>02</td><td>50%</td><td>50%</td></tr>
</table>

Learning Objectives:

1. To Gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2. To understand advance concept of thermodynamics and chemical kinetics in the chemical reactions.
3. To develop scientific temper and research based skills accomplish to encountered in the field of research.
4. The learners will characterize different coordination compounds with the help of conductivity measurements, electronic and magnetic measurements and spectroscopic measurements.
5. The learners will learn to open up different types of Alloys/Ores and carry out a Quantitative Analysis of the elements present in them.

Course Outcomes:

1. To usage of subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions.
2. Learner will train the handling of equipments like potentiometer, conductivity meter, colorimeter and spectrophotometer.
3. Learner will develop scientific temper and research based skills accomplish to encountered in the field of research.
4. Apply the knowledge of quantitative analysis for the determination of metals from ores/alloys.
5. Able to understand the analysis of various commercial inorganic compounds.

Chemistry Practical-I

Course Code: PRCHEMPI 504

Course code-PRCHEMPI 504	**Chemistry Practical-I**	**Credits:02**
	Physical Chemistry	
	Non – Instrumental: 1. To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic/salicylic acid) from solubility measurement at three different temperature. 2. To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature. 3. To investigate the reaction between acetone and iodine. 4. Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable? **Instrumental:** 1. To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement. 2. To study the effect of substituent on the dissociation constant of acetic acid conductometrically. 3. To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode. 4. To verify Ostwald‟s dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.	
	Inorganic Chemistry	
	Ores and Alloys 1) Analysis of Devarda‟s alloy 2) Analysis of Cu – Ni alloy 3) Analysis of Limestone. 4) Analysis of Tin Solder alloy	

	Instrumentation 1) Estimation of Fe (III)solution using Ce (IV) ions Potentiometrically 2) Estimation of Copper using Iodometric method Potentiometrically 3) Estimation of Na_2CO_3 in washing soda by pH metry 4) Estimation of Cl- ion in NaCl/KCl by Conductometry.	

References:

1 Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.

2 Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.

3 Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

4 Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur & Sons Pvt Ltd.

5 Thee Synthesis and Characterization of Inorganic Compounds by William L. Jolly

6 Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant.

Course Title: - Organic Chemistry
Elective- I
Course Code: (CHEM 50311)

PROGRAM(s): M.Sc.-I		**SEMESTER: I**			
Course: Elective-I		**Course Code: (CHEM 50311)** **Course Title: - Organic Chemistry Elective- I**			
Teaching Scheme				**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)** **(Marks- 25)**	**Semester End Examina** **(Marks- 25)**
02	**NA**	**NA**	**02**	**50%**	**50%**

Course Outcomes:

After completing the course students will be able to:

1) predict the reactivity of organic compound from its structure.
2) understand different methods used for determination of Organic Reaction Mechanism
3) understand the fundamental concept in stereochemistry by applying various symmetry elements of organic molecule.
4) acquire the knowledge of chirality by taking examples of symmetrical and unsymmetrical molecule.
5) develop interest in stereochemistry by studying stereochemical features of different classes of organic compounds
6) identify the nomenclature of various stereochemical phenomena

Course Code: (CHEM 50311)	Unit	Course Title: - Organic Chemistry Elective- I	redits:02 0L
		Physical Organic Chemistry:	**(15L)**
	1.1.	**Thermodynamic and kinetic requirements of a reaction:** rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, Reactivity *vs* selectivity, Curtin-Hammett Principle, Microscopic reversibility, Kinetic *vs* thermodynamic control of organic reactions.	
	1.2.	**Determining mechanism of a reaction:** Product analysis, kinetic studies, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect). Detection and trapping of intermediates, crossover experiments and stereochemical evidence.	
	1.3.	**Acids and Bases:** Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity and solvation. Comparative study of acidity and basicity of organic compounds on the basis of pKa values, Leveling effect and non-aqueous solvents. Acid and base catalysis – general and specific catalysis with examples.	
	2	**Stereochemistry**	**(15 L)**
	2.1.	**Concept of Chirality:** Recognition of symmetry elements.	
	2.2.	**Molecules with tri- and tetra-coordinate centers**: Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities	
	2.3.	**Molecules with two or more chiral centers:** Constitutionally unsymmetrical molecules: rythron-threo and syn-anti systems of	

		nomenclature. Interconversion of Fischer, Sawhorse, Newman and Flying wedge projections. Constitutionally symmetrical molecules with odd and even number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudoasymmetric centres. R-S nomenclature for chiral centres in acyclic and cyclic compounds.	
	2.4.	**Axial and planar chirality:** Principles of axial and planar chirality. Stereochemical features and configurational descriptors (R,S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spirans, biaryls (buttressing effect) (including BINOLs and BINAPs), ansa compounds, cyclophanes, trans-cyclooctenes.	
	2.5.	**Prochirality:** Chiral and prochiral centres; prochiral axis and prochiral plane. Homotopic, heterotopic (enantiotopic and diastereotopic) ligands and faces. Identification using substitution and symmetry criteria. Nomenclature of stereoheterotopic ligands and faces. Symbols for stereoheterotopic ligands in molecules with i) one or more prochiral centres ii) a chiral as well as a prochiral centre, iii) a prochiral axis iv) a prochiral plane v) pro-pseudoasymmetric centre. Symbols for enantiotopic and diastereotopic face.	

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Reference Books.

1. Physical Organic Chemistry, Neil Isaacs
2. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
3. Comprehensive Organic chemistry, Barton and Ollis, Vol 1
4. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
5. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.
6. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
7. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
8. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
9. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
10. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.

11. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
12. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
13. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
14. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
15. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
16. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press.
17. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan.
18. Organic reactions and their Mechanisms, P.S. Kalsi, New Age International Publishers.
19. Organic Synthesis, Jagdamba Singh, L.D.S Yadav, Pragati Prakashan.
20. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Nelson Thornes

Course Code: (CHEM 50312)
Course Title: - Organic Chemistry Elective – II
Sem I

PROGRAM(s): M.Sc.-I		**SEMESTER: I**			
Course: Elective-II		**Course Code: (CHEM 50312)** **Course Title: - Organic Chemistry Elective – II**			
Teaching Scheme				**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)** **(Marks- 25)**	**Semester End Examina** **(Marks- 25)**
02	**NA**	**NA**	**02**	**50%**	**50%**

Course Learning Outcomes.
After completing the course students will be able to:

1) organize the techniques of aromatic nucleophilic substitution reactions for synthesizing/transforming molecules.
2) understand the concept of aromaticity and to know the nature of bonds, electronic effects and other properties of molecules.
3) understand the preparation of important oxidizing reagent and predict the selectivity of the reagents in organic reactions.
4) explain the preparation and uses of important reducing reagents in various organic transformation reaction.

Course Code: (CHEM 50312)	Unit	Course Title:- Organic Chemistry Elective- II	redits:02 0L
	1	**Nucleophilic substitution reactions and Aromaticity**	L
		1.1. Nucleophilic substitution reactions: (9 L) 1.1.1 Aliphatic nucleophilic substitution**:** S_N1, S_N2, $S_N{}^i$ reactions, mixed S_N1 and S_N2 and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, σ and π-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1" and S_N2" reactions. S_N at sp^2 (vinylic) carbon. 1.1.2. Aromatic nucleophilic substitution**:** S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. 1.1.3 Ester hydrolysis**:** Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples	
		1.2. Aromaticity: (6 L) 1.2.1. Huckel's (4n+2) and 4n rules, structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. 1.2.2. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C_{60}).	
	2	**Oxidation and Reduction:**	5L
	2.1	**Oxidation:** General mechanism, selectivity, and important applications of the following: 2.1.1. Dehydrogenation**:** Dehydrogenation of C-C bonds including aromatization of six membered rings using metal (Pt, Pd, Ni) and organic reagents (chloranil, DDQ). 2.1.2. Oxidation of alcohols to aldehydes and ketones**:** Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin's reagent), PCC (Corey's reagent) and PDC (Cornforth reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Corey-Kim oxidation - advantages over Swern and limitations; and Pfitzner-Moffatt oxidation-DCC and DMSO and Oppenauer oxidation.	

		2.1.3. Oxidation involving C-C bonds cleavage: Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$, CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$. 2.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH_2 to CO by SeO_2, oxidation of arylmethanes by CrO_2Cl_2 (Etard oxidation). 2.1.5. Oxidation of aldehydes and ketones: with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation)	
		2.2. Reduction: General mechanism, selectivity, and important applications of the following reducing reagents: 2.2.1. Reduction of CO to CH_2 in aldehydes and ketones- Clemmensen reduction, Wolff Kishner reduction and Huang-Minlon modification. 2.2.2. Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane, 9-BBN, $Na(OAc)_3BH$, aluminium reagents ($LiAlH_4$, DIBAL-H, Red Al, L and K-selectrides). 2.2.3. N_2H_2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzsch dihydropyridine). 2.2.4. Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 mediated reduction of aromatic compounds (Birch reduction) and Alkynes.	

Reference Books.

1. Physical Organic Chemistry, Neil Isaacs
2. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A. Dougherty
3. Comprehensive Organic chemistry, Barton and Ollis, Vol 1
4. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
5. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A and B, Plenum Press.
6. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi.
7. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
8. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
9. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd.
10. March’s Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
11. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.

12. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
13. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
14. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
15. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
16. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
17. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press.
18. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan.
19. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press.
20. Organic reactions and their Mechanisms, P.S. Kalsi, New Age International Publishers.
21. Organic Synthesis, Jagdamba Singh, L.D.S Yadav, Pragati Prakashan.
22. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Nelson Thornes

Course Code: CHEM 50311/CHEM 50312
Course Title: - Elective Practical: Chemistry Practicals
Sem I

PROGRAM(s): M.Sc.-I		**SEMESTER: I**			
Course: Practical		**Course Code: CHEM 50311/CHEM 50312** **Course Title: - Elective Practical: Chemistry Practicals**			
Teaching Scheme				**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 25)**	**Semester End Examination (Marks- 25)**
NA	**04**	**NA**	**02**	**50%**	**50%**

Learning points:

Planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt.

Purify the product by crystallization. Formation and purity of the product should be checked by TLC

Report mass and melting point of the purified product.

Elective Practical: Chemistry Practicals
Course Code: CHEM 50311/CHEM 50312

Course Code: CHEM 50311/CHEM 50312	**Elective Practical: Chemistry Practicals**	**Credits 02**
	Organic Chemistry	
	One step preparations (1.0 g scale) 1. Bromobenzene to p-nitrobromobenzene 2. Anthracene to anthraquinone 3. Benzoin to benzil 4. Anthracene to Anthracene maleic anhydride adduct 5. 2-Naphthol to BINOL 6. p-Benzoquinone to 1,2,4-triacetoxybenzene 7. Ethyl acetoacetate to 3-methyl-phenylpyrazol-5-one 8. *o*-Phenylenediamine to 2-methylbenzimidazole 9. *o*-Phenylenediamine to 2,3-diphenylqunooxaline 10. Urea and benzil to 5,5-diphenylhydantoin	
	Analytical Chemistry	
	Instrumental Experiments 1. To determine percentage purity of sodium carbonate in washing soda pH metrically. 2. To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically. 3. To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titration with perchloric acid in a non-aqueous medium using glass calomel system potentiometrically. 4. To determine the amount of nitrite present in the given water sample colorimetrically. **Non-Instrumental Experiments** 1.To carry out assay of the sodium chloride injection by Volhard's method.	

	2.To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin. 3.To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA. 4.To determine number of nitro groups in the given compound using $TiCl_3$.	

(Minimum 08 experiments are expected)

References:

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by ; A. I. Vogels, 3rd Ed. ELBS (1964)

2. Vogel's textbook of quantitative chemical analysis, Mendham, Denny, Barnes, Thomas, Pearson education, Sixth Ed.

3. Standard methods of chemical analysis ; F. J. Welcher, 1975

4. Standard methods of chemical analysis :Instrumental methods of Analysis ; F. J. Welcher , vol. 3, 1966

5. "Standard methods of Chemical Analysis"; W. W. Scott, Vol. I, Van Nostrand Company, Inc.,1939.

6."Spectrophotometric Determination of Traces of Metals"; E.B.Sandell and H.Onishi, ,Part II,4th Ed. ,A Wiley Interscience Publication, New York

Research Methodology

PROGRAM(s): M.Sc-I				SEMESTER: I	
Course code: CHEM 506				Course Title:- Research Methodology	
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	-	-	04	50%	50%

Learning Objectives:

1. To create awareness and understanding the terms like intellectual property, patents, copyright, industrial designs, trademarks, geographical indications etc.
2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements.
3. To explore cheminformatics to facilitate molecular modeling and structure elucidations.
4. To apply the knowledge gained about various chemistry principles, techniques and tools in drug designing, target identification and validation, lead finding and optimization.

Course Outcomes:

At the end of the Course,

1. To enable the student to be able to extract information from journals and digital resources.
2. Understanding tools to analyse the data, writing and presenting scientific papers.
3. Safe working procedure And ethical handling of chemicals.
4. Describe research, identification of research problems, and preparation of proposals.
5. Practice ethics in all the domains of research.
6. Analyze the results using mathematical and statistical tools.

Course Code:- CHEM 506	Unit	Course/ Unit Title: Research Methodology	04 Credits / 60 Lectures
I		**Literature Survey**	**15 L**
	1.1	Print: Primary, Secondary and Tertiary sources. Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.	**5 L**
	1.2	Digital: Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.	**5 L**
	1.3	Information Technology and Library Resources: The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	**5 L**
II		**Data analysis**	**15 L**
		The Investigative Approach: Making and recording Measurements, SI units and their use, Scientific methods and design of experiments. Analysis and Presentation of Data: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.	
III		**Methods Of Scientific Research And Writing Scientific Papers**	**15 L**
		Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation. Writing Scientific Papers: Justification for scientific contributions, bibliography, description of methods,	

		conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.	
IV		**Chemical Safety & Ethical Handling Of Chemicals**	**15 L**
		Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	

Reference books:-

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 2 nd Ed., Prentice Hall, Harlow.

2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press.

3. Topping, J., (1984) Errors of Observation and their Treatment 4 th Ed., Chapman Hill, London.

4. Harris, D. C. (2007) Quantative Chemical Analysis 6 th Ed., Freeman Chapters 3-5

5. Levie, R. De. (2001) How to use Excel in Analytical Chemistry and in general scientific data analysis Cambridge Universty Press.

6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.

7. OSU Safety manual 1.01

Semester – II

PROGRAM(s): M.Sc.-I	SEMESTER: II				
Course: Paper-I	Course Code: CHEM 507 Course Title:- Physical Chemistry-II				
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks-50)
04	NA	–	04	50%	50%

Learning Objectives:

1. To gain knowledge of the advanced concepts in quantum mechanics, applications of HMO theory, chemical kinetics and molecular dynamics.
2. To understand the advanced concepts in chemical thermodynamics and photochemistry.
3. To develop the skill to solve the problems encountered in the field of quantum and electrochemistry.

Course outcomes: -

1. To learn the concept of quantum chemistry and able to solve problems related to 1D box, 2D box, 3D box and to explain the role of operators in quantum chemistry.
2. To understand the use of Schrodinger wave equation in one and two electron systems along with applications of HMO.
3. To develop the skill to solve the problems based on chemical thermodynamics, molecular dynamics and quantum Chemistry.
4. To apply the concept of Jablonski mechanism in photochemical reactions.
5. Learners will get knowledge of advanced chemical kinetics and molecular dynamics.

Semester – II

Course Code:- CHEM-507	Unit	Course/ Unit Title: Physical Chemistry-II	04 Credits / 60 Lectures
		Chemical Thermodynamics II	
	1.1.	Fugacity of real gases, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity. Gibbs energy of mixing, entropy and enthalpy of mixing.	
	1.2	**Real solutions:** Chemical potential in non ideal solutions excess functions of non ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation.	
	1.3	**Thermodynamics of surfaces**, Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected).	
	1.4	Bioenergetics : standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP. [Ref 2 and 1,10,11,12]	
	2	**Quantum Chemistry II**	
	2.1	Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wavefunction, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics.	
	2.2	Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the Radial (R), Zenith (theta) and Azimuthal (Phi) equations, solution of the equation, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots, points of maximum probability.	

	2.3.	Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation	
	2.4.	Hückel Molecular Orbitals theory for ethylene, 1,3-butadiene, cyclobutadiene and benzene. ***(Derivation expected)*** [Ref 7, 8 and 9]	
	3	**Chemical Kinetics and Molecular Dynamics-II**	
	3.1.	**Elementary Reactions in Solution:-** Solvent Effects on reaction rates, Reactions between ions- influence of solvent Dielectric constant, influence of ionic strength, Linear free energy relationships Enzyme action	
	3.2.	**Kinetics of reactions catalyzed by enzymes** -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses	
	3.3.	**Inhibition of Enzyme action**: Competitive, Noncompetitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes	
	3.4.	**Kinetics of reactions in the Solid State:-** Factors affecting reactions in solids **Rate laws for reactions in solid**: The parabolic rate law, The first order rate law, the contracting sphere rate law, Contracting area rate law, some examples of kinetic studies. (Ref: 7 and 2, 22)	
		Photochemistry	
	4.1	Absorption of light, laws of photochemistry, electronic structure of molecules, molecular orbital, electronically excited singlet states, designation based on multiplicity rule, construction of Jablonski diagram, electronic transition, Frank Condon principle, selection rules, intensity of absorption bands, nature of electronic spectra and primary process, photo-dissociation, pre-dissociation.	
	4.2	Photo physical phenomena: physical pathways of excited molecular system (radiative and non-radiative), prompt fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching: concentration quenching, collisional quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photo-excited donor and acceptor systems.	

	4.3.	Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and applications in chemical analysis. Photochemical reactions, photo-oxidation, photoreduction, photo-dimerization, photoisomerization and photosensitized reactions. Photochemistry of environment: Greenhouse effect.	

References

1. Peter Atkins and Julio de Paula, Atkin‟s *Physical Chemistry*, 7th Edn., Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Robert J. Silby and Robert A. Alberty, *Physical Chemistry*, 3rd Edn., John Wiley and Sons (Asia) Pte. Ltd., 2002.
4. Ira R. Levine, *Physical Chemistry*, 5th Edn., Tata McGraw-Hill New Delhi, 2002.
5. G.W. Castellan, *Physical Chemistry*, 3rd Edn., Narosa Publishing House, New Delhi, 1983.
6. S. Glasstone, *Text Book of Physical Chemistry*, 2nd Edn., McMillan and Co. Ltd., London, 1962.
7. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
8. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003.
9. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994.
10. R.K. Prasad, *Quantum Chemistry*, 2nd Edn., New Age International Publishers, 2000.
11. S. Glasstone, *Thermodynamics for Chemists*, Affiliated East-West Press, New Delhi, 1964.
12. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772.
13. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983.
14. Ira N. Levine, *Quantum Chemistry*, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.
15. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edn., Pearson Education Limited 2013.
16. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edn., 1992.
17. C. H. DePuy, O. L. Chapman, Molecular reactions and photo
Chemistry, Prenticehall of India PVT.LTD.1988.
18. K. K. Rohatgi-Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher, 1978.
19. Principles of physical Chemistry , Marrown and Prutton 5th edition
20. Essentials of Physical Chemistry , Arun Bahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.
21. Introduction of Solids L.V Azaroff , Tata McGraw Hill .
22. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.
23. A Text book of physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd, 2011
24. New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td colspan="3">SEMESTER: II</td></tr>
<tr><td colspan="3">Mandatory Course –II</td><td colspan="3">Course Code: CHEM 508
Course title :Inorganic Chemistry-II</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination (Marks- 50)</td></tr>
<tr><td>04</td><td>NA</td><td>-</td><td>04</td><td>50%</td><td>50%</td></tr>
</table>

Learning Objectives:

1. The course aims at the detailed mechanistic study of various inorganic complexes.
2. The course aims at the detailed interception of bonding concepts in organometallic and bioinorganic chemistry.
3. The course also aims at a detailed understanding of bio inorganic chemistry of metals.
4. The course also aims to study the preparation of different inorganic complexes.

Course Outcomes:

The learners will be able to study rates of reactions and the factors affecting them and understand the different techniques used to study the rate of the reaction.

1. The learners will be able to learn ligand substitution reactions of Octahedral and Square planar complexes, Trans effect and factors affecting these substitution reactions.
2. The learners will be able to understand the 18 e^- and 16 e^- electron square planar complexes by studying different examples. They will also learn the preparation and properties of a few selected compounds including sandwich compounds of Fe, Cr
3. The learners will understand the structure and bonding of a few inorganic compounds like Ziese's salt, ferrocene and bis(arene)chromium(0)
4. The learners will understand the occurrence and effect of toxic metals like Pb, As, Cu, Cd, and Hg on the environment, the different diseases caused by poisoning of metals and the impact these metals have on the living organism.
5. The learners will be familiar with the role of Inorganic chemistry in Biological systems, understand the structure of various biological oxygen carriers and molecules involved in electron storage and transport.

Paper II

Inorganic Chemistry-II

(CHEM508)
[60 L]

Course Code:- CHEM 508	Unit	Course/ Unit Title: Inorganic Chemistry-II	04 Credits / 60 Lectures
	1	**Inorganic Reaction Mechanism**	**15 L**
	1.1	Rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction (Direct chemical analysis, spectrophotometric method, electrochemical and flow methods).	
	1.2	Ligand substitution reactions of: a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labelling method) b) Square planar complexes, trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions.	
	1.3	Redox reactions: inner and outer sphere mechanisms, complimentary and non-complimentary reactions.	
	1.4	Isomerization and racemization reactions	
	2	**Organometallic Chemistry of Transition metals**	**15 L**
	2.1	Eighteen electron rule & electron counting with examples, sixteen electron Square Planar complexes.	
	2.2	Preparation and properties of the following compounds (a) Alkyl and aryl derivatives of Pd and Pt complexes	

		(b) Carbenes and carbynes of Cr, Mo and W (c) Alkene derivatives of Pd and Pt (d) Alkyne derivatives of Pd and Pt (e) Allyl derivatives of nickel (f) Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo.	
	2.3	Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: Zeise‟s salt, bis(triphenylphosphine)diphenylacetylene platinum (0) [Pt(PPh_3)$_2$(HC≡CPh)$_2$], diallylnickel(diallylnickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl (η^2-butadiene) iron(0).	
	3	**Environmental Chemistry:**	**15 L**
	3.1.	Conception of Heavy Metals: Critical discussion on heavy metals	
	3.2.	**Toxicity of metallic species**: a) Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment. b) Itai-itai disease for Cadmium toxicity, c) Arsenic Poisoning in the Indo-Bangladesh region.	
	3.3.	**Interaction of radiation in context with the environment:** Sources and biological implication of radioactive materials. Effect of low-level radiation on cells- Its applications in diagnosis and treatment, Effect of radiation on cell proliferation and cancer.	
	4	**Bioinorganic Chemistry**	**15 L**
	4.1.	Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and differences in mechanism of oxygen binding, Differences between hemoglobin and myoglobin: Cooperativity of oxygen binding in hemoglobin and Hill equation, pH dependence of oxygen affinity in hemoglobin and myoglobin and its implications	

	4.2.	Activation of oxygen in biological system with examples of mono-oxygenases	
	4.3.	Copper containing enzymes- superoxide dismutase,	
	4.4.	Nitrogen fixation-nitrogenase, hydrogenases	
	4.5.	Metal ion transport and storage: Ionophores, transferrin, ferritin and metallothionins	
	4.6.	Medicinal applications of cis-platin and related compounds	

References

Unit I

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.

2. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.

3. W. H. Malik, G. D./ Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.

4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.

5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002

6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house,
7. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.

8. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.

9. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001.

10. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd Ed., Oxford University Press 2008.

Unit II

1. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.

2. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000.

3. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.

4. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.

5. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.

Unit III

1. Environmental Chemistry 5th edition, Colin Baird Michael Cann, W. H. Freeman and Company, New York, 2012.

2. Environmental Chemistry 7th edition, Stanley E. Manahan, CRC Press Publishers,

3. Environmental Contaminants, Daniel A. Vallero, ISBN: 0-12-710057-1, Elsevier Inc., 2004.

4. Environmental Science 13th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-495-56016-2, Brooks/Cole, Cengage Learning, 2010.

5. Fundamentals of Environmental and Toxicological Chemistry 4th edition, Stanley E. Manahan, ISBN: 978-1-4665-5317-0, CRC Press Taylor & Francis Group, 2013.

6. Living in the Environment 17th edition, G. Tyler Miller Jr. and Scott E. Spoolman, ISBN-10: 0-538-49414-X, Brooks/Cole, Cengage Learning, 2011

7. Poisoning and Toxicology Handbook, Jerrold B. Leikin, Frank P. Paloucek, ISBN: 1-4200-4479-6, Informa Healthcare USA, Inc.

8. Casarett and Doull‟s Toxicology- The Basic Science of Poisons 6th edition, McGraw-Hill, 2001.

Unit IV

1. R. W. Hay, *Bioinorganic Chemistry,* Ellis Harwood, England, 1984.

2. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998.

3. J. A. Cowan, *Inorganic Biochemistry-An introduction,* VCH Publication, 1993.

4. S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry,* University Science Publications, Mill Valley, Caligronic, 1994.

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7. E.Frienden, J.Chem. Educ., 1985, 62.

8. Robert R.Crechton, Biological Inorganic Chemistry – An Introduction, Elsevier

9. J. R. Frausto da Silva and R. J. P. Williams *The Biological Chemistry of the Elements,* Clarendon Press, Oxford, 1991.

10. JM. D. Yudkin and R. E. Offord *A Guidebook to Biochemistry*, Cambridge University Press, 1980.

<table>
<tr><td colspan="4">PROGRAM(s): M.Sc.-I</td><td>SEMESTER: II</td></tr>
<tr><td colspan="4"></td><td>Course Code: (CHEM 510)
Course Title:-Analytical Chemistry-II</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks- 50)</td><td>Semester End Examination
(Marks- 50)</td></tr>
<tr><td>04</td><td>NA</td><td>04</td><td>50%</td><td>50%</td></tr>
</table>

Course Objectives:

1. To gain knowledge of the chromatography techniques and its applications.

2. To understand application of X-ray spectroscopy for qualitative and quantitative analysis.

3. To introduce radio analytical techniques.

4.To apply the surface analytical techniques for system.

5.To study advantages and applications of electroanalytical methods.

Course outcomes: -

After completion of this Course, the learner will be

1. able to compare the advantages/disadvantages of SEM, STM and TEM.

2. able to develop different techniques to separate the components of mixture.

3. conversant with basic principles and theories of mass spectrometry.

4. able to apply the electroanalytical methods to sample under consideration.

5. able to elaborate on electrogravimetry and coulometry techniques.

Course Code:- CHEM 510	Unit	Course/ Unit Title: **Analytical Chemistry-II**	04 Credits / 60 Lectures
	1	**Chromatography**	**15L**
	1.1	**Basic concepts and theories of chromatography**: **[5 L]** 1.1.1 Introduction and Classification of chromatographic methods. 1.1.2 Concept of plate and rate theories in chromatography, efficiency, resolution, selectivity and separation capability. 1.1.3 Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions.	
	1.2	**Gas Chromatography**: **[5 L]** 1.2.1 Instrumentation –sample injection systems (split/split less), column types (solid/ liquid stationary phases), column switching techniques, temperature programming. 1.2.2 Requirements of an ideal detector and types of detectors in GLC and GSC. 1.2.3 Applications -Qualitative and quantitative analysis.	
	1.3	**High Performance Liquid Chromatography (HPLC):[5 L]** 1.3.1 Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). 1.3.2 Diode array type and fluorescence detector. 1.3.3 Applications of HPLC.	
	2	**Instrumental methods - II**	**15L**
		2.1 X-ray spectroscopy: **[6 L]**	

		Principle, instrumentation, applications, advantages and limitations of **2.1.1** X-ray absorption spectroscopy. (XAS) **2.1.2** X-ray fluorescence spectroscopy (XRF) **2.1.3** X-ray diffraction spectroscopy. (XRD)	
		2.2 Mass spectrometry: **[6 L]** **2.2.1** Instrumentation - i) Ion sources - electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources. ii) Mass analyzers: Quadrupole, time of flight and ion trap. **2.2.2** Applications	
		2.3 Radio analytical Methods –[3 L] 2.3.1 Neutron Activation Analysis(NAA)- Introduction, Principle, Theory and Applications. **2.3.2** Advantages and Limitations of NAA.	
		Instrumental methods - III	
	3.1	**Surface Analytical Techniques – [9 L]** Principle, Instrumentation and Applications of: **3.1.1** Scanning Electron Microscopy (SEM) **3.1.2** Scanning Tunneling Microscopy (STM) **3.1.3** Transmission Electron Microscopy (TEM)	
	3.2	**Atomic Spectroscopy [6 L]** **3.2.1** Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications. **3.2.2**Advantages and Limitations of AAS	

		Electroanalytical Methods	**15L**
	4.1	**Ion selective potentiometry and Polarography**: **4.1.1**Ion selective electrodes: Applications of - solid state, precipitate, liquid –liquid, enzyme, gas sensing, bio-catalytic membrane and enzyme-based biosensors electrodes. **4.1.2** Polarography**:** Ilkovic equation, Cottrell equation, effect of complex formation on the polarographic waves.	
	4.2	**Electrogravimetry**: **[2 L]** **4.2.1**Introduction, Principle and Instrumentation. **4.2.2** Factors affecting the nature of the deposit. **4.2.3** Applications**.**	
	4.3	**Coulometry: [3 L]** **4.3.1** Introduction, Principle and Instrumentation. **4.3.2** Coulometry at controlled potential and controlled current.	

References:

Unit I

1. Instrumental Analysis, Skoog, Holler and Crouch, 7th edition
2. HPLC Practical and Industrial Applications; E.B.Sandell and H.Onishi 2 nd Ed., CRC Press

Unit II

1. Essentials of Nuclear Chemistry; H J Arnikar, New Age Publishers (2005)
2. Fundamentals of Radiochemistry; D. D. Sood A. V. R. Reddy and N. Ramamoorthy, , IANCAS 4th edition, 2010
3. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 12, 20

Unit III

1. Instrumental Analysis; Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition, (2003), ISBN-10: 8131505421, ISBN-13: 978-8131505427

2. Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM

   ; Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0- 387-26016- 7 (Online)

3. Modern techniques of surface science; D.P. Woodruff and T.A. Delchar, Cambridge Univ. Press, 1994.

4. Introduction to Scanning Tunneling Microscopy ; C. J. Chen, Oxford University Press, New York, 1993.

5. Transmission Electron Microscopy: A text book for Material Science; David B Williams and C., Barry Carter, Springer, 2009

6. Modern Spectroscopy,; J.M. Hollas, , John Wiley, New York, 3rd Edition (1996),

7. Principles of Instrumental Analysis; Skoog, Holler, Nieman, Harcourt College Publishers, 5th ed., 1998.

8. Instrumental Analysis; Douglas A. Skoog - F. James Holler - Crouch, Publisher: Cengage; Edition (2003), ISBN10: 8131505421, ISBN-13: 978-8131505427

Unit IV

1. Principles of Instrumental Analysis – ; Skoog, Holler, Nieman, Harcourt College Publishers, 5th Edition, 1998. Chapters - 23, 24, 25.

2. Analytical Chemistry Principles – ; John H Kennnedy, Saunders College Publishing, 2nd edition, (1990).

3. Modern Analytical Chemistry; David Harvey; McGraw Hill Higher education publishers, (2000).

4. Vogel‟s Text book of quantitative chemical analysis; Pearson Education Limited, 6th edition, (2007).

5. Electrochemical Methods Fundamentals and Applications; Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).

PROGRAM(s): M.Sc.-I	SEMESTER: II				
Course: Practical	Course Code: PRCHEMPI 511 Course Title:- Chemistry Practical-II (Physical and Inorganic Chemistry)				
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-25)	Semester End Examination (Marks-25)
NA	04	–	02	50%	50%

Learning Objectives:
Physical Chemistry

1.To gain knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2.To develop scientific temper and research based skills accomplish to encountered in the field of research.

Inorganic Chemistry

1. The learners will be able to synthesize and characterize different inorganic coordination complexes.
2. The learners will be trained in calculating the equilibrium constant for Fe3-/SCN1- by slope intercept method and in determining the electrolytic nature of some inorganic compounds by conductance measurements.

Course Outcomes:-

Physical Chemistry

1.To use the concept of quantum chemistry to interpret the shape and information about the orbitals like 1s, 2pz and 3dz2.

2. To apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions

3. Learner will train to handle the sophisticated instrument like digital potentiometer, conductivity meter, spectrophotometer.

Inorganic Chemistry

1. The learners will characterize different coordination compounds with the help of conductivity measurements, electronic and magnetic measurements and spectroscopic measurements.
2. Able to calculating the equilibrium constant for Fe3-/SCN1- by slope intercept method
3. Able to determine the electrolytic nature of some inorganic compounds by conductance measurements.

Course code:- PRCHEMP I 511	**Chemistry Practical-II**	**Credits 02**
	Physical Chemistry	**01 Credit**
	Non – Instrumental: 1. Polar plots of atomic orbitals such as 1*s*, 2Pz and 3 dz2 orbitals by using angular part of hydrogen atom wave functions. 2. To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate. 3. To study phase diagram of three component system water – chloroform /toluene - acetic acid. 4. To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method. **Instrumental:** 1. To determine the formula of silver ammonia complex by potentiometric method. 2. To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations. 3. To determine Hammette constant of *m*- and *p*- amino benzoic acid/nitro benzoic acid by pH measurement. 4. To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically	

	Inorganic Chemistry	
	Inorganic Preparations (Synthesis and Characterization) 1) Bis-(tetramethylammonium) tetrachloro Cuprate (II) $(Me_4 N)_2[CuCl_4]$ 2) Bis-(tetramethylammonium) tetrachloro Nickelate (II) $(Me_4 N)_2 [NiCl_4]$ 3) Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$ 4) Hexaaamine Ni(II) Sulfate $[Ni(NH_3)_6]SO_4$ 5)Potassium trioxalato Chromate(III) $K_3[Cr(C_2O_4)_3]$ 6) Tetrammine monocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$ **Instrumentation** 1) Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system 2) Determination of Electrolytic nature of inorganic compounds by Conductance measurement.	

References

1.Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.

2.Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.

3.Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.

4. Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1st Edn., 2010., U.N.Dhur & Sons Pvt Ltd

5. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly

6. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr Deepak Pant

Course Code: (CHEM 50911)
Course Title: - Organic Chemistry III
SEM-II

PROGRAM(s): M.Sc.-I	SEMESTER: II				
Course: Elective-I	Course Code (CHEM 50911) Course Title: - Organic Chemistry III				
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 25)	Semester End Examina (Marks- 25)
02	NA	NA	02	50%	50%

Course Learning Outcomes.
After completing the course students will be able to:

1) Recognise the type of mechanism & intermediates involved in the given organic reaction and to prove mechanism for the reaction.
2) Identify the ways to modify aliphatic and aromatic compounds via Nucleophilc substitution reactions.
3) Understand the HOMO-LUMO concept and it significance in organic chemistry.
4) Understand the basic principle and concepts in UV and IR spectroscopy

Course Code:- CHEM 50911	Unit	Course/ Unit Title: Organic Chemistry -III	02 Credits / 30 Lectures
		1.1. Alkylation of Nucleophilic Carbon Intermediates: (7 L)	

		1.1.1. Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. 1.1.2. Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. 1.1.3. Alkylation of aldehydes, ketones, esters, amides and nitriles. 1.1.4. Nitrogen analogs of enols and enolates- Enamines and Imines anions, alkylation of enamines and imines. 1.1.5. Alkylation of carbon nucleophiles by conjugate addition (Michael reaction).	
		1.2. Reaction of carbon nucleophiles with carbonyl groups: (8 L) 1.2.1. Mechanism of Acid and base catalyzed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction and Robinson annulation. 1.2.2. Addition reactions with amines and iminium ions; Mannich reaction. 1.2.3. Amine catalyzed condensation reaction: Knoevenagel reaction. 1.2.4. Acylation of carbanions	
	2	**Introduction to Molecular Orbital Theory for Organic Chemistry: (7L)** **2.1.1. Molecular orbitals:** Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allyl cation, anion and radical. Concept of nodal planes and energies of π-MOs **2.1.2. Introduction to FMOs:** HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra as well as chemical reactions. MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde. A brief description of MOs of nucleophiles and electrophiles. Concept of 'donor-acceptor' interactions in nucleophilic addition reactions on formaldehyde. Connection of this HOMO-LUMO interaction with 'curved arrows' used in reaction mechanisms. The concept of hardness and softness and its application to electrophiles and nucleophiles. Examples of hard and soft nucleophiles/ electrophiles.	

		Identification of hard and soft reactive sites on the basis of MOs. **2.1.3.** Application of FMO concepts in (a) S_N2 reaction, (b) Lewis acid base adducts (BF_3-NH_3 complex), (c) ethylene dimerization to Cyclobutane, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with allyl anion (f) addition of hydride to formaldehyde.	
		2.2. Applications of UV and IR spectroscopy: (8L) **2.2.1. Ultraviolet spectroscopy:** Recapitulation, UV spectra of dienes, conjugated polyenes (cyclic and acyclic), carbonyl and unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents). **2.2.2. Infrared spectroscopy:** Fundamental, overtone and combination bands, vibrational coupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds.	

Course Code: (CHEM 50912)
Course Title:- Organic Chemistry -IV
SEM-II

PROGRAM(s): M.Sc.-I	**SEMESTER: II**				
Course: Elective-II	**Course Code (CHEM 50912)** **Course Title: - Organic Chemistry -IV**				
Teaching Scheme				**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)** **(Marks- 25)**	**Semester End Examina** **(Marks- 25)**
02	**NA**	**NA**	**02**	**50%**	**50%**

Course Learning Outcomes.

After completing the course students will be able to:

1) Predict the mechanism and stereochemistry of important organic reactions.
2) Understand and write the mechanism of rearrangement reactions with stereochemistry and its applications.
3) Understand the basic concepts of ^{1}H, ^{13}C NMR, and mass spectroscopy.
4) Understand how ^{1}H, ^{13}C NMR and Mass spectroscopy are important for the structure determination of organic compounds.

Course Code:- CHEM 50912	Unit	Course/ Unit Title: Organic Chemistry -IV (Elective -II)	02 Credits / 30 L
	1	**Reactions and Rearrangements:** Mechanisms, stereochemistry (if applicable) and applications of the following:	(15L)
		Reactions: Baylis-Hillman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction.	
		Concerted rearrangements: Hofmann, Curtius, Lossen, Schmidt, Wolff, Boulton-Katritzky	
		Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein.	
		Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Baker-Venkataraman.	
	2	**^{1}H and ^{13}C NMR spectroscopy and Mass spectrometry**	(15L)
	2.1	**Proton magnetic resonance spectroscopy:** Principle, Chemical shift, Factors affecting on chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal, Karplus equation, long range coupling (allylic and aromatic).	
	2.2	**^{13}C NMR spectroscopy:** Theory and comparison with proton NMR, proton coupled and decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons.	

	2.3	**Mass spectrometry:** Basic Principle, Molecular ion peak, base peak, isotopic abundance, metastable ions. Nitrogen rule, Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect.	
	2.4	Structure determination involving individual or combined use of the above spectral techniques.	

References:

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press.
3. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael, B. Smith, Jerry March, Wiley.
4. Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson Publication (7^{th} Edition)
5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
10. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education.
11. Mechanism in Organic Chemistry, Peter Sykes, 6^{th}
12. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley
13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons.
15. Organic Spectroscopy, William Kemp, W.H. Freeman & Company.
16. Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication.
17. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co.
18. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.
19. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha Science International, 2011.
20. Reactions, Rearrangements and Reagents by S. N. Sanyal
21. Name Reactions, Jie Jack Li, Springer
22. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K Parasher, Alpha Science International, 2011.
23. Name Reactions, Jie Jack Li, Springer.

24. Name reactons and Reagents in Organic Synthesis, Bradford P. Mundy, M.G. Ellerd and F.G. Favaloro, John Wiley & Sons.
25. Organic reactions and their Mechanisms, P.S. Kalsi, New Age International Publishers.
26. Elementary Organic Spectroscopy By- Y R Sharma, (S. Chand Publications)

Course Code: CHEM 50911/ CHEM 50912
Course Title: - Elective Practical: Chemistry Practicals

Sem II

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-I</td><td colspan="3">SEMESTER: II</td></tr>
<tr><td colspan="3">Course: Practical</td><td colspan="3">Course Code: CHEM 50911/ CHEM 50912
Course Title: - Elective Practical: Chemistry Practicals</td></tr>
<tr><td colspan="4">Teaching Scheme</td><td colspan="2">Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Practical (Hours per week)</td><td>Tutorial (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 25)</td><td>Semester End Examir
(Marks- 25)</td></tr>
<tr><td>NA</td><td>04</td><td>NA</td><td>02</td><td>50%</td><td>50%</td></tr>
<tr><td colspan="6">Learning Objectives:
1. To Gain knowledge of the Fundamental concepts in the branch of Analytical chemistry and to develop a research aptitude.
2. To apply the basic knowledge of Analytical chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the job requirements as per global standards.
3. To deduce qualitative and quantitative information of analyte using prescribed Analytical technique and to develop practical skills in them during the course.</td></tr>
</table>

4. To develop skills in solving calculations in analytical chemistry.
5. To introduce the importance and role of Quality control and Quality assurance in industries.
6. To develop separation skills of binary/ternary organic mixtures by physical and chemical methods.
7. To develop purification skills of separated organic compounds
8. To characterise separated compound with the help of chemical analysis and

To confirm the structure with the help of derivative preparation and its physical constant.

Course Outcomes: At the end of the Course,

1. The learners will be able to percentage purity of various samples.
2. The learners will be able to do qualitative and quantitative analysis of samples using instruments like colorimeter, spectrophotometer and AAS.
3. The learners will be able to carry out non aqueous titration.
4. The learners will be able to separate binary/ternary organic mixtures.
5. The learners will be able to purify the separated organic compound.
6. The learners will be able to analyse the separated compound by chemical analysis.

The learners will be able to confirm the structure with the help of derivative preparation and its physical constant.

Elective Practical

Chemistry Practicals CHEM 50911/ CHEM 50912

Course code- CHEM 50911/ CHEM 50912	**Elective Practical: Organic and Analytical Chemistry**	**Credits 02**
	Organic Chemistry	
	Separation of Binary mixture using micro-scale technique	
	1. Separation of binary mixture using physical and chemical methods. 2. Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant. 3. Purification and determination of mass and physical constant of the second component. The following types are expected: (i) Water soluble/water insoluble solid and water insoluble solid, (ii) Non-volatile liquid-Non-volatile liquid (chemical separation) (iii) Water-insoluble solid-Non-volatile liquid. **(Minimum two mixtures from each type and a total of eight mixtures are expected.)**	

	Analytical Chemistry	
	1. To determine percentage purity of sodium carbonate in washing soda pH metrically. 2. To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically. 3. To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titration with perchloric acid in a non aqueous medium using glass calomel system potentiometrically. 4. To determine the amount of nitrite present in the given water sample colorimetrically. 5. To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically. 6. Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically. 7. To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$ 8. To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.	

Course: On Job Training/ Field Projects
Course Code: CHEM 512

PROGRAM(s): M.Sc-I		SEMESTER: II		
Course: On Job Training/ Field Projects		Course Code: CHEM 512		
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Semester End Examination (Marks- 100)
NA	08	–	04	Viva-20 marks, Dissertation/ Thesis-40 marks, Presentation-40 marks

Learning Objectives:

1) To provide students the opportunity to test their interest in a particular career before permanent commitments are made.
2) To develop skills in the application of theory to practical work situations. To develop skills and techniques directly applicable to their careers.

Course Outcomes:

At the end of the Course,

1) Understand the Organizational Structure of a company.
2) Develop work habits and attitudes necessary for job success (technical competence, professional attitude, organization skills etc.)
3) Develop written communication and technical report writing skills.

Modality of Assessment

Theory Examination Pattern:

A. Internal Assessment- 50%- 50 Marks per paper

Sr. No.	Evaluation Type	Marks
1	**Written Objective/Short Answer Examination**	**25**
2	**Assignment/ Case study/ field visit report/ presentation/ project**	**25**
	Total	**50**

B. External Examination- 50%-
50 Marks per paper Semester
End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.

2. Theory question paper pattern:

   a. There shall be 05 questions each of 10 marks on each unit.

   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern for 50 marks:

Question	Options	Marks
Q.1	2 out of 4	10
Q.2	2 out of 4	10
Q.3	2 out of 4	10
Q.4	2 out of 4	10
Q.5	5 out of 8	10
	TOTAL	**50**

Paper Pattern for 25 marks:

25 Marks per paper Semester
End Theory Examination:

1. Duration - These examinations shall be of **one hour** duration.

2. Theory question paper pattern:

   a. There shall be 02 questions each of 08 marks on each unit and one mix question for 09 marks

b. All questions shall be compulsory with internal choice within the questions.

Question	Options	Marks
Q.1	2 out of 4	08
Q.2	2 out of 4	08
Q.3	3 out of 6	09
	TOTAL	**25**

Semester End Practical Examination:

Particulars	Continuous assessment (CA)	Semester end external examination
Laboratory work	15	15
Viva	05	05
Journal	**05**	**05**
Total	**25**	**25**

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Letter Grades and Grade Points

Semester GPA/ Program CGPA/Semester	**% Marks**	**Letter Grade Result**
9.00-10.00	90.0-100.0	O (Outstanding)
8.00≤9.00	80.0≤90.0	A+ (Excellent)
7.00≤8.00	70.0≤80.0	A (Very Good)
6.00≤7.00	60.0≤70.0	B+ (Good)
5.50≤6.00	55.0≤60.0	B (Above Average)
5.00≤5.50	50.0≤55.0	C (Average)
4.00≤5.00	40.0≤50.0	P (Pass)
Below 4.00		F (Fail)
Ab (Absent)		Absent

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

HEAD
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MUMBAI

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Team for Creation of Syllabus

Name	College Name	Sign
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Sign of HOD

Garje

Prof. Shivram S. Garje
Head of Department,
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HEAD
DEPARTMENT OF CHEMISTRY
UNIVERSITY OF MUMBAI

Sign of Dean,

Garje

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Appendix B

Justification for M.Sc . (Physical Chemistry)

1.	The necessity for starting the course:	M.Sc. (Physical Chemistry) course is necessary for those who seek to deepen their knowledge, specialize in a particular area, and pursue advanced careers in research, industry, academia, or other chemistry-related fields. It offers numerous opportunities for personal and professional growth, enabling you to make a positive impact on the world through scientific exploration and discovery.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	The course has already commenced from the academic year from 1967 and in the academic year 2022-23 it is restructured under NEP 2020
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?:	This course is not self-financed. There are adequate PG recognized teachers available in the colleges
5.	To give details regarding the duration of the Course and is it possible to compress the course?:	The duration of the program is two years (4 semesters). It is not possible to compress the course. Under NEP 2020 students have option of exit at the end of first year with PG Diploma in Physical Chemistry.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity of the program is variable as per college intake capacity. Number of admission for the academic year 2022-23 is variable as per college intake capacity.
7.	Opportunities of Employability / Employment available after undertaking these courses:	M.Sc. (Physical Chemistry) students have a wide range of employment opportunities across various sectors. The skills and knowledge acquired during their master's program make them well-equipped for diverse roles. Some of the common areas where M.Sc. (Physical Chemistry) students

		can find employment include; Research and Development (R&D), Pharmaceutical Industry, Chemical Manufacturing, Environmental and Analytical Chemistry, Quality Assurance and Control, Materials Science and Nanotechnology, Teaching and Academia, Healthcare and Clinical Research etc. The key to employability for M.Sc. (Physical Chemistry) students are to build a strong resume through internships, research projects, and networking. Additionally, staying updated with the latest advancements in the field and continuously improving their skills can enhance their competitiveness in the job market.

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Garje

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

UNIVERSITY OF MUMBAI

No. UG/85 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular Nos. UG/226 of 2006, dated 29th June, 2006 relating to syllabus of the Master of Science (M.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Chemistry at its meeting held on 28th May, 2018 have been accepted by the Academic Council at its meeting held on 14th June, 2018 **vide** item No. 4.71 and that in accordance therewith, the revised syllabus as per the (CBCS) for the M.Sc. in Organic Chemistry (Sem – III & IV), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
19th July, 2018

(Dr. Dinesh Kamble)
I/c REGISTRAR

To

The Principals of the affiliated Colleges, the Head University Departments & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C./4.71/14/06/2018

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No. UG/ 85 -A of 2018 MUMBAI-400 032 19th July, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

AC – 14/06/2018

Item No. 4.71

UNIVERSITY OF MUMBAI

Program : M.Sc.

(Choice Based Credit System)

Course : M.Sc. Organic Chemistry

Part – I

Syllabus for Semester III & IV

(To be implemented from the Academic year 2018-2019)

M.Sc. Organic Chemistry

Semester – III
Course Code: PSCHO301
Paper - I (**Theoretical organic chemistry-I**)

Unit 1	**Organic reaction mechanisms**	**[15L]**
1.1	Organic reactive intermediates, methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes**.**	**[5L]**
1.2	Neighbouring group participation**:** Mechanism and effects of anchimeric assistance, NGP by unshared/ lone pair electrons, π-electrons, aromatic rings, σ-bonds with special reference to norbornyl and **bicyclo[2.2.2]octyl cation** systems (formation of non-classical carbocation)	**[3L]**
1.3	Role of FMOs in organic reactivity**:** Reactions involving hard and soft electrophiles and nucleophiles, ambident nucleophiles, ambident electrophiles, the α effect.	**[2L]**
1.4	Pericyclic reactions: Classification of pericyclic reactions; thermal and photochemical reactions. Three approaches: Evidence for the concertedness of bond making and breaking Symmetry-Allowed and Symmetry-Forbidden Reactions – • The Woodward-Hoffmann Rules-Class by Class • The generalised Woodward-Hoffmann Rule Explanations for Woodward-Hoffmann Rules • The Aromatic Transition structures [Huckel and Mobius] • Frontier Orbitals • Correlation Diagrams, FMO and PMO approach Molecular orbital symmetry, Frontier orbital of ethylene, 1,3 butadiene, 1,3,5 hexatriene and allyl system.	**[5L]**

Unit 2	**Pericyclic reactions**	**[15L]**
2.1	Cycloaddition reactions: Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes. Diels-Alder reactions, 1, 3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, torquoselectivity, site selectivity and effect of substituents in Diels-Alder reactions. **Other Cycloaddition Reactions- [**4+6] Cycloadditions, Ketene Cycloaddition, Allene Cycloadditions, Carbene Cycloaddition, Epoxidation and Related Cycloadditions. Other Pericyclic reactions: Sigmatropic Rearrangements, Electrocyclic Reactions, Alder 'Ene' Reactions.	**[7L]**
2.2	Electrocyclic reactions: Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron and allyl systems.	**[3L]**
2.3	Sigmatropic rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations. Cope (including oxy-Cope and aza-Cope) and Claisen rearrangements. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A.	**[5L]**

Unit 3:	**Stereochemistry-I**	**[15L]**
3.1	Classification of point groups based on symmetry elements with examples (nonmathematical treatment).	**[2L]**
3.2	Conformational analysis of medium rings: Eight **to** ten membered rings and their unusual properties**,** I-strain, transannular reactions.	**[3L]**
3.3	Stereochemistry of fused ring and bridged ring compounds: decalins, hydrindanes, **perhydroanthracenes**, steroids, and Bredt's rule.	**[5L]**
3.4	**Anancomeric systems,** Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones **(with $LiAlH_4$, selectride and MPV reduction)** and oxidation of cyclohexanols**.**	**[5L]**
Unit 4	**Photochemistry**	**[15L]**
4.1	Principles of photochemistry: quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process.	**[3L]**
4.2	Photochemistry of carbonyl compounds:$\pi\rightarrow\pi^*$, $n\rightarrow\pi^*$ transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, calculation of quantum yield, photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction.	**[8L]**
4.3	Photochemistry of olefins: cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di- π- methane rearrangement including aza-di- π -methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation of alkenes.	**[2L]**
4.4	Photochemistry of arenes**:** 1, 2- , 1, 3- and 1, 4- additions. Photocycloadditions of aromatic Rings.	**[1L]**
4.5	Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions. Chemiluminescence.	**[1L]**

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35 Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.
36 Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.
37 Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication)

Course Code: PSCHO302
Paper-II
Synthetic Organic Chemistry-I

Unit 1:	**Name reactions with mechanism and application**	**[15L]**
1.1	Mukaiyama esterification, Mitsonobu reaction, Darzen's Glycidic Ester syntheis, Ritter reaction, Yamaguchi esterification, Peterson olefination.	**[5L]**
1.2	**Domino reactions**: Characteristics; Nazerov cyclization	**[3L]**
1.3	**Multicomponent reactions**: Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis	**[5L]**
1.4	**Click Reactions**: Characteristics; Huisgen 1,3-Dipolar Cycloaddition	**[2L]**
Unit 2:	**Radicals in organic synthesis**	**[15L]**
2.1	**Introduction:** Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals.	[3L]
2.2	**Radical Initiators**: azobisisobutyronitrile (AIBN) and dibenzoyl peroxide.	[1L]
2.3	**Characteristic reactions** - Free radical substitution, addition to multiple bonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity),radical cyclizations, autoxidations: synthesis of cumene hydroperoxide from cumene.	[4L]
2.4	**Radicals in synthesis**: Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds. Oxidative coupling, C-C bond formation in aromatics: $S_{RN}Ar$ reactions.	[4L]
2.5	Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation.	[3L]
Unit 3:	**Enamines, Ylides and α-C-H functionalization**	**[15]**
3.1	**Enamines:** Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison between enamines and enolates. Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines.	[4L]
3.2	**Phosphorus, Sulfur and Nitrogen Ylides:** Preparation and their synthetic applications along with their stereochemical aspects. Wittig reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination.	[6L]

3.3	**α-C-H functionalization:** By nitro, sulfoxide, sulfone and phosphonate groups: generation of carbanions by strong bases (LDA/n-butyl lithium) and applications in C-C bond formation. Bamford-Stevens reaction, Julia olefination and its modification, Seyferth–Gilbert homologation, Steven's rearrangement.	[5L]
Unit 4:	**Metals / Non-metals in organic synthesis**	**[15]**
4.1	**Mercury in organic synthesis:** Mechanism and regiochemistry of oxymercuration and demercuration of alkenes, mercuration of aromatics, transformation of aryl mercurials to aryl halides. Organomercurials as carbene transfer reagents.	[3L]
4.2	**Organoboron compounds:** Mechanism and regiochemistry of hydroboration of alkenes and alkynes, asymmetric hydroboration using chiral boron reagents, 9-BBN hydroboration, oxazaborolidine (CBS catalyst) and functional group reduction by diborane.	[3L]
4.3	**Organosilicons:** Salient features of silicon governing the reactivity of organosilicons, preparation and important bond-forming reactions of alkyl silanes, alkenyl silanes, aryl silanes and allyl silanes. β-silyl cations as intermediates. Iodotrimethylsilane in organic synthesis.	[3L]
4.4	**Silyl enol ethers**: Application: As nucleophiles (Michael reaction, Mukaiyama aldol reaction), in ring contraction reactions.	[2L]
4.5	**Organotin compounds**: Preparation of alkenyl and allyl tin compounds; application in C-C bond formation, in replacement of halogen by H at the same C atom.	[2L]
4.6	**Selenium in organic synthesis:** Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and seleno acetals as α-C-H activating groups	[2L]

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- **Name Reactions,** Jie Jack Lie, 3^{rd} Edn., Springer
- **Organic Electrochemistry,** H. Lund, and M. Baizer, 3^{rd} Edn., Marcel Dekker.

Course Code: PSCHO303
Paper-III
Natural products and Spectroscopy

Unit 1:	**Natural products-I**	**[15L]**
1.1	**Carbohydrates:** Introduction to naturally occurring sugars: Deoxysugars, aminosugars, branched sugars. Structure elucidation of lactose and D-glucosamine (synthesis not expected).Structural features and applications of inositol, starch, cellulose, chitin and heparin**.**	[5L]
1.2	**Natural pigments:** General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of β-carotene and Cyanin (with synthesis). Synthesis of ubiquinone from 3, 4, 5-trimethoxyacetophenone.	[5L]
1.3	**Insect pheromones:** General structural features and importance. Types of pheromones (aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of bombykol from acetylene, disparlure from 6-methylhept-1-ene, grandisol from 2-methyl-1, 3-butadiene**.**	[3L]
1.4	**Alkaloids:** Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of coniine.	[2L]
Unit 2:	**Natural products-II**	**[15L]**
2.1	**Multi-step synthesis of natural products:** Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations: a) Woodward synthesis of Reserpine from benzoquinone b) Corey synthesis of Longifoline from resorcinol c) Gilbert-Stork synthesis of Griseofulvin from phloroglucinol d) Corey's Synthesis of Caryophyllene from 2-Cyclohexenone and Isobutylene e) Synthesis of Juvabione from Limonene	[8L]

f) Synthesis of Taxol.

2.2 **Prostaglandins:** Classification, general structure and biological importance. Structure elucidation of **PGE_1**. [2L]

2.3 **Lipids:** Classification, role of lipids, Fatty acids and glycerol derived from oils and fats. [2L]

2.4 **Insect growth regulators:** General idea, structures of JH_2 and JH_3 . [1L]

2.5 **Plant growth regulators:** Structural features and applications of arylacetic acids, gibberellic acids and triacontanol. Synthesis of triacontanol (synthesis of stearyl magnesium bromide and 12-bromo-1-tetrahydropyranyloxydodecane expected). [2L]

Unit 3: Advanced spectroscopic techniques-I [15L]

3.1 **Proton NMR spectroscopy:** Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (A_2, AB, AX, AB_2, AX_2, AMX and A_2B_2-A_2X_2 spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and Coupling in aromatic and heteroaromatic systems), Temperature effects, Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents. [7L]

3.2 **^{13}C –NMR spectroscopy:** Recapitulation, equivalent and non-equivalent carbons (examples of aliphatic and aromatic compounds), ^{13}C- chemical shifts, calculation of ^{13}C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to ^{19}F and ^{31}P. [4L]

3.3 Spectral problems based on UV, IR, ^{1}HNMR and ^{13}CNMR and Mass spectroscopy . [4L]

Unit 4: Advanced spectroscopic techniques-II [15L]

4.1 **Advanced NMR techniques:** DEPT experiment, determining number of attached hydrogens (Methyl/methylene/methine and quaternary carbons), two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY techniques. [10L]

4.2 Spectral problems based on UV, IR, ^{1}HNMR, ^{13}CNMR (Including 2D technique) and Mass spectroscopy [5L]

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Course Code: PSCHOEC-I 304

Paper-IV

Medicinal , Biogenesis and green chemistry

Unit 1:	**Drug discovery, design and development**	**[15L]**
1.1	Introduction, important terms used in medicinal chemistry: receptor, therapeutic index, bioavailability, drug assay and drug potency. General idea of factors affecting bioactivity: Resonance, inductive effect, bioisosterism, spatial considerations. Basic pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H-bonding, partition coefficient and isomerism in drug distribution and drug-receptor binding.	[7]
1.2	Procedures in drug design: Drug discovery without a lead: Penicillin, Librium. Lead discovery: random screening, non-random (or targeted) screening. Lead modification: Identification of the pharmacophore, Functional group modification. Structure-activity relationship, Structure modification to increase potency and therapeutic index: Homologation, chain branching, ring-chain transformation, bioisosterism, combinatiorial synthesis (basic idea).	[8L]
Unit 2:	**Drug design, development and synthesis**	**[15L]**
2.1	Introduction to quantitative structure activity relationship studies. QSAR parameters: - steric effects: The Taft and other equations; Methods used to correlate regression parameters with biological activity: Hansch analysis- A linear multiple regression analysis.	[5L]
2.2	Introduction to modern methods of drug design and synthesis- computer-aided molecular graphics based drug design, drug design via enzyme inhibition (reversible and irreversible), bioinformatics and drug design.	[3L]
2.3	Concept of prodrugs and soft drugs. (a) Prodrugs: Prodrug design, types of prodrugs, functional groups in prodrugs, advantages of prodrug use. (b) Soft drugs: concept and properties.	[3L]
2.4	Synthesis and application of the following drugs: Fluoxetine, cetrizine, esomeprazole, fluconazole, zidovudine, methotrexate, diclofenac, labetalol, fenofibrate.	[4L]
Unit 3:	**Biogenesis and biosynthesis of natural products**	**[15L]**
3.1	Primary and secondary metabolites and the building blocks, general pathway of amino acid biosynthesis.	[3L]

3.2 Acetate pathway: Biosynthesis of malonylCoA, saturated fatty acids, prostaglandins from arachidonic acid, aromatic polyketides. [4L]

3.3 Shikimic Acid pathway: Biosynthesis of shikimic acid, aromatic amino acids, cinnamic acid and its derivatives, lignin and lignans, benzoic acid and its derivatives, flavonoids and isofalvonoids. [4L]

3.4 Mevalonate pathway: Biosynthesis of mevalonic acid, monoterpenes – geranyl cation and its derivatives, sesquiterpenes – farnesyl cation and its derivatives and diterpenes. [4L]

Unit 4: Green chemistry **[15L]**

4.1 Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts. [1L]

4.2 Use of the following in green synthesis with suitable examples: [9L]

a) Green reagents: dimethylcarbonate, polymer supported reagents.

b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts [Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers], biocatalysts.

c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide.

d) Solid state reactions: solid phase synthesis, solid supported synthesis

e) Microwave assisted synthesis: reactions in water, reactions in organic solvents, solvent free reactions.

f) Ultrasound assisted reactions.

4.3 Comparison of traditional processes versus green processes in the syntheses of ibuprofen, adipic acid, 4-aminodiphenylamine, p-bromotoluene and benzimidazole. [3L]

4.4 Green Catalysts : Nanocatalyst, Types of nanoctalysts, Advantages and Disadvantages of Nanocatalysts, Idea of Magnetically separable nanocatalysts. [2L]

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2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers**.**
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43. Organic synthesis in water. By Paul A. Grieco, Blackie.
44. Green chemistry, Theory and Practical, Paul T. Anastas and John C. Warner.
45. New trends in green chemistry By V. K. Ahulwalia and M. Kidwai, 2nd edition, Anamaya Publishers, New Delhi.
46. An introduction to green chemistry, V. Kumar, Vishal Publishing Co.
47. Organic synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal.

Course Code: PSCHOEC-II 304
Paper-IV
Bioorganic chemistry

Unit 1:	**Biomolecules-I**	**[15L]**
1.1	Amino acids, peptides and proteins: Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, α- helix, β-sheets, super secondary structure. Tertiary structure of protein: folding and domain structure. Quaternary structure.	[2L]
1.2	Nucleic acids: Structure and function of physiologically important nucleotides (c-AMP, ADP, ATP) and nucleic acids (DNA and RNA), replication, genetic code, protein biosynthesis, mutation.	[3L]
1.3	Structure: Purine & pyrimidine bases, ribose, deoxyribose, nucleosides and nucleotides (ATP, CTP, GTP, TTP, UTP) formation of polynucleotides strand with its shorthand representation**.**	[3L]
1.4	RNAs (various types in prokaryotes and eukaryotes) m- RNA and r- RNA – general account , t- RNA-clover leaf model, Ribozymes**.**	[2L]
1.5	DNA: Physical properties – Effect of heat on physical properties of DNA (Viscosity, buoyant density and UV absorption), Hypochromism, Hyperchromism and Denaturation of DNA. Reactions of nucleic acids (with DPA and Orcinol).	[2L]
1.6	Chemical synthesis of oligonucleotides: Phosphodiester, Phosphotriester,	[3L]

Phosphoramidite and H- phosphonate methods including solid phase approach.

Unit 2:	**Biomolecules-II**	**[15L]**
2.1	Chemistry of enzymes: Introduction, nomenclature, classes and general types of reactions catalyzed by enzymes. Properties of enzymes: a) enzyme efficiency/ catalytic power b) enzyme specificity; Fischer's 'lock and key' and Koshland 'induced fit' hypothesis. Concept and identification of active site.	[6L]
2.2	Factors affecting enzyme kinetics: Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and irreversible inhibition.	[4L]
2.3	Mechanism of enzyme action: transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Mechanism of chymotrypsin catalyzed hydrolysis of a peptide bond.	[5L]
Unit 3:	**Biomolecules - III**	**[15L]**
3.1	Chemistry of coenzymes. Structure, mechanism of action and bio-modeling studies of the following coenzymes: nicotinamide adenine dinucleotide, flavin adenine dinucleotide, thiamine pyrophosphate, pyridoxal phosphate, Vitamin B12, biotin, lipoic acid, Coenzyme A.	[12L]
3.2	Oxidative phosphorylation, chemiosmosis, rotary model for ATP synthesis and role of cytochrome in oxygen activation.	[3L]
Unit 4:	**Biomolecules – IV**	**[15L]**
4.1	Role of main enzymes involved in the synthesis and breakdown of glycogen.	[2L]
4.2	Enzyme catalyzed organic reactions: Hydrolysis, hydroxylation, oxidation and reduction.	[6L]
4.3	Enzymes in organic synthesis. Fermentation: Production of drugs/drug intermediates by fermentation. Production of chiral hydroxy acids, vitamins, amino acids, β-lactam antibiotics. Synthesis of chemicals via microbial transformation, synthesis of L-ephedrine. Chemical processes with isolated enzymes in free form (hydrocyanation of m-phenoxybenzaldehyde) and immobilized form (production of 6-aminopenicillanic acid).	[7L]

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1. Nelson, D. L, and Cox, M. M, (2008) Lehninger principles of Biochemistry 5th Edition, W. H. Freeman and Company, NY., USA.
2. Stryer, Lubert; Biochemistry; W. H. Freeman publishers.
3. Voet, D. and J. G. Voet (2004) Biochemistry, 3rd Edition, John Wiley & sons, Inc. USA.

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47. Organic synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal.

Semester III: Practicals

Course code: PSCHO3P1

Separation of a ternary mixture of organic compounds and identification including derivative preparations using micro-scale technique

1. Separation of a ternary mixture (S-S-S, S-S-L, S-L-L and L-L-L) (for solid mixture: water insoluble/ soluble including carbohydrates) based upon differences in the physical and the chemical properties of the components.
2. Identification of the two components (indicated by the examiner) using micro-scale technique.
3. Preparation of derivatives (any one of separated compound).

(**Minimum 8 experiments**)

Course code: PSCHO3P2

Single step organic preparation(1.0 g scale) involving purification by Steam distillation / Vacuum distillation or Column chromatography.

1. Preparation of acetanilide from aniline and acetic acid using Zn dust. (Purification by column chromatography)
2. Preparation of 1-nitronaphthalene from naphthalene. (Purification by steam distillation)
3. .Preparation of acetyl ferrocene from ferrocene. (Purification by column chromatography)

4. .Preparation of 3-nitroaniline from 1,3-dinitrobenzene. (Purification by column chromatography)
5. Preparation of benzyl alcohol from benzaldehyde. (Purification by vacuum distillation).
6. Preparation of methyl salicylate from salicylic acid. (Purification by vacuum distillation).
7. .Preparation of 4-methylacetophenone from toluene. (Purification by vacuum distillation).
8. .Preparation of phenyl acetate from phenol. (Purification by vacuum distillation)
9. Preparation of 2-chlorotoluene from *o*-toluidine. (Purification by steam distillation)
10. Preparation of 4-nitrophenol from phenol. (Purification by steam distillation/ column chromatography)
11. Preparation of fluorenone from fluorene. (Purification by column chromatography)
12. Preparation of dimethylphthalate from phthalic anhydride. (Purification by vacuum distillation)

(Minimum 8 experiments)

Note:

1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Students are expected to purify the product by Steam distillation / Vacuum distillation or Column chromatography, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

References for Practicals

1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
7. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
8. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold.
10. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008,

B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
11. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
12. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4^{th} ed., 2011.

1. The candidate is expected to submit a journal and project certified by the Head of the Department /institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

Semester – IV
Course Code: PSCHO401

Paper - I (**Theoretical organic chemistry-II**)

Unit 1:	**Physical organic chemistry**	**[15L]**
1.1	Structural effects and reactivity**:** Linear free energy relationship (LFER) in determination of organic reaction mechanism, The Hammett equation, substituent constants, theories of substituent effects, interpretation of σ-values, reaction constants ρ, Yukawa-Tsuno equation**.**	**[7L]**
1.2	Uses of Hammett equation, deviations from Hammett equation. Dual parameter correlations, Inductive substituent constants. The Taft model, σ_I and σ_R scales, steric parameters Es and β. Solvent effects, Okamoto-Brown equation, Swain-Scott equation, Edward and Ritchie correlations, Grunwald-Winstein equation, Dimroth's E_T parameter, Solvatochromism Z-scale, Spectroscopic Correlations, Thermodynamic Implications.	**[8L]**
Unit 2	**Supramolecular chemistry**	**[15L]**
2.1	Principles of molecular associations and organizations as exemplified in biological macromolecules like nucleic acids, proteins and enzymes.	**[3L]**
2.2	Synthetic molecular receptors: receptors with molecular cleft, molecular tweezers, receptors with multiple hydrogen sites.	**[3L]**
2.3	Structures and properties of crown ethers, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins. Synthesis of crown ethers, cryptands and calixarenes.	**[5L]**
2.4	Molecular recognition and catalysis, molecular self-assembly.Supramolecular Polymers, Gelsand Fibres.	**[4L]**
Unit 3	**Stereochemistry- II**	**[15L]**

3.1	Racemisation and resolution of racemates including conglomerates: Mechanism of racemisation, methods of resolution: mechanical, chemical, kinetic and equilibrium asymmetric transformation and through inclusion compounds.	**[3L]**
3.2	Determination of enantiomer and diastereomer composition: enzymatic method, chromatographic methods. Methods based on NMR spectroscopy: use of chiral derivatising agents (CDA), chiral solvating agents (CSA) and Lanthanide shift reagents (LSR).	**[3L]**
3.3	Correlative method for configurational assignment: chemical, optical rotation, and NMR spectroscopy.	**[4L]**
3.4	Molecular dissymmetry and chiroptical properties: Linearly and circularly polarized light. Circular birefringence and circular dichroism. ORD and CD curves. Cotton effect and its applications. The octant rule and the axial α–haloketone rule with applications.	**[5L]**
Unit 4:	**Asymmetric synthesis**	**[15L]**
4.1	Principles of asymmetric synthesis: Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions.	**[3L]**
4.2	Synthesis of L-DOPA [Knowles's Mosanto process]. Asymmetric reactions with mechanism: Aldol and related reactions, Cram's rule, Felkin-Anh model, Sharpless enantioselective epoxidation, hydroxylation, aminohydroxylation, Diels-Alder reaction, reduction of prochiral carbonyl compounds and olefins.	**[9L]**
4.3	Use of chiral auxiliaries in diastereoselective reductions, asymmetric amplification. Use of chiral BINOLs, BINAPs and chiral oxazolines asymmetric transformations.	**[3L]**

<u>REFERENCES:</u>

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2 A guide to mechanism in Organic Chemistry, 6th edition, 2009, Peter Sykes, Pearson education, New Delhi.

3 Advanced Organic Chemistry: Reaction Mechanisms, R. Bruckner, Academic Press (2002).

4 Mechanism and theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.

5 Organic Reaction Mechanism, 4th edition, V. K. Ahluvalia, R. K. Parashar, Narosa Publication.

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11 Organic Chemistry, Seventh Edition, R.T. Morrison, R. N. Boyd & S. K. Bhattacharjee, Pearson.Advanced Organic Chemistry: Reactions & Mechanisms, second edition, B. Miller and R. Prasad, Pearson.

12 Organic reactions & their mechanisms, third revised edition, P.S. Kalsi, New Age International Publishers.

13 Organic Chemistry: Structure and Function, P. Volhardt and N. Schore, 5th Edition, 2012

14 Organic Chemistry, W. G. Solomons, C. B. Fryhle, , 9th Edition, Wiley India Pvt. Ltd.,2009.

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19 Organic chemistry, ^{8th} edition, John McMurry

20 Modern methods of Organic Synthesis, 4th Edition W. Carruthers and Iain Coldham, Cambridge University Press 2004

21 Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books,2006

22 Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman

23 Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd.

24 Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India edit

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26 Organic Stereochemistry, M. J. T. Robinson, Oxford University Press, New Delhi, India edition, 2005

27 Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers

28 Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH.

29 Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992.

30 Large ring compounds, J.A.Semlyen, Wiley-VCH, 1997.

31 Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wiley-Eastern

32 Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Sciertific Publication.

33 Molecular Photochemistry, N. J. Turro, W. A. Benjamin.

34 Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill

35 Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson.

36 Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press.

37 Molecular Orbitals and Organic Chemical Reactions by Ian Fleming (Wiley – A john Wiley and Sons, Ltd., Publication)

Course Code: PSCHO402
Paper - II (Synthetic organic chemistry-II)

Unit 1: **Designing Organic Synthesis-I** **[15L]**

1.1 **Protecting groups in Organic Synthesis:** Protection and deprotection of the hydroxyl, carbonyl, amino and carboxyl functional groups and its applications. [3L]

1.2 **Concept of umpolung (Reversal of polarity):** Generation of acyl anion equivalent using 1,3-dithianes, methyl thiomethyl sulfoxides, cyanide ions, cyanohydrin ethers, nitro compounds and vinylated ethers. [3L]

1.3 **Introduction to Retrosynthetic analysis and synthetic planning:** Linear and convergent synthesis; Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group interconversions (FGI), functional group addition (FGA), functional group removal (FGR) importance of order of events in organic synthesis, one and two group C-X disconnections (1,1; 1,2; 1,3 difunctionalized compounds), selective organic transformations: chemoselectivity, regioselectivity, stereoselectivity, enantioselectivity. [9L]

Unit 2: **Designing Organic Synthesis-II** **[15L]**

2.1 **General strategy:** choosing a disconnection-simplification, symmetry, high yielding steps, and recognisable starting material. [3L]

2.2 **One group C-C Disconnections:** Alcohols (including stereoslectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. [6L]

2.3 **Two group C-C Disconnections:** 1,2- 1,3- 1,4- 1,5- and 1,6-difunctionalized compounds, Diels-Alder reactions, α, β-unsaturated compounds, control in carbonyl condensations, Michael addition and Robinson annelation. [6L]

Unit 3: **Electro-organic chemistry and Selected methods of Organic synthesis** **[15L]**

3.1 **Electro-organic chemistry:** [7L]

3.1.1 Introduction: Electrode potential, cell parameters, electrolyte, working electrode, choice of solvents, supporting electrolytes.

3.1.2 Cathodic reduction: Reduction of alkyl halides, aldehydes, ketones, nitro compounds, olefins, arenes, electro-dimerization.

3.1.3 Anodic oxidation: Oxidation of alkylbezene, Kolbe reaction, Non-Kolbe oxidation, Shono oxidation.

3.2 **Selected Methods of Organic synthesis** [8L]

Applications of the following in organic synthesis:

3.2.1 Crown ethers, cryptands, micelles, cyclodextrins, catenanes.

3.2.2 Organocatalysts: Proline, Imidazolidinone.

3.2.3 Pd catalysed cycloaddition reactions: Stille reaction, Saeguse-Ito oxidation to enones, Negishi coupling.

3.2.4 Use of Sc(OTf), and Yb(OTf) as water tolerant Lewis acid catalyst in aldol condensation, Michael reaction, Diels-Alder reaction, Friedel – Crafts reaction.

Unit 4:	**Transition and rare earth metals in organic synthesis**	**[15L]**
4.1	**Introduction to basic concepts:** 18 electron rule, bonding in transition metal complexes, C-H activation, oxidative addition, reductive elimination, migratory insertion.	[3L]
4.2	**Palladium in organic synthesis:** π-bonding of Pd with olefins, applications in C-C bond formation, carbonylation, alkene isomerisation, cross-coupling of organometallics and halides. Representative examples: Heck reaction, Suzuki-Miayura coupling, Sonogashira reaction and Wacker oxidation. Heteroatom coupling for bond formation between aryl/vinyl groups and N, S, or P atoms.	[5L]
4.3	**Olefin metathesis** using Grubb's catalyst.	[1L]
4.4	**Application of Ni, Co, Fe, Rh, and Cr carbonyls** in organic synthesis.	[4L]
4.5	**Application of samarium iodide** including reduction of organic halides, aldehydes and ketones, α-functionalised carbonyl and nitro compounds.	[1L]
4.6	**Application of Ce(IV)** in synthesis of heterocyclic quinoxaline derivatives and its role as a de-protecting agent**.**	[1L]

<u>REFERENCES:</u>

- **Advanced Organic Chemistry,** Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
- **Modern Methods of Organic Synthesis,** 4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004.
- **Chem.Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis,** S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam.
- **Organic Chemistry,** Clayden Greeves Warren and Wothers, Oxford Press (2001).
- **Moder Organic Synthesis: An Introduction,** G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, (2007).
- **Advanced Organic Chemistry: Reaction Mechanism,** R. Bruckner, Academic Press (2002).
- **Principles of Organic Synthesis,** R.O.C. Norman & J. M. Coxon, 3rd Edn., Nelson Thornes
- **Organic Chemistry,** 7th Edn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
- **Strategic Applications of Name Reactions in Organic Synthesis**, L. Kurti & B. Czako (2005), Elsevier Academic Press

- **Advanced Organic Chemistry: Reactions & Mechanisms,** 2^{nd} Edn., B. Miller & R. Prasad, Pearson
- **Organic reactions and their mechanisms,** 3^{rd} revisededition, P.S. Kalsi, New Age International Publishers
- **Organic Synthesis: The Disconnection Approach,** Stuart Warren, John Wiley & Sons, 2004
- **Name Reactions and Reagents in Organic Synthesis,** 2^{nd} Edn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
- **Name Reactions,** Jie Jack Lie, 3^{rd} Edn., Springer
- **Organic Electrochemistry,** H. Lund, and M. Baizer, 3^{rd} Edn., Marcel Dekker.

Course Code: PSCHO403
Paper - III (Natural products and heterocyclic chemistry)

Unit 1:	**Natural products-III**	**[15L]**
1.1	**Steroids:** General structure, classification. Occurrence, biological role, important structural and stereochemical features of the following: corticosteroids, steroidal hormones, steroidal alkaloids, sterols and bile acids.	[5L]
1.2	Synthesis of 16-DPA from cholesterol and plant sapogenin.	[2L]
1.3	Synthesis of the following from 16-DPA: androsterone, testosterone, oestrone, oestriol, oestradiol and progesterone.	[5L]
1.4	Synthesis of cinerolone, jasmolone, allethrolone, exaltone and muscone.	[3L]
Unit 2:	**Natural products-IV**	**[15L]**
2.1	**Vitamins:** Classification, sources and biological importance of vitamin B_1, B_2, B_6, folic acid, B_{12}, C, D_1, E (α-tocopherol), K_1, K_2, H (β- biotin). Synthesis of the following: Vitamin A from β-ionone and bromoester moiety. Vitamin B_1 including synthesis of pyrimidine and thiazole moieties Vitamin B_2 from 3, 4-dimethylaniline and D(-)ribose Vitamin B_6 from: 1) ethoxyacetylacetone and cyanoacetamide, 2) ethyl ester of N-formyl-DL-alanine (Harris synthesis) Vitamin E (α-tocopherol) from trimethylquinol and phytyl bromide Vitamin K_1 from 2-methyl-1, 4-naphthaquinone and phytol.	[5L]
2.2	**Antibiotics:** Classification on the basis of activity. Structure elucidation, spectral data of penicillin-G, cephalosporin-C and chloramphenicol. Synthesis of chloramphenicol (from benzaldehyde and β-nitroethanol) penicillin-G and phenoxymethylpenicillin from D-penicillamine and t-butyl phthalimide malonaldehyde (synthesis of D-penicillamine and t-butyl phthalimide malonaldehyde expected).	[6L]
2.3	**Naturally occurring insecticides:** Sources, structure and biological properties of pyrethrums (pyrethrin I), rotenoids (rotenone). Synthesis of pyrethrin I.	[2L]
2.4	**3.4 Terpenoids**: Occurrence, classification, structure elucidation,	[2L]

stereochemistry, spectral data and synthesis of zingiberene .

Unit 3: **Heterocyclic compounds-I** **[15L]**

Heterocyclic compounds: Introduction, classification, Nomenclature of heterocyclic compounds of monocyclic (3-6 membered) (Common, systematic (Hantzsch-Widman) and replacement nomenclature)
Structure, reactivity, synthesis and reactions of pyrazole, imidazole, oxazole, isoxazole, thiazole, isothiazole, pyridazines, pyrimidine, pyrazines and oxazines.

Unit 4: **Heterocyclic compounds-II** **[15L]**

Nomenclature of heterocyclic compounds of bicyclic/tricyclic (5-6 Membered) fused heterocycles (up to three hetero atoms)**.** (Common, systematic (Hantzsch-Widman) and replacement nomenclature)
Nucleophilic ring opening reactions of oxiranes, aziridines, oxetanes and azetidines.
Structure, reactivity, synthesis and reactions of coumarins, quinoxalines, cinnolines, indole, benzimidazoles, benzoxazoles, benzothiazoles, Purines and acridines.

REFERENCES:

1. Natural product chemistry, A mechanistic, biosynthetic and ecological approach, Kurt B.G. Torssell, Apotekarsocieteten – Swedish Pharmaceutical Press.
2. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011.
3. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011.
4. Chemistry of natural products, F. F. Bentley and F. R. Dollish, 1974
5. Natural Product Chemistry Vol.1 and 2, K. Nakanishi J. Goto. S.Ito Majori and S. Nozoo, Academic Press, 1974.
6. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co. 2008.
7. Heterocyclic chemistry, 3rd edition, Thomas L. Gilchrist, Pearson Education, 2007.
8. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley
Eastern Ltd., 1990.
9. Heterocyclic Chemistry, J. A. Joule and G. F. Smith, ELBS, 2nd edition, 1982.
10. The Conformational Analysis of Heterocyclic Compounds, F.G. Riddell, Academic Press,1980.
11. Principles of Modern Heterocyclic Chemistry, L.A. Paquette, W.B. Benjamin, Inc., 1978.
12. An Introduction to the Chemistry of Heterocyclic Compounds, 2nd edition, B.M. Acheson, 1975.

13. Natural Products: Chemistry and Biological Significance Interscience, J. Mann, R.S.Davidson, J.B.Hobbs, D.V. Banthrope and J. B. Harborne, Longman,Essex, 1994.
14. Organic Chemistry, Vol 2, I.L. Finar, ELBS, 6th edition, Pearson.
15. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
16. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
17. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
18. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers, 1998.
19. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers, 1998.
20. Insecticides of Natural Origin, Sukh Dev, Harwood Academic Publishers.
21. Total. Synthesis of Longifolene, J. Am. Chem. Soc., E. J. Corey, M. Ohno, R. B. Mitra, and P. A. Vatakencherry. 1964, 86, 478.
22. Total. Synthesis of Longifolene, J. Am. Chem. Soc. 1961, 83, 1251.
23. The structure and total synthesis of 5-Vetivone, J. A. Marshall and P. C. Johnson, J. Org. Chem., 35, 192 (1970).
24. Total synthesis of spirovetivanes, J. Am. Chem. Soc. 1967, 89, 2750.
25. The Total Synthesis of Reserpine, Woodward, R. B.; Bader, F. E.; Bickel, H., Frey, A. J.; Kierstead, R. W. Tetrahedron 1958, 2, 1-57.
26. Total synthesis of Griseofulvin, Stork, G.; Tomasz, M. J. Am. Chem. Soc. 1962, 84, 310.
27. Synthesis of (±)-4-demethoxydaunomycinone,A. V. Rama Rao , G. Venkatswamy , S. M. Javeed M. , V. H. Deshpande, B. Ramamohan Rao, J. Org. Chem., 1983, 48 (9), 1552.
28. The Alkaloids, The fundamental Chemistry A biogenetic approach, Marcel Dekker Inc. New York, 1979.
29. Comprehensive Organic Chemistry by Barton and Olis, Pergamon Press, Oxford, 1979.
30. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley and Sons, 2002.
31. Biosynthesis of Natural Products, Mannitto Paolo, Ellis Horwoocl Limited, 1981.
32. Selected Organic synthesis, Ian Fleming, John Wiley and Sons, 1973.
33. Total synthesis of Natural Products, J. Apsimon, John Wiley and Sons.
34. The Logic of Chemical Synthesis, E. J. Corey and Xue-Min Cheng,

Wiley Interscience.
35. Classics in Total Synthesis , K. C. Nicolaou and E. J. Sorensen, Weinhem: VCH, 1996.
36. Spectroscopy of Organic compounds, P.S. Kalsi, New Age International Pub. Ltd. And Wiley Eastern Ltd., Second edition, 1995.
37. Applications of Absorption Spectroscopy of Organic compounds, J. R. Dyer, Prentice Hall of India, 1987.
38. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991
39. Absorption spectroscopy of organic Molecules, V.M. Parikh, 1974.
40. Spectroscopic methods in organic chemistry, Williams and Fleming, Tata McGraw Hill, 4th ed, 1989.
41. Organic spectroscopy, William Kemp, ELBS, 3rd ed., 1987.
42. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., .2011
43. Introduction to spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, 4th ed., 2009.
44. Organic spectroscopic structure determination: a problem-based learning approach Douglass F. Taber, Oxford University Press, 17-Sep-2007.
45. Organic Spectroscopy: Principles And Applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004
46. Alkaloids,V.K. Ahuluwalia,Ane Books Pvt.Ltd.
47. Biotransformations in Organic Chemistry, 5thEdition, Kurt Faber, Springer
48. Structure Determination of Organic Compounds, EPretsch, P. Buhlmann, C.Affolter, Springer

Course Code: PSCHOOC-I 404

Paper – IV (INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS)

Unit 1: **[15L]**

Introduction to Intellectual Property: [2L]

Historical Perspective, Different types of IP, Importance of protecting IP.

Patents: [5L]

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

Industrial Designs: [2L]

Definition, How to obtain, features, International design registration.

Copyrights: [2L]

Introduction, How to obtain, Differences from Patents.

Trade Marks: [2L]

Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc.

Geographical Indications: [2L]

Definition, rules for registration, prevention of illegal exploitation, importance to India.

<u>Unit 2:</u> [15L]

Trade Secrets: [2L]

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

IP Infringement issue and enforcement: [2L]

Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.

Economic Value of Intellectual Property: [2L]

Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.

Different International agreements:

(a) World Trade Organization (WTO): [5L]

(i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade Related Services (GATS) Madrid Protocol.

(iii) Berne Convention

(iv) Budapest Treaty

(b) Paris Convention [6L]

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.

Unit III: [15L]

Introduction to Cheminformatics: [5L]

History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.

Representation of molecules and chemical reactions: [5L]

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching Chemical Structures: [5L]

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit IV: [15L]

Applications:

Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design, Application of Cheminformatics in Drug Design.

REFERENCES:

1. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.

Course Code: PSCHOOC-II 404

PAPER – IV: RESEARCH METHODOLOGY

Unit 1: [15L]

Print: [5L]

Primary, Secondary and Tertiary sources.

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: [5L]

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources: [5L]

The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.

Unit II: DATA ANALYSIS [15L]

The Investigative Approach:

Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.

Analysis and Presentation of Data:

Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.

Unit III: METHODS OF SCIENTIFIC RESEARCH AND WRITING [15L]

SCIENTIFIC PAPERS

Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.

Writing Scientific Papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.

Unit IV: CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS [15L]

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressur, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* Oxford University Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) *How to use Excel in Analytical Chemistryand in general scientific data analysis* Cambridge Universty Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

Semester IV: Practicals
Course code: PSCHO4P1

Two steps preparations

1. Acetophenone → Acetophenone phenyl hydrazine → 2-phenyl

indole.

2. 2-naphthol → 1-phenyl azo-2-naphthol → 1-amino-2-naphthol.
3. Cyclohexanone → cyclohexanone oxime → Caprolactum.
4. Hydroquinone → hydroquinone diacetate → 2,5-dihydroxyacetophenone.
5. 4-nitrotoluene → 4-nitrobenzoic acid → 4-aminobenzoic acid.
6. *o*-nitroaniline → *o*-phenylene diamine → Benzimidazole.
7. Benzophenone → benzophenone oxime → benzanilide.
8. *o*-chlorobenzoic acid → N-phenyl anthranilic acid → acridone.
9. Benzoin → benzil → benzilic acid.
10. Phthalic acid → phthalimide → anthranilic acid.
11. Resorcinol → 4-methyl-7-hydroxy coumarin → 4-methyl-7-acetoxy coumarin.
12. Anthracene → anthraquinone → anthrone.

(Minimum 8 experiments)

Note:

1. Students are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Students are expected to purify the product by recryllization, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

Course code: PSCHO4P2

Session-I: Combined spectral identification: Interpretation of spectral data of organic compounds (UV, IR, PMR, CMR and Mass spectra).

A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc (**Minimum 8 spectral analysis).**

Session-II: Project evaluation

References for Practicals

1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V.
K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd
3. Systematic Laboratory Experiments in Organic Synthesis- A. Sethi, New Age International Publications
4. Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fuson and D.Y. Curtin Wiley, New York.
5. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendham, ELBS
6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall

7. Macro-scale and Micro-scale Organic Experiments, K. L. Williamson, D. C. Heath.
8. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold.
10. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
11. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
12. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

1. The candidate is expected to submit a journal and project certified by the Head of the Department /institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

UNIVERSITY OF MUMBAI

No. UG/86 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular Nos. UG/226 of 2006, dated 29th June, 2006 relating to syllabus of the Master of Science (M.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Chemistry at its meeting held on 28th May, 2018 have been accepted by the Academic Council at its meeting held on 14th June, 2018 **vide** item No. 4.72 and that in accordance therewith, the revised syllabus as per the (CBCS) for the M.Sc. in Physical Chemistry (Sem – III & IV), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
19th July, 2018

(Dr. Dinesh Kamble)
I/c REGISTRAR

To

The Principals of the affiliated Colleges, the Head University Departments & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C./4.72/14/06/2018

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No. UG/ 86 -A of 2018 MUMBAI-400 032 July, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

AC – 14/06/2018
Item No. 4.72

UNIVERSITY OF MUMBAI

Program : M.Sc.

(Choice Based Credit System)

Course : M.Sc. Physical Chemistry

Syllabus for Semester III & IV

(To be implemented from the Academic year 2018-2019)

M.Sc. PHYSICAL CHEMISTRY

SEMESTER III

PSCHP301

Paper I

Chemistry: Polymer, Surface & Photo

UNIT- I: Polymer Chemistry-I (15L)

1.1 Introduction: Polymer Science, fundamental terms, historical outline, classification based on: the origin (natural, semi-synthetic, synthetic etc.),the structure (linear, branched, network, hyper branched, dendrimer, ladder, cross linked, IPN),the type of atom in the main chain(homochain,heterochain),the formation(condensation,addition), homo polymers,co polymers(random,alternate,block,graft),the behavior onapplication of heat (thermoplastic and thermosetting),the form and application (plastics, fibre, elastomersandresins). **(05L)**

1.2 Molar Mass: Molecular weight averages, fractionation, molecular weight determination by GPC/SEC,end group analysis, viscometry, vapour phase osmometry, gradientelution, and molecular weight distribution curve**.** **(05L)**

1.3 Types of polymerization: condensation, addition (cationic and anionic)and copolymerization(withkinetics),chain transfer reactions. **(05L)**

Reference Books:

1. ***P. Bahadur and N. V. Sastry, Principles of Polymer Science, second edition,NarosaPublishingHouse,2005.***
2. ***C. E. Carraher, Jr., Carraher's Polymer Chemistry, 8th edition, CRC Press, New York,2010.***
3. ***JoelR.Fried,PolymerScienceandTechnology,Prentice-HallofIndiaPvt.Ltd., 2000.***
4. ***V.R.Gowarikar,H.V.ViswanathanandJ.Sreedhar,PolymerScience.NewAge InternationalPvt.Ltd.,NewDelhi,1990.***
5. ***F. W. Billmeyer Jr., Text Book of Polymer Science, 3rd edition, John Wiley and Sons,1984.***
6. ***V.K.Ahluwalia&A. Mishra, Polymer Science, A text book,Ane-Books Pvt. Ltd,2008.***
7. ***R.Sinha, Outline of Polymer Technology manufacture of Polymers, Prenticehall ofIndiaPvt.Ltd.2000***
8. ***F.J.Davis,PolymerChemistry,Oxford UniversityPress,2000.***
9. ***D.Walton&P.lotimer,Polymer,Oxford UniversityPress,2000.***
10. ***R.Ypung,IntroductiontoPolymers,Chapman&Hall,reprint,989.***
11. ***V.Jain.OrganicPolymerChemistry,IVYPublishingHouse,2003.***
12. ***A.Singh,PolymerChemistry,CampusBookInternational,2003.***

Books for further reading:

1. ***J. M. G. Cowie, Polymers: Chemistry and Physics of Modern Materials, 2nd ed. (firstIndianReprint2004),ReplikaPressPvt.Ltd.***
2. ***G.S.Misra,IntroductoryPolymerChemistry,NewAgeInternational(P)Limited, Publishers,1993.***
3. ***L. H. Sperling, Introduction to Physical Polymer Science. 2nd Edition, John WileyandSons.Inc.***
4. ***Hans-GeorgElias,AnIntroductiontopolymerScience,VCH1997.***
5. ***Charles E. Seymour, Jr., Seymour/Carraher's Polymer Chemistry, 6th ed., Marcel Dekker, Inc.,2003.***
6. ***A. Ravve, Principles of Polymer Science, 2nd ed., Kluwer Academic/Plenum Publishers,NewYork,2000.***
7. ***VidyagauriLele, Chemical modification of starch by green process, Techno World Press, 2015.***
8. ***VidyagauriLele, Graft copolymers of starch-Synthesis & Characterization, Neeraj Publishing House, 2015.***

UNIT-II Modern Applications of Surface Chemistry (15L)

2.1 Surface active agents and micelle: (08L)

2.1.1 Surface active agents andt their classification,hydrophile-lipophile balance**(02L)**

2.1.2 Micellization: shape and structure of micelles , hydrophobic interaction, critical

Micelles concentration (cmc), factors affecting cmc of surfactants, counter ion binding to micelles,micelle catalysis,reverse micelles. **(04L)**

2.1.3 Emulsions: Solubilization,micro emulsions, characterization of microemulsions, (02L)

Reference Books:

1. M. J. Rosen. Surfactants and Interfacial Phenomena (3rd edn.), John Wiley (2004).

2. Y. Moroi, Micelles: Theoretical and Applied Aspects, (1992) Plenum Press,New York

3.ArunK.Chattopadhyay,KashmiriLalMittal,SurfactantsinSolution,Volume64of Surfactant Science Series,Volume 64 of Lecture Notes in Pure and Applied Mathematics,illustrated,MarcelDekker,1996

4.K.L.Mittal,AmericanChemicalSociety,Micellization,solubilization,and microemulsions,Volume1 Micellization,Solubilization,andMicroemulsions,AmericanChemicalSociety, illustrated,PlenumPress,1977

5.DeepakThassu,MichelDeleers,YashwantPathak,NanoparticleDrugDelivery Systems Volume166ofDrugsandthePharmaceuticalSciencesSeriesillustrated,CRC Press,2007

Reference Books

1. K.R.Lange.Surfactants,HanserPub.(1999).
2. R.Zana(ed.).DynamicsofSurfactantSelf-Assemblies,CRCPress(2005).
3. M.Abe&J.F.Scamehorn.MixedSurfactantSystems,CRCPress(2004).

2.2 Hydrogen storage by Adsorption: (07L)

2.2.1 Hydrogen storage: fundamentals physisorption , temperature and pressure influence,chemisorption,adsorptionenergy,'Electrochemical'adsorption. (03L)
2.2.2. Practical adsorption: storage of hydrogen with carbon materials, activated carbon,graphite graphene,carbon nano structures,fullerene.Carbon nano fibres(CNF) and graphite nano fibers electrochemical storage of hydrogen in carbon materials.(04)
Reference books:

1.Tushar K. Ghosh, Energy Resources and Systems: Volume 2: Renewable Resources,Volume2 of Energy Resources and Systems,Energy Resources and Systems,Springer Link:Bücher,Springer,2011

2.R. Str¨obel a, J. Garche b, P.T. Moseley c, L. J¨orissen b, G. Wolfd. "Review Hydrogen storage by carbon materials." Journal of Power Sources (WWW.Sciencedirect.com) 159 (June 2006): 781–801.

3. Agata Godula-Jopek,Walter Jehle,Joerg Wellnitz,Hydrogen Storage Technologies:New Materials,Transport,and Infrastructure,JohnWiley&Sons, 2012

4. [Yury Gogotsi](), CarbonNanomaterials, illustrated Volume1of Advanced Materials Series, Advanced Materials and Technologies Series, CRCPress, 2006

5. Robert A. Varin, TomaszCzujko, Zbigniew S. Wronski, Nano materials for Solid State Hydrogen Storage FuelCellsandHydrogenEnergy illustratedSpringer, 2009

UNIT-III Photo Chemistry-I **(15L)**

3.1 Photo chemical principles: Environmental effect on absorption and emission spectra, properties ofexcited states, excited stateacidity constants, dipole momentsand redox properties, Importance of photochemistry, origin of life, **(04L)**

3.2 Photo physical processes in electronically excited molecules: types of photo physical pathways, types of radiation less transitions, fluorescence emission, fluorescence and structure. Triplet state and phosphorescence emission, delayed fluorescence–etypeandp-typedelayedfluorescence. **(06L)**

3.3 Photo chemical reactions: ketones,olefins conjugated olefins andaromatic compounds, photosynthesis. **(05L)**

Reference Books for Photochemistry

1 C.H.DePuy,O.L.Chapman,Molecular reactions and photo chemistry,Prenticehall of India PVT.LTD.1988.

2 K.K.Rohatgi-Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher,1978.

UNIT-IV Applications of Fluorescence Phenomena **(15L)**

4.1 Fluorescence sensing: Mechanism of sensing; sensing techniques based on Coalitional quenching, energy transfer, electron transfer; examples of pH sensors glucose sensorsand protein sensors. **(05L)**

4.2 Novel fluorophores: Quantum dots, lanthanides and long-lifetime Metal- ligand complexes. **(05L)**

4.3 Radiative decay engineering: metal enhanced fluorescence**(03L)**

4.4 DNA technology–sequencing. **(02L)**

Reference Books:

1. B. Valeur, Molecular Fluorescence: Principles and Applications, Wiley-VCH (2001).

2. J.R.Lakowicz, Principles of Fluorescence Spectroscopy,Springer(2006).

Reference Book

1. D.L.Andrews &A. A. Demidov, Resonance Energy Transfer, John Wiley & Sons (1999).

Semester – III

PSCHP302

Paper II

Nano chemistry, statistical mechanics &Nuclear chemistry

UNIT-I:Nano chemistry of ,gold,cadmium,selenide. (15L)

1.1 Variation of optical and magnetic properties of non material lwith size,shape,surface characteristics and impurities **(04L)**

1.2 Relationship between size and shape of nano materials **(03L)**

1.3 Nano architecture: self assembly and template methods **(03L)**

1.4 Diagnosis and treatment of diseases using nano particles **(03L)**

1.5 Safety and ethics of use of nano particles **(02L)**

UNIT-II Nano chemistry of silica and poly dimethyl siloxane: (15L)

2.1 Variation of optical and magnetic properties of nano materials with size, shape, surface characteristics and impurities **(04L)**

2.2 Relationship between size and shape of nano materials. **(03L)**

2.3 Nano architecture:self assembly and template methods. **(04L)**

2.4 Diagnosis and treatment of diseases using nano particles **(04L)**

Reference Books:

1. Ludovico Cademartiri and GeoffreyA.Ozin,Concepts of Nano chemistry,Wiley–VCHVerlagGmbH&co,2009

2.C.Bréchignac,P.Houdy,MarcelLahmani, Nano materials and Nano chemistry, Springer,2007

3.C.N.R.Rao,Achim Müller,Anthony K. Cheetham, Nano materials Chemistry ,John Wiley & Sons, 2007

4.Geoffrey A. Ozin,André C. Arsenault,Ludovico Cademartiri, Nano chemistry: A Chemical Approach to Nano materials, Royal Society of Chemistry (GreatBritain)2, illustrated, Royal Society of Chemistry,2009

Unit- III Statistical Mechanics (15L)

3.1Thermodynamic probability: Combinatral problems, Strilling apporoximation**,** Lagranges method, macro and microstates,ensembles,Boltzmann distribution law.(03)

3.2 Partition functions:Translational,rotational,vibrational,electronic and nuclear partition functions, Expressions for the thermodynamic functions interms of partition function -Internal energy, heat capacity, the Helmholtz and Gibbs functions, Enthalpy, entropy and equilibrium constants. Sackur –Tetrode equation for the entropy of a mono atomic gas. Molecular partition function. **(07L)**

3.3 Maxwell-Boltzmann,Bose-Einstein and Fermi-Dirac statistics. (03L)

3.4 Debye and Einstein theory of specific heats of solids. (02L)

Reference Books:

1. AtkinsP.W,PhysicalChemistry,Oxford UniversityPress,6thedition,1998

2. JohnM.Seddon&JulianD.Gale,Thermodynamics and statistical mechanics, Tutorial Chemistry Textsseries,Vol.10,Royalsociety of Chemistry,2001.

3. Silbey RJ & Alberty RA,Physical Chemistry,3rd edition,John Wiley and sons, Inc.2002.

4. Laidler K.J. and Meiser J.H., Physical Chemistry, 2nd edition, CBS publishers & distributors,1999.

5. B.K.Agarwal and M.Eisner,Statistical Mechanics,(1988)Wiley Eastern,New Delhi.

6. D.A.McQuarrie,Statistical mechanics, (1976)Harper and Row Publishers, New York.

UNIT—IV Nuclear Chemistry (15L)

4.1 Charged particle accelerator- linear accelerator, cyclotron, Betatron, Synchro-cyclotron, synchrotron **(04L)**

4.2 Nuclear forces- characteristics and Meson field theory of nuclear forces **(02L)**

4.3 Nuclear Models-Liquid drop model**,** Fermi Gas Model, Shell Model, Collective Model, Optical Model. **(04L)**

4.4 Applications of Nuclear radiations- geological applications of radioactivity, age of minerals and rocks, age of earth and solar system, medical, industrial and agricultural applications of radiochemistry, positron emission tomography, Radio immune assay. **(05L)**

Reference Books:

1. ***G.Friedlander,J.W.Kennedy.Nuclear and Radio chemistry.Third.John Wiley and sons,,1981.***

2. ***H.J.Arnikar,Essentials of Nuclear Chemistry.second.Wiley Eastern Ltd., 1989.***

SEMESTER-III

PSCHP303

Paper-III

Atomic and Molecular: Structure and Spectroscopy

UNIT-I:Atomic structure **(15L)**

1.1: Introduction to approximate methods in Quantum Mechanics- (09)

1.1.1 Variation Theorem, linear and nonlinear variation functions.

1.1.2 Perturbation Theory, Non degenerate Perturbation Theory, first order wave function correction, first order and second order energy correction.

1.1.3 Application of variation and perturbation theory to ground state of Helium Atom.

1.2:**Multi –electron atoms**:Antisymmetry and Pauli principle, Slater determinants, Hartree. – Fock and configuration interaction wave functions, Slater type orbitals, Gaussian orbitals, orbitals plots, Basis sets. Density functional theory. (06)

UNIT-II Atomic spectroscopy **(15L)**

2.1 Angular momentum, orbital and spin, total angular momentum, total angular momentum (J) of many electron atoms, Russell Saunders (L-S) coupling and J-J coupling, **(04L)**

2.2 Term symbols, term symbols for multi electron atoms like He, Li, Be, B etc. **(04L)**

2.3 Exchange of interactions and multiplicity of states. **(02L)**

2.4 Anomalous Zeeman Effect and Paschen Back effect. **(02L)**

2.5 Atomic spectra and selection rules, energy level diagram of atomic sodium.**(03L)**

UNIT-III: Molecular Structure **(15L)**

3.1 The Born–Oppenheimer approximation **(01L)**

3.2 LCAO method-molecular orbital formation **(01L)**

3.3 Calculation of energy of hydrogen molecule ion using **(05L)**

3.3.1 Valence bond method

3.3.2 Heitler-London treatment

3.3.3 Improvements in Heitler-London treatment

3.4 Electronic structure of polyatomic molecules **(08L)**

3.4.1 Valence bond method for BeH_2, H_2O, NH_3, BH_3 ,CH_4.

3.4.2 Huckel molecular orbital's Theory for–ethylene, Allyl system, cyclopropenyl system and cyclobutadiene. .

Reference Books:

1. ***Laidler and Miser, Physical Chemistry,2nd edition, CBS publishers, New Delhi.(chapters11-14)***
2. ***Silbey and Alberty, Physical Chemistry,3rd edition, JohnWiley and sons, 2000.(Parttwoquantumchemistry)***
3. ***Atkins P.W, Physical Chemistry, Oxford University Press,6th edition,1998.***
4. ***William Kemp, Organic spectroscopy,3rd Edition,ELBS,1996.***
5. ***I.N. Levine, Quantum Chemistry,5th Edition (2000), Pearson Educ. Inc., New Delhi.***
6. ***.D.A.McQuarrie andJ.D.Simon, Physical Chemistry:A Molecular Approach,(1998)Viva Books,NewDelhi.***
7. ***J.N.Murrell,S.F.A.KettleandJ.M.Tedder,ValenceTheory,2nd edition (1965),JohnViley,NewYork.***
8. ***A.K.Chandra,IntroductoryQuantumChemistry,4th edition(1994),Tata McGrawHill,NewDelhi***
9. ***D.A.McQuarrie, Quantum Chemistry, Viva Books Private Limited, New Delhi, first Indian ed.,2003.***
10. ***R. K. Prasad, Quantum Chemistry,3rd Ed., New Age International Publishers,2006.***
11. ***James E. House, Fundamentals of Quantum Chemistry, Second Ed.,Academic Press,2005.***
12. ***T.A. Littlefield and N. Thorley,Atomic and Nuclear Physics– An Introduction,Van Nostrand,1979.***

UNIT-IV:Molecular spectroscopy **(15L)**

4.1Rotational spectroscopy: Einstein coefficients, classification of poly atomic Molecules spherical top, symmetric top and asymmetric top molecules, rotational spectra of polyatomic molecules Stark modulated microwave spectrometer. **(03L)**

4.2 Raman Spectroscopy-Classical theory of molecular polarizability, pure rotational, vibrational and vibration-rotation spectra of diatomic and polyatomic molecules polarization and depolarization of Raman lines correlation between IR and Raman spectroscopy instrumentation. **(05L)**

4.3 Electronic Spectra of molecules: Term symbols for linear molecules, selection rules characteristics of electronic transitions-Franck-Condon principle, types of electronic transitions-d-d, vibronic, charge transfer, π-π^*,n-π^*transitions, fate of electronically excited states, fluorescence, phosphorescence, dissociation and pree-dissociation **(07L)**

<u>ReferenceBooks</u>

1. **C.N.Banwell and E.M.McCash,Fundamentals of Molecular Spectroscopy,4th Ed.,Tata-McGraw-Hill,1994.**
2. **M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers,2001.**
3. **H.S.Randhawa, Modern Molecular Spectroscopy,McMillanIndiaLtd.,2003**
4. **G.Aruldas, Molecular Structure and Spectroscopy,Prentice-HallofIndia,2001.**

5. **J.Michael Hollas, Modern Spectroscopy, 4thEd., John Wiley and Sons,2004.**

List of Books for further reading:

1. **R.Drago, Physical Methods for Chemists,Saunders, Philadelphia,1992.**
2. **B.P.Straughan and S.Walker(Eds.),Spectroscopy–Vol1-3,Chapman and Hall,NewYork,1976.**
3. **R.K.Harris,Nuclear Magnetic Resonance Spectroscopy,Pitman,London,1983.**
4. **Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy,3rded., Thomson, Brooks/Cole,2001.**
5. **John P. Lowe, Quantum Chemistry,3rded.,AcademicPress,NewYork,2006.**
6. **R. Anantharaman, Fundamentals of Quantum Chemistry, McMillan India Limited, 2001.**
7. **Mahendra R. Awode, Quantum Chemistry,S. Chandand Co.Ltd.,New Delhi,2002.**
8. **DavidO. Hayward, Quantum Mechanics for Chemists, Royal Society for Chemistry,2002.**
9. **Jack Simons, An Introduction to Theoretical Chemistry, Cambridge University Press,2003.**
10. **Victor M.S.Gil, Orbitals in Chemistry, A Modern Guide to Students, Cambridge University Press, 2000.**
11. **A.K.Chandra, Introduction to Quantum Chemistry, 4thEd.,Tata-McGraw-Hill, 1994.**
12. **S.N.Datta Lectures on Chemical Bonding and Quantum Chemistry, Prism Books Pvt.Ltd.,1998.**
13. **R.McWeeny, Coulson's Valence,3rd.Ed.,Oxford University Press,1979.**
14. **J.N.Murell,S.F.A.Kettle and J.M.Tedder,The Chemical Bond, Wiley,1985.**
15. **F.A.Cotton,Chemical Applications of Group Theory,3rdEd., John Wiley and Sons(Asia) Pte. Ltm, 1999.**
16. **D.C.Harris and M.D.Bertolucci, Symmetry and Spectroscopy, Oxford University.**

SEMESTER-III

PSCHPEC-I 304

Advanced Instrumental Techniques

UNIT-I Electron Spectroscopy and Microscopy **(15L)**

1.1 Electron Spectroscopy: principles, instrumentation and applications of the following ESCA (XPS), AUGER, UPS. **(09L)**

1.2 Electron Microscopy: principles, instrumentation and applications of the following: Scanning Probe Microscopes, Scanning Electron Microscope(SEM), Scanning Tunneling electron Microscope(STEM) and Atomic Force Microscope(AFM) **(06L)**

UNIT-II Thermal Methods **(15L)**

2.1Thermogravimetry (TG): Principle and Instrumentation, factors affecting thermo gravimetric curves, Interpretation of thermo gravimetric curves. applications of thermo gravimetry **(04L)**

2.2 Differential thermal analysis(DTA)and Differential scanning calorimetry (DSC): Principle and instrumentation, heat flux and power compensated DSC ,Interpretation of DTA and DSC curves applications of DTA and DSC. **(05L)**

2.3 Enthalpimetric methods **(02L)**

2.4 Thermometric titrations: principle instrumentation and applications **(02L)**

2.5 Evolved gas analysis (EGA): principle and applications. **(02L)**

Reference Books:

1) Skoog DA, West DM, Fundamentals of Analytical Chemistry, Thomson Asia Pvt ltd.,8th Ed,(2004)

Skoog, Holler, Nieman, Principles of Instrumental Analysis, Thomson Asia Pvt ltd.,5th Ed(2003)

1) **Sharma B. K., Instrumental Methods of Chemical Analysis, Goel Publishing House.**
2) **Wendlandt., Thermal Methods, WW John Wiley,(1986).**
3) **Willard Merrit and Settle, Instrumental Methods of Analysis.**
4) **Douglas A.Skoog, Holler & Crouch, Instrumental analysis India edition CENGAGE Learning (EighthIndianReprint2011)**
5) **Robert D.Braun. Introduction to Instrumental Analysis(IndianReprint2006)**
6) **J.W.Dodd, K.Tonge, Thermal Methods. Analytical Chemistry, open Learning.**
7) **Pavia, Lapman, kriz, introduction to Spectroscopy, Thomson Pub.**
8) **H.Straw, & K. walker, Spectroscopy Vol.I&II, Science Paper backs.**
9) **M.Mahindersingh, Analytical chemistry, Instrumental techniques, Dominant Pub. Delhi.**
10) **F.W.Fiefield, & D.Kealey, Principles and Practice of analytical Chemistry, Blackwell Pub.**
11) ***G.W.Ewing,Instrumental methods of Chemical analysis, MacGrawHill.***

UNIT-III Hyphenated Techniques **(15L)**

3.1 Introduction, need for hyphenation, possible hyphenation. **(02L)**

3.2 Interfacing devices and applications of the following: GC-MS,GC-IR,MS-MS,HPLC-

MS, ICP-MS, spectro-electro chemistry and radio-chromatography. **(13L)**

Reference Books:

1 R.P.W.Scott, Tandem Techniques, Wiley India Pvt. Ltd.Reprint2009

2 J.Barker, Analytical chemistry for open learning, Mass spectrometry,WiileyIndiaED.

UNIT-IV Electro-Analytical Methods. **(15L)**

4.1 Over view of electrode process: Electro-capillary curve and electro-capillary maximum potential. **(02L)**

4.2 Micro electrodes: mercury electrodes: Stationary mercury drop electrode (SMDE).Hanging mercury drop electrode (HMDE), Mercury film electrode (MFE),Carbon paste electrode and chemically modified electrodes. **(03L)**

4.3 Introduction to three electrode system: modern polarography and voltammetry necessity and development of new voltammetric techniques and their comparison with classical DC polarography, **(03L)**

4.4 Voltammetric methods: Sampled DC polarography (TAST), Linear sweep voltammetry (LSV),Cyclic voltammetry (CV), diagnostic criteria of cyclic voltammetry **(07L)**

Reference Books:

1) ***A.J.BardandL.R.Faulkner,Electrochemical Methods,2ndEd,John Wiley and sons, Asia Pvt. Ltd,(2004)***
2) ***J.J.Lingane , Electro-analytical Chemistry, 2ndEd, Inter science Publishers, Inc., New York (1958)***
3) ***A.M.Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York,(1980)***
4) ***A.J.Bard(Ed), Electro-analytical Chemistry, Marcel DekkreInc., New York (A series of volumes)..***
5) ***Donald T.Sawyer ,A.Sobkowiak and J.L.Roberts,Jr., Electro chemistry for Chemists, 2ndEd., John Wiley and Sons, Inc., New York.,(1995).***
6) ***D.A.Skoog, F.J.Holler, J.A.Nieman, Principles of Instrumental analysis, 6thEd.***
7) ***R.D.Braun.introduction to Instrumental Analysis,MacGrawhill,1987.***
8) ***H.A. Willard, L.L.Merritt, J.A.Dean&F.A.Settle, Instrumnetal methods of analysis, 5thEd.CBS,1986.***
9) ***M.noel,K.J.Vasu,Cyclic Voltammetry and Frontiers of electro chemistry,IBH, NewDelhi,1990.***

SEMESTER-III

PSCHPEC-II 304

Advanced Instrumental Techniques

UNIT-I Spectral Methods

Principle, instrumentation and applications of the following **(15L)**

1.1 Reflectance spectroscopy **(03L)**

1.2 Photo-acoustic spectroscopy **(03L)**

1.3 Polarimetry : ORD, CD **(04L)**
1.4 Chemiluminescence method **(02L)**
1.5 Nuclear quadruple resonance spectroscopy, ENDOR, ELDOR, EWDOR **(03L)**

UNIT-II Electro-analytical Methods – I
Principles, instrumentation and applications **(15L)**

2.1 Ionselective field effect transistors, bio-catalytic membrane electrodes, disposable multi layer pIon systems, screen–printed electrodes. **(08L)**

2.2 Chrono potentiometry and chrono amperometry **(05L)**

2.3 Fused salt electrolysis **(02L)**

Reference Books:

1) ***A.J.BardandL.R.Faulkner, Electrochemical Methods, 2nd Ed, John Wiley and sons, Asia Pvt. Ltd, (2004).***
2) ***J.J.Lingane, Electro-analytical Chemistry, 2nd Ed, Inter science Publishers, Inc., New York (1958)***
3) ***A.M.Bond,Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc.,New York,(1980)***
4) ***A.J.Bard(Ed), Electro-analytica lChemistry, Marcel DekkreInc., NewYork (A series of volumes)..***
5) ***DonaldT. Sawyer ,A.SobkowiakandJ.L.Roberts,Jr.,Electro chemistry for Chemists,2nd Ed.,JohnWileyandSons,Inc.,NewYork.,(1995).***
6) ***D.A.Skoog,F.J.Holler, J.A.Nieman,Principles of Instrumental analysis, 6th Ed.***
7) ***R.D.Braun.introduction to Instrumental Analysis,MacGrawhill,1987.***

8) ***H.A. Willard, L.L.Merritt, J.A.Dean&F.A.Settle, Instrumnetal methods of analysis, 5th Ed.CBS,1986.***
9) ***M.noel,K.J.Vasu,CyclicVoltammetry and Frontiers of electro chemistry,IBH, NewDelhi,1990.***
10) ***P.T.Kissinger,W.R.heinman,LaboratotyTechniques in electro analytical Chemistry,Dekkar,NY.1984.***

UNIT-III Radio-analytical Methods **(15L)**

3.1 Activation analysis-basic principles, fast neutron activation analysis, radio-chemical method inactivation analysis **(04L)**

3.2 Isotopic dilution method-principle and applications. **(02L)**
3.3 Auto, x-ray and gamma radiography (**04L)**
3.4 Radiometric Titrations **(03L)**
3.5 Applications of radio-analytical techniques. **(02L)**

References Books for Radioanalytical Methods:

1) ***J.RutickaandJ.Stary, Sub stoichiometry in Radio chemical Analysis, Pergamon Press,(1968)***
2) ***R.A.FairesandG.G.J.Boswell,Radio isotope Laboratory Technique,4th, Ed, Rutterworths; London, (1981)***
3) ***D.Brune, B. Forkman, B.Person, Nuclear Analytical Chemistry, Chartwell- Bratt Ltd.,(1984)***
4) ***Maheshwar Sharon and Madhuri Sharon, NuclearChemistry, Ane Books Pvt. Ltd.(2009)***
5) ***Nuclear Chemistry By Arnikar***

UNIT-IV Pulse polarography: **(15L)**

4.1 Normal pulse polarography(NPP), Differential pulse polarography(DPP), Double differential pulse polarography(DDPP), **(08L)**
4.2 Sinusoidal AC polarography, Square wave polarography (**05L)**
4.3 Applications of electrochemical methods in Organic synthesis. **(02L)**

References :

1) ***M. Noel and KI.Vasu, Cyclic Voltammetry and the frontiers of Electrochemistry, IBH, NewDelhi,(1990)***
2) ***A.M.Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York,1980.***
3) ***A. J. Bard and Faulkner, Electrochemical Methods, 2ndEd, John Wileyand Sons (Asia) Pvt. Ltd., 2004.***

Practicals

SEMESTER-III

PSCHP3P1

1. To determine of the formula of the copper (II) ammonia complex by partition method.

2 .To determine the transport no. of copper(II)ions by Hittorf's method.

3. To determine the isoelectric point of gelatin by viscosity measurement.

PSCHP3P2

1. To determine the mean ionic activity coefficient of zinc chloride by emf method.

2.To construct the phase diagram for a two component system forming a simple eutectic..

Non instrumental

3. To determine the equilibrium constant for the reaction

$$CaSO_4\,(s) + 2Ag^{+1}\,(aq) = Ag_2SO_4(s) + Ca^{-2}\,(aq)$$

4.To determine the partial molar volume of ethanol.

PSCHP3P3

1. Determination of the energy of activation and other thermodynamic parameters of activation for the acid catalyzed hydrolysis of methyl acetate.

2.To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement.

Conductometry

1 To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant.

2To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex.

Potentiometry

1To determine the E^0 of the quinhydrone electrode.

2 To determine the formula of the zinc(II)ferrocyanide complex by titration of Zn(II) sulphate with potassiumferrocyanide.

p H metry

1To estimate the amount of hydrochloric acid and acetic acid in a mixture by titration with an alkali using a pH meter.

2To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base.

PSCHP3P4

1. To determine the molar mass of a nonvolatile solute by cryoscopic method.

Colorimetr & spectrophotometry

1.To determine the ionization constant of bromophenol blue

2. Tostudycomplexformationbetweennickel(II)witho-phenanthroline.

3. To determine the rate constant and the order of the reaction between persulphate and iodide ions.

1.The candidate is expected to submit a journal certified by the Head of the Department/institutionatthetimeofthepracticalexamination.

2.A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.

3.Use of non-programmable calculator is allowed both at the theory and the practicalexamination.

<u>List of reference Books for Practicals:</u>

1. ***B.VishwanathanandP.S.Raghavan,PracticalPhysicalChemistry,Viva BooksPrivateLimited,2005.***
2. ***A.M.JamesandF.E.Prichard,PracticalPhysicalChemistry,3rd ed., Longman,1974.***
3. ***B.P.Lewitt(ed.),Findlay'sPracticalPhysicalChemistry,9th ed.,1973.***
4. ***C.D.BrennanandC.F.H.Tipper,ALaboratoryManualofExperimentsin PhysicalChemistry,McGraw-Hill,1967.***
5. ***F.Daniel&Others,ExperimentalPhysicalchemistry,19665,KogakashaCoLt d.,Tokyo.***

SEMESTER -IV

PSCHP401

Paper-I

Chemistry: Polymer, Green, Biophysical and Applied.

Unit I: Polymer Chemistry-II **(15L)**

1.1 Polymers in solid state – Transitions (glass transition and crystalline melting temperature), crystalline behaviour, factors affecting crystallinity, polymer blends and Alloys. **(03L)**

1.2 Identificationandcharacterizationofpolymers:Chemical analysis- End group analysis; Physical analysis by Spectral methods: IR, UV, Ramam, NMR,X-ray diffractionanalysis,Microscopic methods: SEM, TEM, Thermal analysis-TGA,DTA, DSC. **(06L)**

1.3 Properties of polymers: Thermal (glass transition temperature, and its determination),mechanical(deformationandfracture)effectsinpolymers,viscoelasticity surface (surface tension, hardness, friction, abrasion), physical (Impactstrength,Tensilestrength,solubility) of polymers, weatherability, rheology and mechanical models, mechanical behavior, Rubber elasticity, **(04L)**

1.4 Polymer degradation and stabilization: Oxidative, thermal, radiation, Biodegradation **(02L)**

Unit II: Polymer Chemistry-III **(15L)**

2.1Techniquesofpolymerization:Bulkpolymerization,solutionpolymerization,suspensionpolymerization,emulsionpolymerizations, **(03L)**

2.2Thermodynamicsofpolymersolutions:Solubility parameter, thermodynamics of mixing**,theta temprature** **(02L)**

2.3 Polymer technology: **(05L)**

2.3.1 Polymer auxiliaries, plasticizers, heat Stabilizers, colorants, flame retardants. F**illers, reinforcements.**

2.3.2 Elastomers: Introduction, Processing, Rubber Types, Vulcanization, Properties.Reclaiming.

2.3.3 Fibers: Introduction, production, Fiber spinning, Textile fibers, Industrial fibers, recycling.

2.3.4 Films sheets: Introduction and processing techniques (injection and blow moulding extrusion),Recyling of plastics.

2.4 Properties and applications of some commercially important polymers. Carbon chain polymers- Polyolefins, ABS group, elastomers, vinyl polymers, acrylic polymers, heterochain polymers- polyethers, polycarbonates, polysaccharides, polyamides fluoropolymers, Resins (epoxy, alkyd, phenol-formaldehyde and urea-formaldehyde), Silicones, polyphosphazenes, sulphur containing polymers **(05L)**

Reference Books:

1. P. Bahadur and N. V. Sastry, Principles of Polymer Science, second

edition,NarosaPublishingHouse,2005.

2. *C. E. Carraher, Jr., Carraher's Polymer Chemistry, 8th edition, CRC Press, New York,2010.*
3. *JoelR.Fried,Polymer Science and Technology, Prentice-Hall of India Pvt. Ltd., 2000.*
4. *V.R.Gowarikar, H.V.Viswanathan and J.Sreedhar,Polymer Science.New Age International Pvt.Ltd., New Delhi,1990.*
5. *F. W. Billmeyer Jr., Text Book of Polymer Science, 3rd edition, John Wiley and Sons,1984.*

6 V.K.Ahluwalia&A. Mishra, Polymer Science, A text book,Ane Books Pvt. Ltd,2008.

7 R.Sinha, Outline of Polymer Technology manufacture of Polymers, Prenticehall ofIndiaPvt.Ltd.2000

8 F.J.Davis,Polymer Chemistry, Oxford university Press,2000.

9 D.Walton&P.lotimer,Polymer, Oxford university Press,2000.

10 R.Ypung,Introduction to Polymers,Chapman&Hall,reprint,1989.

11 V.Jain.OrganicPolymerChemistry, IVY Publishing House,2003.

12 A.Singh,Polymer Chemistry,Campus BookInternational,2003.

13 <u>Books for further reading:</u>

1. *J. M. G. Cowie, Polymers: Chemistry and Physics of Modern Materials, 2nd ed. (firstIndianReprint2004),Replika Press Pvt. Ltd.*
2. *G.S.Misra, Introductory Polymer Chemistry, New Age International (P) Limited, Publishers,1993.*
3. *L. H. Sperling, Introduction to Physical Polymer Science. 2nd Edition, John Wiley and Sons.Inc.*
4. *Hans-Georg Elias,An Introduction to polymer Science, VCH 1997.*
5. *Charles E. Seymour, Jr., Seymour/Carraher's Polymer Chemistry, 6th ed., Marcel Dekker, Inc.,2003.*
6. *A. Ravve, Principles of Polymer*

UNIT-IIIBio-physical Chemistry and Green Chemistry (15L)

3.1 Biophysical Chemistry (08)

3.1.1 Introduction to Complex Biomolecules: Proteins, enzymes, DNA, RNA, polysaccharides andlipids.chirality and pH dependence of biomolecules. **02L)**

3.1.2 Biosensors : Enzyme based, Electrochemical, immunosensor, fluorescence, optical, Piezoelectric Biosensors **(02L**)

3.1.3 Electrophoresis (Technique for bio-molecular study) : Principle and factors affecting electro-phoreticmobility, zone electrophoresis–Paper electrophoresis,cellules acetate electrophoresis, Gel electrophoresis. capillary Electrophoresis, Application of electrophoresis. **(04L)**

Reference Books:

1. U.N Dash,.AText Book of Biophysical Chemistry,Macmillan India Ltd

2. Gurtu and Gurtu, Biophysical Chemistry, Pragati Prakashan.

3. R.P.Budhiraja,Separation chemistry,New Age International(P)Limited,Publisher

4. Avinash Upadhyay, Kakoti Upadhyay, Nirmalendu Nath.Biophysical Chemistry Principles and Techniques Himalaya

5.Susan R.Mikkelson ,Eduardo Corton, Bioanalytical Chemistry, Wiley Interscience.08Science,2nd ed.,Kluwer Academic/Plenum Publishers, New York,2000.

3.2 Green Chemistry: (07L)

3.2.1 Recapitulation of principles of green chemistry, Waste minimization techniques. (01L)

3.2.2 Catalysis and Green Chemistry: Phase transfer catalysts, biocatalyst, photo catalysis. 02L)

3.2.3 Organic solvents, solvent free system, supercritical fluid, ionic liquid, their characteristics,use as catalyst and solvents. 02L)

3.2.4 Alternative energy sources for initiation and execution of chemical reaction: Microwave and sonochemistry. 02L)

Reference Books:

1. MikeLancaster, Green Chemistry An Introductory Text, Royal Society of Chemistry.

2. V.K.Ahluwalia, M.Kidwai, Kluwer Academic Publisher.

UNIT-IV Photochemistry-II: Kinetics and Applications (15L)

4.1: Photophysical Kinetics of bimolecular processes. (10L)

4.1.1: Mechanism of fluorescence quenching.

4.1.2:Collisions in solutions

4.1.3: Kinetics of collisional quenching and Stern-Volmer equation and deviations from Stern Volmer equation,

4.1.4: Concentration dependence of quenching and excimer formation

4.1.5: Quenching by added substances–charge transfer mechanism and energy transfe rmechanism.

4.2: Solar Cells: photovoltaic and photogalvanic cells; photoelectron chemistry; prospects of solar energy conversion and storage,organic solar cells. **05L)**

Reference Book:

K.K.Rohatgi-Mukherjee. Fundamentals of Photochemistry.Reprint 2002. New AgeInternationalPublisher,1978.-

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Semester-IV

PSCHP402

Paper-II
Material Science, network and irreversible thermodynamics,

UNIT-I Metals and alloys: **(15L)**

1.1 Solidification of metals and alloys-homogeneous and heterogeneous nucleation Growth of crystals, growth of silicon single crystal. **(04L)**

1.2 Metallic solid solutions-substitutional and interstitial solid solutions. **(03L)**

1.3 Crystalline imperfections-point ,line and boundary defects **(04L)**

1.4 Atomic diffusions in solids-diffusion mechanisms, steady state and non-steady state diffusions,-impurity diffusion into silicon wafers for integrated circuits.(**04L)**

UNIT-II Mechanical properties of solid materials **(15L)**

2.1 Stress and strain in metals- Engineering stress and engineering strain, shear stress and shear strain, the tensile test and engineering stress -strain diagram, modulus of elasticity, yield strength. **(05L)**

2.2 Hardness and hardness testing plastic deformations of metals in single crystals plastic deformation of polycrystalline metals, solid solution strengthening of metals.

2.3 Fracture of metals-ductile and brittle fracture ,toughness and impact testing, fatigue of metals, the creep test ,creep-rupture test. **(05L)**

Reference Books :

1. *WilliamF.Smith, Principles of Material Science and Engineering, 3rd edition, McGraw–HillInc.1996.*

2. *Keer H.V, Principles of the Solid State, first reprint, Wiley Eastern Limited, 1994.*

3 *Principles of Material science and engineering, 3rd edition, McGraw–Hill Inc.1996.*

List of Books for further reading:

1. *A.R.West,Solid State Chemistry and its Applications,John Wiley and Sons (Asia) Pvt.Ltd.,*
2. *L.E.Smart and E.A.Moore, Solid State Chemistry–An Introduction,3rdEd., Taylor and Francis, 2005.*
3. *V.Raghavan,Materials Science and Engineering, Fifth Ed.,Prentice-Hall of India Pvt. Ltd.,NewDelhi,2004.*
4. *WilliamD.Callister,Jr.,Materials Science and Engineering, An Introduction, Fifth Ed.,John Wiley and Sons (Asia)Pvt.Ltd.,2001.*
5. *S.O.Pillai, Solid State Physics, Fifth Ed., New Age International Publishers, 2002.*
6. *Leonid V.Azaroff, Introduction to Solids, Tata-McGraw-Hill Publishing Co.Ltd., New Delhi, 1977.*
7. *Sandra E.Dann, Reactions and Characterization of Solids, Royal Society of Chemistry, 2000.*

8 *C.N.R.RaoandJ.Gopalakrishnan, New Directions in Solid State Chemistry, Seconded.,Cambridge University Press,1997.*

9 *N.B.Hannay,Solid State Chemistry,Prentice Hall of India, New Delhi,1976.*

10 *M.AliOmer, Elementary Solid State Physics,5thIndian Reprint, Pearson Education, Inc., 1999.*

Unit III Lasers and super conductors **(15L)**

3.1 Lasers in chemistry **(10L)**

3.1.1 General principles of LASER action-Population Inversion, cavity and mode characteristics, Q-switching, Modelocking. **(02L)**

3.1.2 Practical lasers- Solid state lasers-Ruby, neodymium, gas lasers-He-Ne, Ar, Kr, Carbon dioxide, Chemical and exciplex Lasers,Dye lasers LED and Semiconductor Lasers**.** **05L)**

3.1.3 Applications of Lasers in chemistry: Spectroscopy at high photon fluxes, collimated beams, Precision specified transitions, Isotope separation, Study of fast reactions using pulsed techniques**.** **(03L)**

Reference Book:

.Atkins P.W, Physical Chemistry, Oxford University Press, 6th edition, 1998.

3.2 Super conducting solid materials **(05L)**

Band theory of electrical conductivity, Bardeen-Cooper-Schriffer Theory of super conductivity,the superconducting state, High critical temperature super conductors, magnetic properties of superconductors.

Unit IV **(15L)**

4.1 Non-equilibrium thermodynamics :

4.1.1 Features of non-equilibrium thermodynamics, second law of thermodynamics, uncompensated heat and its relation to thermodynamics function. **(02L)**

4.1.2 Entropy production and its rate. Entropy production in heat transfer process and during mixing of gases.Entropy production and efficiency of galvanic cell.**(04L)**

4.1.3 Onsagers theory: Reciprocal relation, principle of microscopic reversibility. Coupled and uncoupled reactions and their condition.**(05L)**

4.1.4 Transport phenomena across membranes. Electro kinetic effect and thermo mechanical effects.**(04L)**

<u>Reference Books:</u>

1. ***D.A.McQuarrieand J.D.Simon, Molecular Thermodynamics, Viva Books Private Limited, First Indian Ed.,2004.***
2. ***D.A.McQuarrieand J.D.Simon,Physical Chemistry,A Molecular Approach, Viva Books Private Limited, First South Asian Ed.,1998.Chap.***
3. ***E.D.Kaufmann, Advanced Concepts in Physical Chemistry, McGraw-Hill,1966.***
4. ***Robert P.H.Gasser and W.Graham Richards, An Introduction to Statistical Thermodynamics,World Scientific Publishing Co.Pte.Ltd.,1995.***
5. ***C.Kalidas and M.V.Sangaranarayan, Non-Equilibrium Thermodynamics, Principles and Applications, McMillanIndia Ltd.,2002.***

<u>List of Books for further reading:</u>

1. ***M.Dole, An Introduction to Statistical Thermodynamics, Dover, NewYork,1986.***

2. ***W. Kauzmann, Thermodynamics and Statistics: with applications to gases,W. A. Benjamin,NewYork,1967.***
3. ***M. C. Gupta, Statistical Thermodynamics, 2nd. Ed., New Age International Publishers, New Delhi,1998.***
4. ***S. Glasstone, Theoretical Chemistry, Affiliated East–West Press Pvt. Ltd., New Delhi, 1973.***
5. ***S. Glasstone, Thermodynamics for Chemists, Affiliated East–West Press Pvt. Ltd.,New Delhi,1964.***
6. ***R. Hasse, Thermodynamics of Irreversible Processes, Addison Wesley London,1969.***
7. ***I.Prigogine, Introduction to Thermodynamics of Irreversible Processes,3rd ed., Interscience ,NewYork, 1967.***

PRACTICALS

SEMESTER-IV

PSCHP403

Paper-III

Symmetry &Spectroscopy

UNIT-I: Symmetry in Chemistry **(15L)**

1.1 Recapitulation: point groups, character tables **(02L)**

1.2 Reduction formula, application of reduction formula to vibrational modes of water molecule**.** **(02L)**

1.3 Application in vibrational spectroscopy, selection rules for IR spectroscopy for molecules such as H_2O, CO_2, HF, H_2 **(03L)**

1.4 Application to Raman spectra, selection rules, comparison of IR and Raman selection rules, general approach to vibrational spectroscopy. **(02L)**

1.5 Symmetry in chemical bonding: symmetry adapted linear combination of _molecular orbitals, H_2^+,H_2, LiH, BeH_2, BH_3, CH_4, molecular orbital energy, and bond order. **06L)**

Reference Books :

1 ***K.Veera Reddy, Symmetry and Spectroscopy of molecules,2nd ed,new age International publishers.***
2 ***U.C.Agarwala,H/L/Nigam,S.Agarwal, S.S.Kalra, Molecular symmetry in Chemistry via group theory, 2013, Ane Books Pvt.ltd.***
3 ***H.N.Dass,symmetry and group theory for chemists,2004 Asian Books Pvt.Ltd.***
4 ***K.V.Raman, group theory and its applications to Chemistry,1980,Tata MacGrawhillPub.Co.Pvt.Ltd.***
5 ***P.K.Bhattacharya, Group theoryand its chemical applications,1999,Himalaya, Pub.House.***
6 ***F.A.Cotton, Chemical applications ofGroup Theory, Wiley Student Ed., 2006, JohnWiley and Sons,(Asia) Pvt.Ltd.***
7 ***R.L.Carter, Molecular symmetry and Group theory, Wiley Student Ed.,1996,John Wiley and Sons, (Asia) Pvt.Ltd.***
8 ***S.Swarnalakshmi, T.saroja, R.M.Ezhilarisi, A simple approach to Group theory in chemistry, 2008, Universities Press (India) Pvt. Ltd.***

UNIT-II N.M.R.Spectroscopy-I **(15L)**

2.1 A review of one dimensional NMR spectroscopy. **(01L)**

2.2 Spin-relaxation.Nuclear Overhauser Effect (NOE).polarization transfer. **(03L)**

2.3 Two-dimensional NMR.Correlated spectroscopy(COSY) **(03L)**

2.4 NuclearOverhauser effect Spectroscopy(NOESY) **(02L)**

2.5 Hetero nuclear correlation Spectroscopy(HETCOR) **(02L)**

2.6 Solid-stateNMR **(02L)**

2.7 Magnetic Resonance Imaging(MRI) **(02L)**

UNIT-III ESR and Mossbauer Spectroscopy **(15L)**

3.1Electron spin Resonance Spectroscopy- **(10L)**

3.1.1 Basic principle, hyperfine splitting(isotropicsystems); (02)

3.2.2 G-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); (03L)

3.3.3 An isotropic effects (the g-value and the hyperfine couplings);The EPR of triplet states; Structural applications to transition metal complexes. (02L)

3.4.4 Fundamentals and hyper fine splitting, application to study of free radicals spin densities McConnell relationship Zero field splitting. (03L)

3.2 Mossbauer Spectroscopy: **(05L)**

Principles, Recoille emission and absorption of γ-rays, experimental methods, isomer shift, hyperfine structure (quadrupole interaction), magnetic hyperfine interaction, applications.

Reference Books:

1. ***C.N.Banwell and E.M.McCash, Fundamentals of Molecular Spectroscopy, 4thEd., Tata-McGraw-Hill,1994.***
2. ***M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers,2001.***
3. ***H.S.Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd.,2003***
4. ***G.Aruldas, Molecular Structure and Spectroscopy, Prentice-HallofIndia,2001.***
5. ***J.MichaelHollas, Modern Spectroscopy ,4thEd.,John Wiley and Sons,2004.***

List of Books for further reading:

1. ***R.Drago,Physical Methods for Chemists, Saunders ,Philadelphia,1992.***
2. ***B. P. Straughan and S. Walker (Eds.), Spectroscopy – Vol 1-3, Chapman and Hall, New York,1976.***
3. ***R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, Pitman, London, 1983.***
4. ***Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy,3rded.,Thomson,Brooks/Cole,2001.***

UNIT-IV ^{13}C-N.M.R.Spectroscopy **(15L)**

4.1 Elementary ideas, instrumental difficulties, FT technique advantages and disadvantages. proton noise decoupling technique advantages and disadvantages, off-resonance technique. **(05L)**

4.2 Chemical shifts of solvents, factors affecting chemical shifts, analogy with^{1}HNMR. **(03L)**

4.3 Calculations of chemical shift of hydrocarbons, effect of substituent's on chemical shifts, different types of carbons (alkene, alkyne and allene). **(03L)**

4.4 Chemical shift of aromatic carbons and effect of substituent. **(02L)**

4.5 Chemical shifts of carbonyl, nitrile, and oxime carbons. **(02L)**

Reference Books:

1. ***A.E. Derome, Modern NMR Techniques for Chemistry Research, Pergamon,Oxford(1987)***
2. ***J.K.M. Sanders and B.K. Hunter, Modern NMR Spectroscopy, 2nd edition (1993), Oxford University Press, Oxford.***
3. ***R.K.Harris,Nuclear Magnetic Resonance Spectroscopy,(1986) Addison-Wesley, Longman Ltd.,London***
4. ***Organic spectroscopy by William Kemp,3rd Edition, ELBS, 1996.***

Course Code: PSCHPOC-I 404

Paper – IV (INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS)

Unit 1: **[15L]**

Introduction to Intellectual Property: [2L]

Historical Perspective, Different types of IP, Importance of protecting IP.

Patents: [5L]

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

Industrial Designs: [2L]

Definition, How to obtain, features, International design registration.

Copyrights: [2L]

Introduction, How to obtain, Differences from Patents.

Trade Marks: [2L]

Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc.

Geographical Indications: [2L]

Definition, rules for registration, prevention of illegal exploitation, importance to India.

<u>Unit 2:</u> [15L]

Trade Secrets: [2L]

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

IP Infringement issue and enforcement: [2L]

Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.

Economic Value of Intellectual Property: [2L]

Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.

Different International agreements:

(a) World Trade Organization (WTO): [5L]

(i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade Related Services (GATS) Madrid Protocol.

(iii) Berne Convention

(iv) Budapest Treaty

(b) Paris Convention [6L]

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.

<u>Unit III:</u> [15L]

Introduction to Cheminformatics: [5L]

History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.

Representation of molecules and chemical reactions: [5L]

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching Chemical Structures: [5L]

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit IV: [15L]

Applications:

Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design, Application of Cheminformatics in Drug Design.

REFERENCES:

1. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.

Course Code: PSCHPOC-II 404

PAPER – IV: RESEARCH METHODOLOGY

Unit 1:

Print:

Primary, Secondary and Tertiary sources.

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital:

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources:

The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.

Unit II: DATA ANALYSIS

The Investigative Approach:

Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.

Analysis and Presentation of Data:

Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.

Unit III: METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS

Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.

Writing Scientific Papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.

Unit IV: CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressur, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* Oxford University Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters

3-5

5. Levie, R. De. (2001) *How to use Excel in Analytical Chemistryand in general scientific data analysis* Cambridge Universty Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

Semester –IV

PSCHP4P1

1.To determine the formula of the zinc(II) ammonia complex by partition

method.

2 Determination of the transport no. of silver(I) ions by Hittorf's method.

.Conductometry.

1.To determine the composition of a mixture of hydrochloric acid, potassium chloride and ammonium chloride by titration with sodium hydroxide and silver nitrate.

2.To determine ΔG, $\Delta H$and ΔS of dissolution of a sparingly soluble salt by conductometry.

pHmetry

1 To determine K_1 and K_2 of a dibasic acid by titration with a base.

2 To determine dissociation constant of p-nitro phenol.

PSCHP4P2

1. To construct the phase diagram for a two component system forming a compound
2. To determine the energy of activation and other thermodynamic parameters of activation for the reaction between persulphate and potassium iodide.
3. To determine the effect of ionic strength of a solution on the reaction between potassium persulphate and potassium iodide.
4. To study the order of the reaction between bromate and bromide.
5. To determine the van't Hoff's factor by cryoscopic method.

Potentiometry

1. To determine the liquid junction potential with a concentration cell with and without transference.

PSCHP4P3

Interpretation of spectra/data:

1. Interpretation of vibrational-rotational spectra of rigid and non-rigid diatomic molecules

2. Interpretation of electronic spectra of diatomic molecules.
3. Interpretation of electronic spectra ofsimple polyatomic molecules.
4. Interpretation of NMR,ESR spectra.
5. Interpretation of Mössbauer spectra.
6. Analysisof XRD pattern of cubic system
7. Interpretation of DTA, TG, and DTG curves

PSCHP4P4

Project Evaluation

List of reference Books for Practicals:

a. ***B.VishwanathanandP.S.Raghavan,PracticalPhysicalChemistry,Viva BooksPrivateLimited,2005.***
b. ***A.M.JamesandF.E.Prichard,PracticalPhysicalChemistry,3rd ed., Longman,1974.***
c. ***B.P.Lewitt(ed.),Findlay'sPracticalPhysicalChemistry,9th ed.,1973.***
d. ***C.D.BrennanandC.F.H.Tipper,ALaboratoryManualofExperimentsin PhysicalChemistry,McGraw-Hill,1967.***
e. ***F.Daniel&Others,ExperimentalPhysicalchemistry,19665,Kogakasha CoLtd.,Tokyo.***

Note:

1. The candidate is expected to submit a journal certified by the Head of the Department/institutionatthetimeofthepracticalexamination.

2. A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.

3. Use of non-programmable calculator is allowed both at the theory and the practicalexamination.

UNIVERSITY OF MUMBAI

No. UG/88 of 2018-19

CIRCULAR:-

Attention of the Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Science & Technology Faculty is invited to this office Circular Nos. UG/226 of 2006, dated 29th June, 2006 relating to syllabus of the Master of Science (M.Sc.) degree course.

They are hereby informed that the recommendations made by the Board of Studies in Chemistry at its meeting held on 28th May, 2018 have been accepted by the Academic Council at its meeting held on 14th June, 2018 **vide** item No. 4.74 and that in accordance therewith, the revised syllabus as per the (CBCS) for the M.Sc. in Inorganic Chemistry (Sem – III & IV), has been brought into force with effect from the academic year 2018-19, accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
19th June, 2018

(Dr. Dinesh Kamble)
I/c REGISTRAR

To

The Principals of the affiliated Colleges, the Head University Departments & Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C./4.74/14/06/2018

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No. UG/ 88 -A of 2018 MUMBAI-400 032 19th June, 2018

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-Ordinator, University Computerization Centre,

(Dr. Dinesh Kamble)
I/c REGISTRAR

M.Sc. INORGANIC CHEMISTRY

SEMESTER III

Course Code	Unit	Topics
		(Numericals and word problems wherever possible.)
PSCHI 301		**1. Chemistry of Inorganic Solids**
	I	**1.1 Descriptive Crystal Chemistry(15 L)**
		(a)Simple structures
		Structures of **AB** type compounds (PbO and CuO), **AB_2** type (β cristobalite, CaC_2 and Cs_2O), **A_2B_3** type (Cr_2O_3 and Bi_2O_3), AB_3 (ReO_3, Li_3N), **ABO_3** type, relation between ReO_3 and perovskite $BaTiO_3$ and its polymorphmic forms, Oxide bronzes, ilmenite structure, **AB_2O_4** type, normal, inverse, and random spinel structures.
		(b) Linked Polyhedra
		(i) Corner sharing: tetrahedral structure (Silicates) and octahedral structure (ReO_3) and rotation of ReO_3 resulting in VF_3, RhF_3 and calcite type structures. (ii) Edge sharing: tetrahedral structures (SiS_2) and octahedral structures (BiI_3 and $AlCl_3$). pyrochlores, octahedral tunnel structures and lamellar structures
	II	**1.2 Imperfection in crystals and Non-Stoichiometry (15 Lectures)** **(a) Point defects**: Point defects in metals and ionic Crystal – Frenkel defect and Schottky defect. Thermodynamics formation of these defects (mathematical derivation to find defect concentration); Defects in non-Stoiochiometric compounds, colour centres.
		(b) Line defects: Edge and Screw Dislocations. Mechanical Properties and Reactivity of Solids.
		(c) Surface Defects: Grain Boundary and Stacking Fault. Dislocation and Grain Boundaries, Vacancies and Interstitial Space in Non-Stoichiometric Crystals, Defect Clusters, Interchangeable Atoms and Extended Atom Defects.
		1.3 Methods of Preparations (15 Lectures)
		(a) Methods of Synthesis: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples).
	III	**(b) Different methods for single crystal growth:** (i) Crystal Growth from Melt–: Bridgman and Stockbargar, Czochralski and Vernuil methods. (ii) Crystal growth from liquid solution: Flux growth and temperature gradient methods (iii) Crystal growth from vapor phase: – Epitaxial growth methods.
		(c) Thin film preparation: Physical and Chemical methods.
		(d) Solid Solutions: Formation of Substitutional, Interstitial and Complex Solid Solutions; Mechanistic Approach; Study of Solid solutions by X-ray

		Powder Diffraction and Density Measurement.
	IV	**1.4 Behaviour of Inorganic Solids (15 Lectures)** **(a) Diffusion in Solids**: Fick's Laws of Diffusion; Kirkendal Effect;Wagner mechanism,Diffusion and Ionic Conductivity; Applications of Diffusion in Carburizing and non-Carburizing Processes in Steel Making.
		(b) Solid state reactions: General principles and factors influencing reactions of solids, Reactivity of solids.
		(c) Liquid Crystals: Introduction and classification of thermotropic liquid crystals, Polymorphism in liquid crystal, Properties and applications of liquid crystals.
		<u>REFERENCE BOOKS</u> 1. L. E. Smart and E. A. Moore, Solid State Chemistry-An introduction, 3rd edition, Taylor and Francis, 2005. 2. A.R.West, Solid State Chemistry and Its Applications, John Wiley & sons, 1987. 3. C.N.R. Rao and J.Gopalkrishnan New Directons in Solid State Chemistry, 2nd Ed., Combridge University Press. 1997 4. L.V. Azaroff, Introductionn to solids, Tata-McGraw Hill Book Ce. New Dehli, 1977. 5. . D.W. Bruce and Dermont O Hare, Inorganic Chemistry, 2nd Ed. Wiely and sons, New York, 1966. 6. J.M. Hollas, Symmetry in Molecuies, Chapman adn Hall Ltd.,1972. 7. Reboert L carter, Molecular Symmeetry and Group Hohn Wiley and Sons, New York, 1988. 8. Ulrich Muller, Inorganic structural Chemistry, 2nd edition, John Wiley and Sons, Chichester, 1993. 9. . R.N.Kutty and J.A.K.Tareen, Fundamentals of Crystal Chemistry, Universities Press (India) Ltd., 2001.. 10. H.V.Keer, Principles of the Solid state, Wiley Eastern Ltd., 1993. Gary L.Miessler and Donald A.Tarr, Inorganic Chemistry, 3rd edition , Pearson Education, Inc., 2004. 11. . D.K.Chakraborty, Solid State Chemistry, New Age International Publishers, 1996. 12. A. Earnshaw, Introduction to Magnetochemistry, Acad. Press,N.Y. (1966)
		2. Bioinorgnic and Coordination Chemistry.
PSCHI 302	**I**	**2.1 Bioinorganic Chemistry(15 Lectures)** (i)Coordination geometry of the metal ion and functions. (ii)Zn in biological systems: Carbonic anhydrase, protolytic enzymes, e.g. carboxy peptidase, Zinc finger.

		(iii)Role of metal ions in biological electron transfer processes: iron sulphur proteins, (iv)Less common ions in biology e.g. Mn (arginase; structure and reactivity), Ni (urease ; structure and reactivity) (v) Biomineralization
	II	**2.2 Reactivity of Chemical Species –I (15Lectures)** 2.2.1 Recapitulation of the definition of Lewis acids and bases, Classification of Lewis acids and bases based on frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases. 2.2.2 Group Characteristic of Lewis acids (Gp-1,13-17). 2.2.3 Pauling rules to determine the strength of oxoacids; classification and Structural anomalies.
	III	**2.3 Reactivity of Chemical Species –II (15Lectures)** **2.3.1 Pourbaix Diagrams.** 2.3.2Amphoteric behavior, Periodic trends in amphoteric properties of p-block and d-block elements 2.3.3 Oxoanions and Oxocations. 2.3.4 Measures of hardness and Softness of Acids and Bases, Drago-wayland equations 2.3.5 Applications of acid-base Chemistry: Super acids and Super bases, heterogeneous acid-base reactions.
	IV	**2.4 Structure, Bonding, and Stereochemistry of Coordination Compounds (15 Lectures)** **(a) Structure and Bonding.** i) Molecular Orbital Theory for Complexes with Coordination Number 4 and 5 for the central ion (sigma as well as Pi bonding) (ii) Angular Overlap Model for octahedral and tetrahedral complexes for sigma and pi bond. **(b) Stereochemistry of Coordination Compounds.** (i) Chirality and Fluxionality of Coordination Compounds with Higher Coordination Numbers. (ii) Geometries of Coordination compounds from Coordination number 6 to 9.
		REFERENCES: 1. Gary Wulfsberg, Inorganic Chemistry ; Viva Books PA Ltd., New Delhi; 2002. 2. F.A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd edition. 3. James E.Huheey, Inorganic Chemistry, 3rd edition, Harper &

		Row,Publishers, Asia, Pte Ltd., 1983. 4. W.W.Porterfield,Inorganic Chemistry-An Unified Approach,Academic press(1993); 5. D.F.Shriver, P.W.Atkins and C.H. Langford, Inorganic Chemistry,3rd edition Oxford University Press, 1999. 6. Asim K.Das, Fundamental Concepts of Inorganic Chemistry,(Volumes-I,II and III)CBS Pub.(2000) 7. N.N.Greenwood and A.Earnshaw, Chemistry of Elements, Pergamon, 1984. 8. J.M.Hollas, Symmetry in Chemistry, Chapmanad Hall Ltd., NY, 1972.\ 9. F.A.Cotton, Chemical Applications of Group Theory, 2nd edition, Wiley Eastern Ltd., New Delhi , 1976 10. C.J.Ballhausen and H.B.Gray, Molecular Orbital Theory, MCGraw-Hill, New York, 1965. 11. H. Sisler, Chemistry in Non-aqueous Solvents: New York Reinhold Publ. 1965. 12. . J.J. Lagowski, The Chemistry of Non-aqueous Solvents, Academic press, New york and London. 13. . C.M. Day and Joel Selbin, Theoretical Inorganic Chemistry,Affiliated East West Press Pvt.Ltd., 1985. 14. L.E.Orgel, An Introduction to Ligand Field Theory , Methuen & Co.Ltd., London, 1960. 15. F.Basolo and R.G.Pearson, Mechanisms of Inorganic Reactions,Wiley, New York, 1967. 16. . J.D.Lee, Concise Inorganic Chemistry, 5th ed., Blackwell ScienceLtd., 2005. 17. R.H. Crabtree, The Organometallic Chemistry of the Transition Metals, Wiley-Interscience, New york, 1988. 18. G.W.Parshall and S.D.Ittel, Homogeneous Catalysis, 2nd edition,John Wiley & sons, Inc., New York, 1992. 19. Gary O. Spessard and Gary L.Miessler, Organometallic Chemistry,Prentice-Hall, (1997). 20. . R.C.Mehrotra and A.Singh, Organometallic Chemistry-A UnifiedApproach, 2nd ed., New Age International Pvt.Ltd., 2000. 21. B.Douglas, D.H. McDaniel and J.J.Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley & Sons,1983. 22. James E.Huheey, Inoganic Chemistry-Principles of structure and reactivity, edn Harper & Row Publishers (1972). 23. . F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann,Advanced Inorganic Chemistry, 6th ed., John Wiley, New York,1999. 24. F.A. Cotton and R.A.Walton, Multiple Bonds between MetalAtoms, 2nd edition, claranden Press, Oxford, 1993. 25. P.L. Soni, Vandana Soni ,Ane Books Pvt.,Ltd
		3. Spectral Methods in Inorganic Chemistry
	I	**3.1 Diffraction Methods –I (15 Lectures)** X-Ray Diffraction: Bragg Condition; Miller

PSCHI 303		Indices; Laue Method; Bragg Method; Debye Scherrer Method of X-Ray Structural Analysis of Crystals.
	II	**3.2 Diffraction Methods –II** **(15 Lectures)** **(a) Electron Diffraction:** Scattering of electrons, Scattering Intensity versus Scattering Angle, Weirl Measurement Technique, Elucidation of Structures of Simple gas Phase Molecules. **(b) Neutron Diffraction:** Scattering of Neutrons: Scattering of neutrons by Solids and Liquids, Magnetic Scattering, Measurement Technique.
	III	**3.3 Electron Spin Resonance Spectroscopy (15 Lectures)**
		(a) Electron behaviour, interaction between electron spin and magnetic field.
		(b) Instrumentation : Source, Sample cavity. Magnet and Modulation coils, Microwave Bridge, Sensitivity.
		(c) Relaxation processes and Line width in ESR transitions: (i) ESR relaxation and chemical bonding. (ii) Interaction between nuclear spin and electron spin (hyperfine coupling) (iii) Spin polarization for atoms and transition metal ions, (iv) Spin-orbit coupling and significance of gtensors, (v) Application to transition metal complexes (having one unpaired electron)
		3.4 Mossbauer Spectroscopy **(15 Lectures)**
	IV	**Mössbauer Spectroscopy:** 3.4.1 Basic principle, recoil energy and Doppler shift. 3.4.2 Instrumentation: sources and absorber; motion devices, detection, reference substances and calibration, 3.4.3 Isomer shift, quadrupole interaction, magnetic interaction, electronegativity and chemical shift. 3.4.4 Applications: *Iron compounds*- low spin and high spin Fe(II) and Fe(III) compounds and complexes, effect of pi-bonding, mono and poly nuclear Iron complexes, spinel oxides and iron-sulphur proteins; *Tin compounds*- tin halides and tin oxides, organotin compounds; *Iodine compounds*- I_2 and alkali metal iodide compounds.

REFERENCES:

1. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis Fifth edition, (1996),ELBS Publication. Chapter 2, 3, 11.
2. W.H. Zachariasen. Theory of X-Ray Diffration in Crystals. JohnWiley. New York. 1946.

		3. B.D. Cality,, Elements of X-Ray Diffraction Procedures. John Wiley and Sons. New York, 1954. 4. R. Reaching, Electron Diffraction, Methuen and Co. London. 1936 5. May and Leopold, An Introduction to Mossbauer Spectroscopy,Plenum, New York, 1971. 6. H.H. Willard, L.L. Merrit, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis, C.B.S. Publishers and Distributors, New Delhi, 1986. 7. P.J. Horne, Nuclear Magnetic Resonance. Oxford University Press, Oxford, 1995. 8. Reverts John D., Nuclear Magnetic Resonance, McGraw Hill, NewYork, 1959. 9. . H. Kambe and P.D.Garn. Thermal Analysis, Kondansha Ltd. Toyo,1974. 10. G.W. Ewing, Instrumental Methods, Of Analysis, 4th Ed. McFraw Hill Ltd., 1970. 11. N.H. Ring, Inorganic Polymers, Academic Press, New York, 1978 12. H.G. Heal, The Inorganic Heterocyclic Chemistry of Sulphur, Nitrogen and Phosphorous, Academic Press, New York, 1980. 13. G.T. Seaborg, Man-made Transuranic Elements Preitce- Hall, 1963. 14. M.T.R. Series, The Superheavy Elements. 15. Haissilsky, Nuclear Chemistry and its Application, 1962. 16. S. Glasstone, Sourcebook of Aomic Energy, East-West Publisher,1969. 17. D.Harvey,Modern Analytical Chemistry, The McGraw-Hill Pub,1st Edition(2000); 18. John H. Block, E.B. Roche, T.P.Soine and Charles O.Wilson, Inorganic Medicinal and Pharmaceutical Chemistry, Lea and Febiger, 1974. 19. R. S. Drago, Physical Methods in Inorganic Chemistry, John-Wiley Pub.,1975 20. . M. Drescher an G. Jeschke,(Eds), EPR Spetroscopy: Applications in Chemistry and Biology, Springer-Verlag Berlin, Heidelberg 2012 21. Graham Smith; David Keeble.Introduction to Modern EPR Spectroscopy CRC Press 2013. 22. C.N.R. Rao, Chemical Applications of Infrared Spectroscopy Academic Pess,N.Y.(1963 23. K. Veera Reddy, Symmetry and Spectroscopy, 24. Paul Gabbott Principles and Applications of Thermal Analysis Wiley-Blackwell ; edition (2007) 25. . Richard Vernon Parish, NMR, NQR, EPR, and Mössbauer spectroscopy in inorganic chemistry, Publisher,E,.Horwood,(1990)
		4. Applied Chemistry(Elective)
		4.1 Safety in Chemistry Laboratories (15 Lectures) 4.1.1 Handling of Hazardous Materials 4.1.2 Toxic Materials (Various types of toxins and their effects on humans)

PSCHI EC-I 304	I	4.1.3 Explosives and Inflammable Materials 4.1.4 Types of fire extinguishers(chemical reaction) 4.1.5 Bioactive materials. 4.1.6 Recycling& recovery of metals with reference to Silver, lead, cobalt, Nickel and chromium 4.1.7 Laboratory Wastes Disposal Management in Chemical Laboratories .
	II	**4.2 Manufacture and Applications of Inorganic Compounds-I(15Lectures)** 4.2.1 Lime, Chlorine and Caustic soda, 4.2.2 Ceramics and refractory materials 4.2.3 Cement 4.2.4 Inorganic explosives (mercury fulminate, Lead azide)
	III	**4.3 Manufacture and Applications of Inorganic Compounds-II (15 Lectures)** 4.3.1 Fertilizers and micronutrients 4.3.2 Glass 4.3.3 Paints and Pigments
	IV	**4.4 Metallurgy (15 Lectures)** 4.4.1 Occurrence, extraction and metallurgy of Zirconium, Hafnium, Niobium, Tantalum Platinum and Palladium metals. 4.4.2 Physical and chemical properties and applications of these metals, 4.4.3 Compounds of these metals, alloys and their uses.
		REFERENCES: 1. G.M.Masters, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd. New Delhi, 1995. 2. Sulabha K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007. 3. K. R. Mahadik and B. S. Kuchekar, Concise Inorganic Pharmaceutical Chemistry, Nirali Prakashan, Pune, 19 . 4. D. A. Skoog, D. M. West, and F. J. Holler, Fundamentals of Analytical Chemistry, 7 th Edition, (printed in India in 2001), ISBN Publication. 5. B. Douglas, D.H. McDaniel and J. J. Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley & Sons, 1983.
	I	**4.1 Inorganic Materials (15 Lectures) Elective** (a) Classification, manufacture and applications of (i) Inorganic fibers, and (ii) Inorganic fillers. Study of (i) Condensed phosphates, and (ii) Coordination polymers. **(b) Preparation, properties and uses of industrially important chemicals** – potassium permanganate, sodium thiosulphate, bleaching powder, hydrogen peroxide, potassium

PSCHI EC-II 304		dichromate
	II	**4.2 Nuclear Chemistry and Inorganic Pharmaceuticals (15 Lectures)** **(a) Nuclear Chemistry :** **Introduction to** of nuclear fuels and separation of fission products from spent fuel rods by PUREX process. Super heavy element, discovery, preparation, position in the periodic table. **(b) Inorganic Pharmaceuticals :** Radiopharmaceuticals containing Tc and Bi, contrast agents for X-ray and NMR imaging. Gasrtrointestinal agents viz. (i) antacids(aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) Cathartics(magnesium sulphate and sodium phosphate). Topical agents viz.(i) protectives and adsorbents(talc, calamine), (ii) antimicrobial agents(potassium permanganate, tincture iodine, boric acid) and astringents(potash alum) .
	III	**4.3 Advances in Nanomaterials: (15 Lectures)** **(a) Types of nanomaterials**, e.g. nanotubes, nanorods, solid spheres, core-shell Inanoparticles, mesoporous materials; isolation of nano materials **(b) Some important properties of nanomaterials:** optical properties of metal and semiconductor nanoparticles, magnetic properties. **(c) Some special nanomaterials:** Carbon nanotubes: Types, synthesis using various methods, growth mechanism, electronic structure; Porous silicon: Preparation and mechanism of porous silicon formation, Factors affecting porous structure, properties of porous silicon; Aerogels: Types of aerogels, Properties and applications of aerogels. **(d) Applications of nanomaterials in** electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense. Environmental effects of nanotechnology
	IV	**4.4 Some Selected Topics (15 Lectures)** i) Isopoly and Hetropoly acids, **ii)** Supramolecular chemistry **iii)** Inorganic pesticides, and iv) Intercalation compounds
		REFERENCES: 1. G.M.Masters, Introduction to Environmental Engineering and Science, Prentice-Hall of India Pvt. Ltd. New Delhi, 1995. 2. Sulabha K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007. 3. K. R. Mahadik and B. S. Kuchekar, Concise Inorganic

		Pharmaceutical Chemistry, Nirali Prakashan, Pune, 19 . 4. D. A. Skoog, D. M. West, and F. J. Holler, Fundamentals of Analytical Chemistry, 7 th Edition, (printed in India in 2001), ISBN Publication. 5. B.Douglas, D.H. McDaniel and J.J.Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley & Sons, 1983.

PRACTICALS
SEMESTER-III

PSCHI3P1: Analysis of ores/alloys

1. Analysis of Brass alloy:
(i) Cu content by iodometric method,
(ii) Zn content by complexometric method.

2. Analysis of Mangelium alloy:
(i) Al content by gravimetric method as basic succinate,
(ii) Mg content by complexometric method.

3. Analysis of Bronze alloy:
(i) Cu content by complexometric method,
(ii) Sn content by gravimetric method.

4. Analysis of steel nickel alloy:
(i) Ni content by homogeneous precipitation method.

PSCHI3P2: Solvent Extraction

1. Separation of Mn and Fe using isoamyl alcohol and estimation of Mn
2. Separation of Co and Ni using n-butyl alcohol and estimation of Co
3. Separation of U and Fe using 8-hydroxyquinoline in chloroform and estimation of U
4. Separation of Fe and Mo using isoamyl alcohol and estimation of Mo
5. Separation of Cu and Fe using n-butyl acetate and estimation of Cu

PSCHI3P3: Inorganic Preparations

1. Preparation of V(oxinate)3
2. Preparation of Sn(IV) Iodide
3. Preparation of Co(α-nitroso-β-naphthol)3
4. Preparation of Ni(salicylaldoxime)2
5. Hexaamine cobalt (III) chloride
6. Preparation of Trans-bis (glycinato) Cu(II)

PSCHI3P4: Analysis of the following samples

1. Calcium tablet for its calcium content by complexometric titration.
2. Bleaching powder for its available chlorine content by iodometric method.
3. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method.
4. Calcium tablet for its calcium content by complexometric titration.
5. Bleaching powder for its available chlorine content by iodometric method.
6. Iron tablet for its iron content colorimetry by 1,10-phenonthroline method.

7. Nycil powder for its Zn content complexometrically.

Reference books for practicals

1. A. I. Vogel, *Quantitative Inorganic Analysis.*
2. J. D. Woolins, *Inorganic Experiments.*
3. Palmer, *Inorganic Preparations.*
4. G. Raj, *Advanced Practical Inorganic Chemistry.*
5. J. E. House, Inorganic chemistry, Academic press, 2nd edition, (2013).

		SEMESTER IV
Course Code	**Unit**	**Topics**
		(Numericals and word problems wherever possible.)
PSCHI 401	**I**	**1 Properties of Inorganic Solids and Group Theory.** **1.1 Electrical Properties- (15 Lectures)** **(a) Electrical properties of solids:** (i) Conductivity: Solid Electrolytes; Fast Ion Conductors; Mechanism of Conductivity; Hopping Conduction. **(b) Other Electrical Properties:** Thomson and Seebeck Effects; Thermocouples and their Applications; Hall Effect; Dielectric, Ferroelectric, Piezoelectric and Pyrroelectric Materials and their Inter-relationships and Applications
	II	**1.2 Magnetic Properties. (15 Lectures)** (a) Behaviour of substances in magnetic field, mechanism of ferromagnetic and antiferromagnetic ordering , superexchange, Hysteresis, Hard and soft magnets, structures and magnetic Properties of Metals and Alloys; Transition metal Oxides; Spinels; garnets, Ilmenites; Perovskite and Magneto plumbites, Application in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets.
	III	**1.3 Thermal and Optical Properties (15 Lectures)** **a) Thermal Properties:** Introduction, Heat Capacitiy and its Temperature Dependance; Thermal Expansion of Metals; Ceramics and Polymers and Thermal Stresses. **(b) Optical properties:** Color Centres and Birefringence; Luminescent and Phosphor Materials; Coordinate Model; Phosphor Model; Anti Stokes Phosphor; Ruby Laser; Neodymium Laser
		1.4 Applications of group theory to –Electronic structures (15

	IV	**Lectures)** (a) Recapitulation of Points groups and Character tables. (b) Transformation Properties of Atomic Orbitals; (c) Sigma and pi- molecular orbitals for AB_4 (tetrahedral) and AB_6 (octahedral) molecules; (d) **Ligand Field Theory :** Electronic structures of free atoms and ions; Splitting of levels and terms in a chemical environment; Construction of energy level diagrams; Direct product ; Correlation diagrams for d^2 ions in octahedral and tetrahedral ligand field; Methods of Ascending and Descending Symmetry; Hole formalism.
		REFERENCE BOOKS 1. L. E. Smart and E. A. Moore, Solid State Chemistry-An introduction, 3rd edition, Taylor and Francis, 2005. 2. A.R.West, Solid State Chemistry and Its Applications, John Wiley & sons, 1987. 3. C.N.R. Rao and J.Gopalkrishnan New Directons in Solid State Chemistry, 2nd Ed., Combridge University Press. 1997 4. L.V. Azaroff, Introductionn to solids, Tata-McGraw Hill Book Ce. New Dehli, 1977. 5. . D.W. Bruce and Dermont O Hare, Inorganic Chemistry, 2nd Ed. Wiely and sons, New York, 1966. 6. J.M. Hollas, Symmetry in Molecuies, Chapman adn Hall Ltd.,1972. 7. Reboert L carter, Molecular Symmeetry and Group Hohn Wiley and Sons, New York, 1988. 8. Ulrich Muller, Inorganic structural Chemistry, 2nd edition, John Wiley and Sons, Chichester, 1993. 9. . R.N.Kutty and J.A.K.Tareen, Fundamentals of Crystal Chemistry, Universities Press (India) Ltd., 2001.. 10. H.V.Keer, Principles of the Solid state, Wiley Eastern Ltd., 1993. Gary L.Miessler and Donald A.Tarr, Inorganic Chemistry, 3rd edition , Pearson Education, Inc., 2004. 11. . D.K.Chakraborty, Solid State Chemistry, New Age International Publishers, 1996. 12. 12. A. Earnshaw, Introduction to Magnetochemistry, Acad. Press,N.Y. (1966)
	I	**2 Organometallics and main group Chemistry (15 Lectures)** **2.1 Organometallic Chemistry** (a) Metal-Metal Bonding and Metal Clusters, (b) Electron Count and Structures of Clusters,, (c) Isolobal Analogy. (d)Organo Palladium and Organo Platinum Complexes (preparations, properties and applications.)
		2.2 Applications of Organometallic Compounds (15 Lectures)

PSCHI 402	**II**	(a) Catalysis-Homogenous and Heterogenous Catalysis: Comparison, Fundamental Reaction Steps. (b) Organometallics as Catalysts in Organic Reactions: (i)Hydrosilation, (ii)Hydroborationn. (iii)_Water gas Shifts Reaction (iv) Wacker process(Oxidation of alkenes) (v)Alcohol corbonylation (c)Coupling reactions : (i) Heck's reaction (ii) Suzuki reaction
	III	**2.3 Inorganic cluster and cage compounds (15 Lectures)** (i) Introduction, (ii) Bonding in boranes, (iii) Heteroboranes, (iv) Carboranes, (v) cluster compounds, (vi) electron precise compounds and their relation to clusters.
	IV	**2.4 Inorganic ring and chain compounds (15 Lectures)** (a) Silicates, polysilicates and aluminosilicates, (b) Phosphazenes, phosphazene polymers (c) Polyanionic and polycationic compounds
		REFERENCES: 1. Gary Wulfsberg, Inorganic Chemistry ; Viva Books PA Ltd., New Delhi; 2002. 2. F.A. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd edition. 3. James E.Huheey, Inorganic Chemistry, 3rd edition, Harper & Row,Publishers, Asia, Pte Ltd., 1983. 4. W.W.Porterfield,Inorganic Chemistry-An Unified Approach,Academic press(1993); 5. D.F.Shriver, P.W.Atkins and C.H. Langford, Inorganic Chemistry,3rd edition Oxford University Press, 1999. 6. Asim K.Das, Fundamental Concepts of Inorganic Chemistry,(Volumes-I,II and III)CBS Pub.(2000) 7. N.N.Greenwood and A.Earnshaw, Chemistry of Elements, Pergamon, 1984. 8. J.M.Hollas, Symmetry in Chemistry, Chapmanad Hall Ltd., NY, 1972.\ 9. F.A.Cotton, Chemical Applications of Group Theory, 2nd edition, Wiley Eastern Ltd., New Delhi , 1976 10. C.J.Ballhausen and H.B.Gray, Molecular Orbital Theory, MCGraw-Hill, New York, 1965. 11. H. Sisler, Chemistry in Non-aqueous Solvents: New York Reinhold Publ. 1965. 12. . J.J. Lagowski, The Chemistry of Non-aqueous Solvents, Academic press, New york and London. 13. . C.M. Day and Joel Selbin, Theoretical Inorganic Chemistry,Affiliated East West Press Pvt.Ltd., 1985. 14. L.E.Orgel, An Introduction to Ligand Field Theory , Methuen &

		Co.Ltd., London, 1960. 15. F.Basolo and R.G.Pearson, Mechanisms of Inorganic Reactions,Wiley, New York, 1967. 16. . J.D.Lee, Concise Inorganic Chemistry, 5th ed., Blackwell ScienceLtd., 2005. 17. R.H. Crabtree, The Organometallic Chemistry of the Transition Metals, Wiley-Interscience, New york, 1988. 18. G.W.Parshall and S.D.Ittel, Homogeneous Catalysis, 2nd edition,John Wiley & sons, Inc., New York, 1992. 19. Gary O. Spessard and Gary L.Miessler, Organometallic Chemistry,Prentice-Hall, (1997). 20. . R.C.Mehrotra and A.Singh, Organometallic Chemistry-A UnifiedApproach, 2nd ed., New Age International Pvt.Ltd., 2000. 21. B.Douglas, D.H. McDaniel and J.J.Alexander, Concepts and Models of Inorganic Chmistry, 2nd edition, John Wiley & Sons,1983. 22. James E.Huheey, Inoganic Chemistry-Principles of structure and reactivity, edn Harper & Row Publishers (1972). 23. . F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann,Advanced Inorganic Chemistry, 6th ed., John Wiley, New York,1999. 24. F.A. Cotton and R.A.Walton, Multiple Bonds between MetalAtoms, 2nd edition, claranden Press, Oxford, 1993. 25. P.L. Soni, Vandana Soni ,Ane Books Pvt.,Ltd
PSCHI 403	**I**	**3 Instrumental methods in Inorganic Chemistry .** **3.1 Spectroscopy (15 Lectures)** **(a) Infrared spectroscopy:** Fundamental modes of vibrations, selection rules, IR absorption bands of metal - donor atom, effect of complexation on the IR spectrum of ligands formations on the IR of ligands like NH_3, CN^-, CO, olefins (C=C) and $C_2O_4^{2-}$. **(b) Raman spectroscopy:** Raman spectroscopy for diatomic molecules.Determination of molecular structures like diatomic and triatomic molecules.
		(c) Applications of Group theory in Infrared and Raman spectroscopy. (c) Molecular Vibrations: Introduction; The Symmetry of Normal Vibrations; Determining the Symmetry Types of the Normal Modes; symmetry based Selection Rules of IR and Raman; Interpretation of IR and Raman Spectra for molecules such as H_2O, BF_3, N_2F_2, NH_3 and CH_4.
		(d) Nuclear Magnetic Resonance Spectroscopy : Introduction to basic principles and instrumentation. Use of ^{1}H, ^{19}F, ^{31}P, ^{11}B NMR spectra in structural elucidation of inorganic compounds; Spectra of paramagnetic materials: Contact shift, application of contact shift, lanthanide shift reagent.
	II	**3.2 Microscopy of Surface Chemistry-I (15 Lectures)** Introduction to surface spectroscopy, Microscopy, problems of surface analysis, distinction of surface species, sputter etching and depth profile and chemical imaging,instrumentations, Ion Scattering Spectra (ISS), Secondary Ion Mass Spectroscopy (SIMS),Auger Emission Spectroscopy

		(AES),
	III	**3.3 Microscopy of Surface Chemistry-II (15 Lectures)** ESCA, Scanning Electron Microscopy (SEM),Atomic force microscopy (AFM) and transmission electron microscopy (TEM): Instrumentation and applications.
	IV	**3.4 Thermal Methods (15 Lectures)** 3.4.1 Application of TGA in Thermal characterization of polymers, quantitative analysis of mixture of oxalates, moisture content in coal, study of oxidation state of alloys etc. 3.4.2 Application of DSC and DTA in determination of thermodynamic parameters such as heat capacity and standard enthalpy of formation of the compounds, investigation of phase transitions, thermal stability of polymeric materials, purity of pharmaceuticals samples, M.P. and B.P. of organic compounds etc. 3.4.3 Basic principle, instrumentation and applications to other thermal methods like Thermomechanical analysis (TMA) and evolved gas analysis (EGA).

REFERENCES:

1. G. H. Jeffery, J. Bassett, J. Mendham and R. C. Denney, Vogel's Textbook of Quantitative Chemical Analysis Fifth edition, (1996),ELBS Publication. Chapter 2, 3, 11.
2. W.H. Zachariasen. Theory of X-Ray Diffration in Crystals. JohnWiley. New York. 1946.
3. B.D. Cality,, Elements of X-Ray Diffraction Procedures. John Wiley and Sons. New York, 1954.
4. R. Reaching, Electron Diffraction, Methuen and Co. London. 1936
5. May and Leopold, An Introduction to Mossbauer Spectroscopy,Plenum, New York, 1971.
6. H.H. Willard, L.L. Merrit, J.A. Dean and F.A. Settle, Instrumental Methods of Analysis, C.B.S. Publishers and Distributors, New Delhi, 1986.
7. P.J. Horne, Nuclear Magnetic Resonance. Oxford University Press, Oxford, 1995.
8. Reverts John D., Nuclear Magnetic Resonance, McGraw Hill, NewYork, 1959.
9. . H. Kambe and P.D.Garn. Thermal Analysis, Kondansha Ltd. Toyo,1974.
10. G.W. Ewing, Instrumental Methods, Of Analysis, 4th Ed. McFraw Hill Ltd., 1970.
11. N.H. Ring, Inorganic Polymers, Academic Press, New York, 1978
12. H.G. Heal, The Inorganic Heterocyclic Chemistry of Sulphur, Nitrogen and Phosphorous, Academic Press, New York, 1980.
13. G.T. Seaborg, Man-made Transuranic Elements Preitce- Hall, 1963.
14. M.T.R. Series, The Superheavy Elements.

		15. Haissilsky, Nuclear Chemistry and its Application, 1962. 16. S. Glasstone, Sourcebook of Aomic Energy, East-West Publisher,1969. 17. D.Harvey,Modern Analytical Chemistry, The McGraw-Hill Pub,1st Edition(2000); 18. John H. Block, E.B. Roche, T.P.Soine and Charles O.Wilson, Inorganic Medicinal and Pharmaceutical Chemistry, Lea and Febiger, 1974. 19. R. S. Drago, Physical Methods in Inorganic Chemistry, John-Wiley Pub.,1975 20. . M. Drescher an G. Jeschke,(Eds), EPR Spetroscopy: Applications in Chemistry and Biology, Springer-Verlag Berlin, Heidelberg 2012 21. Graham Smith; David Keeble.Introduction to Modern EPR Spectroscopy CRC Press 2013. 22. C.N.R. Rao, Chemical Applications of Infrared Spectroscopy Academic Pess,N.Y.(1963 23. K. Veera Reddy, Symmetry and Spectroscopy, 24. Paul Gabbott Principles and Applications of Thermal Analysis Wiley-Blackwell ; edition (2007) 25. . Richard Vernon Parish, NMR, NQR, EPR, and Mössbauer spectroscopy in inorganic chemistry, Publisher,E,.Horwood,(1990)

Course Code: PSCHIOC-I 404
Paper – IV (<u>INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS</u>)

Unit 1: **[15L]**

Introduction to Intellectual Property: [2L]

[2L]

Historical Perspective, Different types of IP, Importance of protecting IP.

Patents: [5L]

[5L]

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

Industrial Designs: [2L]

[2L]

Definition, How to obtain, features, International design registration.

Copyrights: [2L]

[2L]

Introduction, How to obtain, Differences from Patents.

Trade Marks: [2L]

[2L]

Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc.

Geographical Indications: [2L]

[2L]

Definition, rules for registration, prevention of illegal exploitation, importance to India.

Unit 2: [15L]

[15L]

Trade Secrets: [2L]

[2L]

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

IP Infringement issue and enforcement: [2L]

[2L]

Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.

Economic Value of Intellectual Property: [2L]

[5L]

Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.

Different International agreements:

[6L]

(a) World Trade Organization (WTO): [5L]

(i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement

(ii) General Agreement on Trade Related Services (GATS) Madrid Protocol.

(iii) Berne Convention

(iv) Budapest Treaty

(b) Paris Convention [6L]

WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.

Unit III: [15L]

[15L]

Introduction to Cheminformatics: [5L]

[5L]

History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.

Representation of molecules and chemical reactions: [5L]

[5L]

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching Chemical Structures: [5L]

[5L]

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit IV: [15L]

[15L]

Applications:

Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial

Libraries, Ligand-based and Structure based Drug design, Application of Cheminformatics in Drug Design.

REFERENCES:

1. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.

Course Code: PSCHIOC-II 404

PAPER – IV: RESEARCH METHODOLOGY

Unit 1:

[15L]

Print:

[5L]

Primary, Secondary and Tertiary sources.

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital:

[5L]

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources:

[5L]

The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.

Unit II: DATA ANALYSIS

[15L]

The Investigative Approach:

Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.

Analysis and Presentation of Data:

Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.

Unit III: METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS

[15L]

Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.

Writing Scientific Papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.

Unit IV: CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS

[15L]

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressur, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry,* 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* Oxford University Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) *How to use Excel in Analytical Chemistryand in general scientific data analysis* Cambridge Universty Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

PRACTICALS
SEMESTER-IV

PSCHI4P1: Analysis of Ores

1. Analysis of galena ore:
   (i) Pb content as PbCrO4 by gravimetric method using 5% potassium chromate,
   (ii) Fe content by colorimetrically using 1, 10- phenonthroline.
2. Analysis of Zinc blend ore:
   (i) Zn content by complexometric method,
   (ii) Fe content by colorimetric method (Azide method).
3. Analysis of Pyrolusite ore:
   (i) Mn content by complexometric method,
   (ii) Acid insoluble residue by gravimetric method.

PSCHI4P2: Coordination Chemistry

1. Determination of Stability constant of $[Zn(NH_3)_4]^{2+}$ by potentiometry
2. Determination of Stability constant of $[Ag(en)]^+$ by potentiometry
3. Determination of Stability constant of $[Fe(SCN)]^{2+}$ by slope ratio method
4. Determination of CFSE values of hexa-aqua complexes of Ti^{3+} and Cr^{3+}.
5. Determination of Racah parameters for complex $[Ni(H_2O)_6]^{2+}$ and $[Ni(en)_3]^{2+}$

PSCHI4P3: Analysis of the following samples

1. Electral powder for Na/K content flame photometrically.
2. Fasting salt for chloride content conductometrically.
3. Sea water for percentage salinity by Volhard's method.
4. Soil for mixed oxide content by gravimetric method.
5. Fertilizer for potassium content by flame photometry.

PSCHI4P4: Project Evaluation & Spectral interpretation

Reference books for practicals	
1.	A. I. Vogel, *Quantitative Inorganic Analysis.*
2.	J. D. Woolins, *Inorganic Experiments.*
3.	Palmer, *Inorganic Preparations.*
4.	G. Raj, *Advanced Practical Inorganic Chemistry.*
5.	J. E. House, Inorganic chemistry, Academic press, 2^{nd} edition, (2013).