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).

(Prof. Sunil Bhirud)
I/c. REGISTRAR

MUMBAI – 400 032
13th July, 2023

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

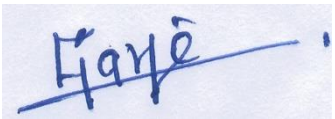
(The learner should draw diagrams and write-ups providing uses of the items mentioned in (a and b) and Principle, Construction care and Uses of items (c) to (f) in his journal.)

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.



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