Assam University, Silchar

Four Year Undergraduate Programme

CHEMISTRY

Implemented under NEP 2020

Effective from the Academic Year 2023-24

Approved in the 94th meeting of the Academic Council on 20th July 2023 vide Resolution No AC: 94:07-23:6

Contents

Abbreviations

1. **DSC** Discipline Specific Core Course
2. **DSM** Discipline Specific Minor
3. **IDC** Interdisciplinary Course
4. **AEC** Ability Enhancement Course
5. **SEC** Skill Enhancement Course
6. **VAC** Value Added Course

Four Years UG-Course Curriculum as per NEP scheme 2020
Chemistry

Year	Sem	Paper code	Name of the Paper	Th/Pract	Credits	Marks
1	I	DSC-101	Inorganic Chemistry-I *(Atomic Structure, Chemical Bonding and Metallurgy)*	Theory	3	100
		DSC-102	Physical Chemistry-I *(State of Matter and Solution)*	Theory	3	100
		DSM-101	Fundamentals in Chemistry-I	Theory	3	100
		SEC-101	Separation Techniques	Theory	3	100
		IDC-101	Application of Chemistry in Everyday life	Theory	3	100
		AEC-I	MIL-101	Theory	2	50
		VAC-101	NSS/NCC/DTS/Sports/HW/Yoga/GCS/UI	Theory	3	100
			TOTAL		**20**	**650**
	II	DSC-151	Organic Chemistry -I *(Introductory Organic Chemistry)*	Theory	3	100
		DSC-152	Inorganic, Organic and Physical chemistry	Practical	3	100
		DSM-151	Fundamentals in Chemistry	Theory	3	100
		SEC-151	Basic Analytical Chemistry	Theory	3	100
		IDC-151	Indian Chemistry Through the Ages	Theory	3	100
		AEC-II	EL-151	Theory	2	50
		VAC-151	Environmental Studies (EVS)	Theory	3	100
			TOTAL		**20**	**650**
Certificate Course in Introductory Chemistry						
2	III	DSC-201	Inorganic Chemistry-II *(s-, p-block Elements, Coordination Chemistry and its Application)*	Theory	4	100
		DSC-202	Organic Chemistry -II *(Functional Group Chemistry)*	Theory	4	100
		DSM-201	Fundamentals in Chemistry-II	Theory	4	100
		SEC-201	Forensic Chemistry	Theory	3	100

		IDC-201	Heritage of Indian Metallurgy	Theory	3	100
		AEC-III	MIL-201	Theory	2	50
			TOTAL		**20**	**550**
	IV	DSC-251	Physical Chemistry-II	Theory	4	100
		DSC-252	Inorganic & Analytical Chemistry-III	Theory	4	100
		DSC-253	Org, Inorg & Phy Chemistry	Practical	4	100
		DSM-251	Org, Inorg & Phy Chemistry	Practical	3	100
		DSM-252	Fundamentals in Chemistry-II(DSM-201)	Theory	3	100
		AEC-IV	MIL-201	Theory	2	50
			TOTAL		**20**	**550**
Diploma in Chemical Science						
3	V	DSC-301	Photochemistry and Quantum Chemistry	Theory	4	100
		DSC-302	Organic Chemistry -III *(Heterocyclic, Biochemistry, Natural products and photochemistry)*	Theory	4	100
		DSC-303	Org, Inorg & Phy Chemistry	Practical	4	100
		DSM-301	Fundamentals in Chemistry-III	Theory	3	100
		DSM-302	Fundamentals in Chemistry-III (DSM-301)	Theory	3	100
			Internship with Industry / Community Engagement / Field Study	Theory	2	50
			TOTAL		**20**	**550**
	VI	DSC-351	Advance Material	Theory	4	100
		DSC-352	Spectroscopy (Theory and application)	Theory	4	100
		DSC-353	Physical Chemistry-III	Theory	4	100
		DSC-354	Org, Inorg & Phy Chemistry	Practical	4	100
		DSM-351	Org, Inorg & Phy Chemistry (DSM-251)	Practical	4	100
			TOTAL		**20**	**500**
B. Sc. Degree in Chemistry						
4	VII	DSC-401	Selected topics in Chemistry-I	Theory	4	100

		DSC-402	Selected topics in Chemistry-II *(Reagents & reactions, Green chemistry)*	Theory	4	100
		DSC-403	Org, Inorg & Phy Chemistry	Practical	4	100
		DSC-404	Org, Inorg & Phy Chemistry	Practical	4	100
		DSM-401	Fundamentals in Chemistry-IV	Practical	4	100
			TOTAL		**20**	**500**
	VIII	DSC-451	Research Methodology (with research)/ Selected topics in Chemistry-III	Theory	4	100
		DSC-452	Applied Chemistry	Theory	4	100
		DSC-453	Chemistry in everyday life	Theory	4	100
		DSC-454	Instrumental Techniques	Theory	4	100
		DSM-451	Fundamentals in Chemistry-IV (DSM-451)	Theory	4	100
			TOTAL		**20**	**500**
B. Sc. Degree in Chemistry with Honours						
			OR			
	VIII	DSC-451	Research Methodology (with research)/ Selected topics in Chemistry-III	Theory	4	100
		DSM-451	Fundamentals in Chemistry-IV (DSM-451)	Theory	4	100
			Research Project / Dissertation		12	300
			TOTAL		**20**	**500**
B. Sc. Degree in Chemistry with Honours and Research						

NOTE:-

1. One Credit means one hour of theory or Two hours of Laboratory work/ Field Study/ Dissertation per week.
2. 30 marks of all theory papers *(Credits 3 or 4)* have Internal Assessment (Unit test 20 marks and Attendance 10 marks) except AEC-I, II & III paper.
3. Same subject cannot be selected as DSC, DSM and IDC. Students should opt for two DSM, one as first minor and other as second minor.
4. SEC shall have to be opted from either DSC or DSM.

CHEMISTRY
(Major)
(1st Semester)
Course No.: **CHM-DSC-101**
(Inorganic Chemistry -I)
Atomic Structure, Chemical Bonding and Metallurgy
Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-1: Atomic structure

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f- orbitals. Contour boundary and probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations.

UNIT-2: Periodicity of Elements

s–, *p*–, *d*–, *f*– block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s*– & *p*– block.

(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

(b) Atomic radii (van der Waals)

(c) Ionic and crystal radii.

(d) Covalent radii (octahedral and tetrahedral)

(e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.

(f) Electron gain enthalpy, trends of electron gain enthalpy.

(g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.

UNIT-3: Chemical Bonding-I

(i) *Ionic bond*: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond*: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Resonance and

resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ– and π– bond approach) and bond lengths.

Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization.

Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

UNIT-4: Chemical Bonding-II

(i) *Metallic Bond*: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

(ii) *Weak Chemical Forces*: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Hydrogen bonding (theories of hydrogen bonding, valence bond treatment).

UNIT-5: Oxidation-Reduction and Principles of Metallurgy

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Principles involved in volumetric analysis: Fe (II) and oxalic acid using standardized $KMnO_4$ solution, Fe (II) with $K_2Cr_2O_7$ solution.

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic processes and Mond's process, Zone refining.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Lee, J. D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B. E. and Mc Daniel, D. H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
- Day, M. C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

CHEMISTRY
(Major)
(1st Semester)
Course No.: **CHM-DSC-102**
(Physical Chemistry -I)
States of Matter and Solution
Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Unit 1: Gaseous State I

Postulates of Kinetic theory of Gases and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartitions of energy and degrees of freedom.

Unit 2: Gaseous State II

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Vander Waals equation of state, its derivation and application in explaining real gas behaviour. PV isotherm of Carbon dioxide, critical state, relation between critical constants and van der Waals constants, law of corresponding states, liquefaction of gas, inversion temperature.

Unit 3: Liquid State

Physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Interficial tension, Surface active agent, Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases.

Unit 4: Solid State

Types of crystal, space lattice, unit cell, seven crystal systems, fourteen Bravais lattices, law of constancy of interfacial angles, law of rational indices, Miller indices, and; X-ray diffraction, Bragg's law. Defects in crystals, Colour center, Energy band theory of Conductor, Semiconductors and insulators, Glasses, liquid crystal and their phases (Nematic, Smectic A and Smectic C)

Unit 5: Solutions

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. Distillation of solutions. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids-Principle of steam distillation. Nernst distribution law and its applications, solvent extraction

Reference Books

- Puri, Sharma, Pathania; Principles of Physical Chemistry, Vishal Publishing Co. 45th edition (2011)
- Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13
- (2006).
- Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

CHEMISTRY
(Minor)
(1st Semester)
Course No.: **CHM-DSM-101**
(Fundamentals of Chemistry -I)
Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-I: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m*l* and m*s*. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m*s*).
Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

UNIT-II : Chemical Bonding and Molecular Structure

Ionic Bonding

General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding

Valence Bond Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

Molecular Orbital Approach

Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

UNIT-III: Gases

Gases: Kinetic Theory of Gases: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. Vander Waals equation of state for real gases. Most probable, average and root mean square velocities (no derivation). Collision number and mean free path of molecules.

UNIT-IV: Liquids and Solids

Liquids: Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

Solids: Forms of solid: covalent solid, molecular solid, ionic solid, Different types of cubic Unit cells, crystal systems, Bravais lattice types. Defects in crystals: line defect, point defect, Schottky & Frenkel Defect.

UNIT-V: Fundamentals of Organic Chemistry

Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting *p*K values. Aromaticity: Benzenoids and Hückel's rule.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Puri, Sharma, Pathaniaa; Principles of Physical Chemistry, Vishal Publishing Co. 45th Edition(2011)
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.

CHEMISTRY
(Skill Development Course)
(1st Semester)
Course No.: **CHM-SEC-101**
Separation Techniques
Contact Hours: 60; Credits: 03
Full Marks = 100 [End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit-1: Solvent based Techniques
Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions.

Unit-2: Chromatographic Techniques
Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption. Development of chromatograms: frontal, elution and displacement methods, Rf value. Qualitative and quantitative aspects of chromatographic methods of analysis: Paper, TLC, Column Chromatography and HPLC

Unit-3: Stereoisomeric separation and analysis
Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Unit-4: Ion exchange Chromatography
Introduction, classification, ion exchange resins, properties, mechanism of ion exchange process, factors affecting ion exchange, methodology and applications.

Unit-5: Case Studies (Demonstration suggested)
Techniques involved in separation and purification of components of binary solid mixture, Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p-Aminobenzoic acid; p-Nitrotolune/p-Anisidine based on the solubility in common laboratory reagents.
Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
Separation of a mixture of two sugars by ascending paper chromatography
Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Suggested Readings

- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles
- Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974

CHEMISTRY
(Interdisciplinary)
(1st Semester)
Course No.:**CHM-IDC-101**
(Fundamentals of Chemistry -I)
Application of Chemistry in Everyday life
Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit 1: Vitamins, minerals and enzyme

Classification and nomenclature of vitamins. Need for vitamin in body, Types of vitamins, water soluble and fat-soluble vitamins, Sources, deficiency diseases and structures of vitamin A1, vtamin B12, Vitamin C (Cyanocobalamine), vitamin D vitamin E and vitamin K. Role of minerals in body, iodine deficiency and remedy.

Classification and nomenclature, prosthetic groups, cofactors of enzyme, properties of enzymes as catalysts, specific activity, turn over number and catalytic center activity. Isolation of enzymes from different sources.

Unit 2: Respiration and energy production in human body

Respiration, Respiratory enzymes, brief outline of hemoglobin and myoglobin, oxygen transport mechanism in body, co-operativity, Respiration in lower animals, hemocyanine, hemerythrine. Energy production in body, ATP, enzyme responsible for food digestion, mechanism of food digestion, active site of cytochrome c-oxidase.

Unit 3: Food and food preservation

Basics of human physiological system and food science: digestive system: structure and functions of G.I. tract. Process of digestion and absorption of food, structure and function of liver, gall bladder and pancreas. Basic concept on food, nutrition and nutrients (nutrition, malnutrition and health scope of nutrition). Classification of food, classification of nutrients.

Definition, objectives and principles of food preservation. Different methods of food preservation. Preserved products: jam, jelly, Marmalade, sauces, pickles, Squashes, syrupstypes, composition and manufacture, selection, cost, storage, uses and nutritional aspects. Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI.

Unit 4: Food additives, adulterants and contaminants

Defination, objectives and principles of food additives, adulterants and contaminants. Defferent types of food additives (benzoates, propionates, sorbates, disulphites), artificial sweeteners (aspartame, saccharin, dulcin, sucralose and sodium cyclamate), flavours [vanillin, alkyl esters (fruit flavours) and monosodium glutamate].

Artificial food colorants: coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food.

Unit 5: Chemistry of Materials:

Soaps and Detergents – their action, Biofuels – production of biofuels and its utility as alternative fuel source, Fibers: natural fibers, cotton, wool, silk, rayon, artificial fibers, polyamides, acrylic acid, PVC, Examples of natural biodegradable polymers, cellulose,

cellulose acetate, cellophane, synthetic biodegradable polymers. Use of polymeric materials in daily life.

Reference Books:

1. Srilakshmi B (2017): Nutrition Science,6th Multicolour Ed. New Age International (P) Ltd.
2. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford University Press.
3. Mann J and Truswell S (2017): Essentials of Human Nutrition, 5th Ed. Oxford University Press.
4. Ashtoush Kar: Medicinal Chemistry, New Age International Publishers, 7th edition (2018).
5. Sadasivan S and Manikam K (2007): Biochemical Methods, 3rd Ed. New Age International (P) Ltd.
6. N. Shakuntala Many and S. Swamy: Foods-, Facts and Principles, New Age International Publishers, 4th edition (1998).
7. B. Srrilakshmi: Nutrition Science, New Age International Publishers, 6th edition (2016).
8. Subalakshmi, G and Udipi, SA (2006): Food processing and preservation, 1st Ed. New Age International (P)Ltd.
9. S. N. Mahindru,: Food Additives: Characteristics, Detection and Estimation, Aph Publishing Corporation, New Delhi (2008)
10. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S. (1994) Bioinorganic Chemistry. University Science Books (1994)

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CHEMISTRY
(Major)
(2nd Semester)
Course No.:**CHM-DSC-151**
(Organic Chemistry -I)
Introductory Organic Chemistry
Contact Hours: 60; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

UNIT-1: Basics concepts in Organic Chemistry

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

UNIT-2: Aliphatic Hydrocarbon

Formation of alkanes, Wurtz Reaction, Corey House synthesis, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Electrophilic additions their mechanisms (Markownikoff / Anti Markownikoff addition), ozonolysis, reduction (catalytic and chemical). 1, 2-and 1, 4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl Benzene.

Alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

UNIT-3: Aromatic and Polynuclear hydrocarbon

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/ carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Polynuclear hydrocarbons, Reactions of naphthalene, phenanthrene and anthracene. Preparation, structure elucidation and important derivatives of naphthalene and anthracene; Annulens.

UNIT-4: Stereochemistry and Conformation analysis

Fischer, Newmann and Sawhorse Projection formulae and their inter-conversions;

Geometrical isomerism: *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 or more chiral-centres, diastereoisomers, meso structures, racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Conformation analysis of alkanes: Types of cycloalkanes and their relative stability, Baeyer strain theory, Relative stability, Energy diagrams of cyclohexane, monosubstituted, 1,2-, 1,3-, 1,4-disubstituted cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams, Strain-less ring theory.

UNIT-5: Carbohydrates

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani Fischer synthesis and Ruff and Wohl degradation;

Disaccharides – Structure elucidation of sucrose, lactose

Polysaccharides – Elementary treatment of starch and cellulose.

Reference Books:

- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

CHEMISTRY

(Major)

(2nd Semester)

Course No.:**CHM-DSC-152**

Practical

(Inorganic, Organic and Physical Chemistry)

Contact Hours: 45; Credits: 03

Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Examination Time: 18 hours (3 days)

Section-A (Inorganic Chemistry)

1(a). Inorganic preparation and reactions **10 marks**

i) Preparation of Chrome alum

ii) Tetraamminecopper(II) sulphate

iii) Sodium Trioxalatochromate (III)

iv) Preparation of Aluminium potassium sulphate, Potash alum

v) Preparation of Manganese (III) phosphate

1(b). Titrimetric Analysis **10 Marks**

i) Calibration of glass ware, pipette, burette and volumetric flask.

ii) Preparation of solutions of different Molarity / Normality

Section-B (Organic Chemistry)

2. Preparation of derivative **20 Marks**

Prepare a derivative of the given organic compound containing monofunctional group, recrystallize the derivative and determine the melting point.

Functional group

a) -COOH (ester/amide/anhydride)
b) -CHO/ -CO- (phenyl hydrazone)
c) -OH (benzoate)
d) $-NH_2$ (benzamide)
e) $-NO_2$ (reduction/

Section-C (Physical Chemistry)

3. Any *two experiment out of the following can set in examination* 15+15=30Marks

a) To determine the surface tension of glycerol/acetic acid Solutions at different concentrations and construction of graph.

b) To determine the viscosity of glycerol/acetic acid Solutions at different concentrations and construction of graph.

c) Determination of transition temperature of the given substance by thermometric method (e.g., $MgSO_4/MnCl_2/Na_2SO_4.10H_2O$).

d) To determine the solubility of Salt ($BaCl_2$, KCl, KNO_3) in water at room temperature.

e) To determine the refractive index of a given liquid by Abbe refractometer and to find the specific and molar refraction.

Internal Assessment

4. Viva-voce 15 marks

5. Regularity in maintenance of Lab Note Book 5 marks

6. Attendance 10 marks

Reference Books:

- Vogel, A. I., A Textbook of Quantitative Inorganic Analysis, ELBS.
- Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
- Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
- Vogel, A. I., A Textbook of Qualitative Organic Analysis, ELBS.
- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
- Jadav, J. B., Advance Physical Practical Chemistry, Goel Publishing House, New Delhi (1981)
- Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CHEMISTRY
(Minor)
(2nd Semester)
Course No.:**CHM-DSM-151**
(Fundamentals of Chemistry -I)
Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-I: Atomic Structure

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m*l* and m*s*. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m*s*).
Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

UNIT-II : Chemical Bonding and Molecular Structure

Ionic Bonding

General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding

Valence Bond Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

Molecular Orbital Approach

Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

UNIT-III: Gases

Gases: Kinetic Theory of Gases: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. Vander-Waals equation of state for real gases. Most probable, average and root mean square velocities (no derivation). Collision number and mean free path of molecules.

UNIT-IV: Liquids and Solids

Liquids: Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

Solids: Forms of solid: covalent solid, molecular solid, ionic solid, Different types of cubic Unit cells, crystal systems, Bravais lattice types. Defects in crystals: line defect, point defect, Schottky & Frenkel Defect.

UNIT-V: Fundamentals of Organic Chemistry

Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting *p*K values. Aromaticity: Benzenoids and Hückel's rule.

Reference Books

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Puri, Sharma, Pathaniaa; Principles of Physical Chemistry, Vishal Publishing Co. 45th Edition
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.

CHEMISTRY

(Skill Development Course)

(2nd Semester)

Course No.:**CHM-SEC-151**

Basic Analytical Chemistry

Contact Hours: 60; Credits: 03

Full Marks = 100 [End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit-1: Basic Concepts

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements, significant figures. Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC, Developing reagent.

Unit-2: Analysis of Soil and Water

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification method.

Unit-3: Analysis of Cosmetics

Definition of Cosmetics, historical background, classification. Major and minor constituents of cosmetics and their function. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Unit-4: Analysis of Food

Analysis of food products: Nutritional value of foods, food preservations and adulteration. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. Analysis of preservatives and colouring matter.

Unit-5: Case Studies (Demonstration suggested)

Collection of water sample and determination of pH, acidity and alkalinity, dissolved oxygen (DO) of a water sample. Collection of soil sample from a study area, estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration .Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.

Suggested Readings

- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.
- Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
- Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.

- Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
- Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
- Vogel, A. I. Vogel's Quantitative Chemical Analysis 6 th Ed., Prentice Hall.
- Robinson, J.W. Undergraduate Instrumental Analysis 5 th Ed., Marcel Dekker, Inc., New York (1995).

CHEMISTRY
(Inter Disciplinary Course)
(2nd Semester)
Course No.:**CHM-IDC-151**

Indian Chemistry Through the Ages

Contact Hours: 60; Credits: 03
Full Marks = 100 [End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-I: Basic Concepts in Chemistry
Matter, elements, atoms, and molecules. Metal and Non-Metals, The structure of the atom, Chemical Bonding (covalent, Ionic, co-ordinate) with examples, Lewis structural representation, Melting and boiling points, Scientific Notation. Chemical reactions in atmosphere: Acid rain, Greenhouse effect and global warming.

UNIT-II: Chemistry in Ancient India
Alchemy, Alchemy and Iatrochemistry in India, Rasasastra, Catagorization of chemical substances: mahārasas, uparasas, navaratnas, dhātus. Special position of mercury in Indian alchemy, Noted alchemical texts from Acharya Nagarjuna, Govind Bhagwatpad, Vagbhatta, Siddha Nityanatha, Somadeva, and Yasodhara.
Contributions of Nagarjuna, General layout of the laboratory and apparatus used in ancient chemistry, the mūsa yantra or crucible, the koṣṭhi yantra, the pātana yantra (sublimation or distillation), the dhūpa yantra (for fumigation)

UNIT-III: Chemical Arts and Crafts in Historic period
Glass making, Soap, Dyeing, Cosmetics and Perfumes, Ink, Metallurgy: Iron, Steel, Copper, Bronze

UNIT-IV: Modern Indian Chemistry
Sir Acharya Prafulla Chandra Ray – Father of Indian Chemistry: His contributions in chemical rresearch, and development of Indian chemical industry, Ray's classification of five stages in development of Chemistry in India.

UNIT-V: Lives of Some Chemists from Modern India and Their Contributions in Chemistry
Works and Contribution of Nobel laureate Professor Har Govind Khorana, Prof C N R Rao, Dr. Shanti Swarup Bhatnagar, Dr.Asima Chatterjee, Nobel laureate Venkatraman Ramakrishnan, Dr. Kamala Sohonie, Dr.Yellapragada Subba Rao, Dr. Darshan Ranganathan.

Reference Books:

1. Basic Chemistry, 5th Edn. K. Timberlake and W. Timberlake, Pearson
2. History of Chemistry in Ancient and Medieval India, P. C. Ray, Editor P. Ray and B.G. Guha.
3. Ancient Indian Metallurgy, Ashoka Kumar Mishra, 2009
4. Copper and its Alloys in Ancient India, D. K.Chakrabarti, N. Lahiri, 1996.
5. Chemical Research of Sir P. C. Ray, S. Goswami and S. Bhattacharya, Resonance, 2001.
6. Life and Experiences of a Bengali Chemist, Vol I and II, P. C. Ray.

CHEMISTRY
(Major)
(3rd Semester)
Course No.:**CHM-DSC-201**
(Inorganic Chemistry -II)
(s-, p-block Elements, Coordination Chemistry and its Application)
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

UNIT-1: Chemistry of s- and p-block Elements

Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s*- and *p*- block elements.

Hydrides and their classification ionic, covalent and interstitial.

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses.

Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.

Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF_2, XeF_4 and XeF_6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF_2). Molecular shapes of noble gas compounds (VSEPR theory).

UNIT-2: Acids and Bases and Inorganic Polymers

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB), Application of HSAB principle.

Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. borazines, silicates.

UNIT-3: Coordination Chemistry

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt).

Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.

IUPAC (2005) nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

UNIT-4: d- and f-block Elements

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties and ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Ebsworth diagrams). Difference between the first, second and third transition series. Chemistry of Cr and Mn in various oxidation states (excluding their metallurgy).

Lanthanoids and Actinoids: Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

UNIT-5: Bio-inorganic Chemistry

Metal ions present in biological systems, classification of elements according to their action in biological system. Excess and deficiency of some trace metals.

Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J., Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Greenwood, N. N. & Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
- Cotton, F. A. & Wilkinson, G., Advanced Inorganic Chemistry, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr., Inorganic Chemistry 4th Ed., Pearson, 2010.
- Shriver & Atkins, Inorganic Chemistry 5th Ed.

CHEMISTRY
(Major)
(3rd Semester)
Course No.:**CHM-DSC-202**
(Organic Chemistry -II)
Functional Group Chemistry
Contact Hours: 60; Credits: 04
Full Marks = 100 [End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

UNIT-1: Halogenated Hydrocarbon

Alkyl halides: Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2 and S_ni mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.

Aryl halides: Preparation, including preparation from diazonium salts. Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism.

Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

UNIT-2: Alcohols, phenols and ethers

Alcohols: preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;

Phenols: Preparation & properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;

Ethers and Epoxides: Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$.

UNIT-3: Carbonyl Compounds

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction, Baeyer Villiger oxidation, α- substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, LiAlH4, MPV). Addition reactions of unsaturated carbonyl compounds: Michael addition.

UNIT-4: Carboxylic acid and their derivative

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of

esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann bromamide degradation and Curtius rearrangement.

UNIT-5: Sulphur & Nitrogen containing functional groups

Preparation and reactions of thiols, thioethers and sulphonic acids.

Preparation and important reactions of nitro compounds, nitriles and isonitriles; Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: Preparation and their synthetic applications.

Reference Books:

- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

CHEMISTRY
(Minor)
(3nd Semester)
Course No.:**CHM-DSM-201**
(Fundamentals of Chemistry -II)
Contact Hours: 45; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit 1: p- block elements

Group13 Elements

General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group, Boron-physical and chemical properties, some important compounds, Borax, Boric acid, Boron Hydrides, Aluminium: Reactions with acids and alkalies, uses.

Group 14 Elements

General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behavior of first element. Carbon-catenation, allotropic forms, physical and chemical properties; uses of some important compounds: oxides. Important compounds of Silicon and a few uses: Silicon Tetrachloride, Silicones, Silicates and Zeolites, their uses.

Unit 2: Chemical Thermodynamics

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature– Kirchhoff's equation.

Unit 3: Solutions and Phase Equilibria

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. Distillation of solutions. Azeotropes.

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs

Phase Rule. Phase diagrams of one-component systems (water and sulphur).

Unit 4: Aliphatic and aromatic Hydrocarbons

Alkanes:

Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignardreagent. Reactions: Free radical Substitution: Halogenation.

Alkenes:

Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkylhalides (Saytzeff's rule). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition(bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

Alkynes:

Preparation: Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation oftetra halides and dehydrohalogenation of vicinal dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

Unit 5: Alkyl and Aryl Halides

Alkyl Halides: Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides: Preparation: (Chloro, bromo and iodo-benzene) from phenol, Sandmeyer& Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Puri, Sharma, Pathania; Principles of Physical Chemistry, Vishal Publishing Co.45th Edition (2011)
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.

CHEMISTRY
(Skill Development Course)
(3rd Semester)
Course No.:**CHM-SEC-201**
Forensic Chemistry
Contact Hours: 60; Credits: 03
Full Marks = 100 [End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit-1: Instrumentation
Fundamental principles and forensic applications of thin layer chromatography, gas chromatography and liquid chromatography. Fundamental principles of Ultraviolet-visible spectroscopy, infrared spectroscopy, Colorimetric analysis and Lambert-Beer law.

Unit-2: Development of Fingerprints
Latent prints. Constituents of sweat residue. Latent fingerprints' detection by physical and chemical techniques. Mechanism of detection of fingerprints by different developing reagents. Application of light sources in fingerprint detection. Preservation of developed fingerprints.

Unit-3: Basics of Toxicology
Significance of toxicological findings. Techniques used in toxicology. Toxicological analysis and chemical intoxication tests. Lethal dose 50 and effective dose 50.

Unit-4: Narcotics, Drugs and Psychotropic Substances
Definition of narcotics, drugs and psychotropic substances. Broad classification – Narcotics, stimulants, depressants and hallucinogens. General characteristics and common example of each classification. Natural, synthetic and semi-synthetic narcotics, drugs and psychotropic substances. Designer drugs. Tolerance, addiction and withdrawal symptoms of narcotics, drugs and psychotropic substance.

Unit-5: Cases Involving Arson and Explosives
Chemistry of fire. Collection and preservation of arson evidence. Analysis of fire debris. Analysis of ignitable liquid residue. Scientific investigation and evaluation of clue materials. Information from smoke staining.
Classification of explosives – low explosives and high explosives. Synthesis and characteristics of TNT, PETN and RDX. Mechanism of Explosion process. Blast waves. Searching the scene of explosion. Post blast residue collection and analysis.

Suggested demonstrations

1. Separation of explosive substances (e.g., aromatic nitro compounds) using thin layer chromatography
2. Detection and preservation of fingerprints
3. Demonstration of instrumentational techniques (e.g., Ultraviolet-visible spectroscopy, infrared spectroscopy, Colorimetric analysis, etc.)

Suggested Readings

- W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's, *Techniques of Crime Scene Investigation*, CRC Press, Boca Raton (2013).
- S. Ballou, M. Houck, J.A. Siegel, C.A. Crouse, J.J. Lentini and S. Palenik in *Forensic*
- *Science*, D.H. Ubelaker (Ed.), Wiley-Blackwell, Chichester (2013).

CHEMISTRY
(Inter Disciplinary Course)
(3rd Semester)
Course No.:**CHM-IDC-201**
Heritage of Indian Metallurgy
Contact Hours: 60; Credits: 03
Full Marks = 100 [End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit 1: History of metallurgy
What is Metallurgy, Ore and minerals, Metallurgy in Indian Social Context, Seven metals of antiquity, Importance of metals in human civilization, early evidence of metal in the Indian subcontinent, reference of precious metals (Copper, Gold, Silver, etc.) in ancient Indian scripts, Notable archaeological digs related to Indian metallurgy. Alloy: Definition, applications.

Unit II: Landmarks of Indian metallurgy
Metallurgy before and during the Harappan Civilization, first evidence of copper in the Indian subcontinent, discovery of bronze and its applications, alloying ranges on bronze, metal artefacts produced by the Harappans, lost-wax technique for metal sculpture.

Unit III: Coinage of India: Metallurgy of Currency
Origin of metallic currency in Indian subcontinent, Weight standards of coins in Indus Valley civilization: ratti, Satamana, Karshapana. Origins of Indian punch-marked coinage: Indian Karshapana coins, Cast Copper Coins, Die struck coins, Svarna coins. 'Copper Hoard' culture.

Unit IV: Iron Metallurgy
History of Iron Age in Ganges civilization, process of iron-smelting. Indian Wootz steel: definition, production technique, applications of Wootz steel. Role of carbon in steel. Wrought iron: production method, mechanism of Rust-resistance of the Iron Pillars in Delhi, Dhar (Madhya Pradesh) and Kodachadri Hill (coastal Karnataka).

Unit V: Metallurgy of other metals of importance
Gold, Silver, Zinc, Tin: Ores of zinc, method of extraction, applications.

Suggested Readings

1. History of Metallurgy, 2nd Edn, R. F. Tyleote.
2. A History of Metallurgy in India, G. Singh.
3. Science and Metal Technology of Harappans, D. P. Sharma.
4. Coins of Ancient India, Alexander Cunningham, Franklin Classics trade Press, 2018.
5. The Metallurgy of Iron and Still …Vol I, The Metallurgy of Iron, Thomas Tuner, British Library, 2011.
6. A Text Book on Metallurgy of Gold, Silver, Copper, Lead and Zinc, by International Correspondence Schools, Legare street press, 2022

CHEMISTRY
(Major)
(4th Semester)
Course No.: **CHM-DSC-251**
(Physical Chemistry -II)
Chemical Thermodynamics & Equilibrium
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit I: Chemical Thermodynamics I

Intensive and extensive variables; state and path functions; exact differentials, zeroth law of thermodynamics.

First law: Concept of heat (*q*), work (*w*), internal energy (*U*), and statement of first law; enthalpy (*H*), relation between heat capacities, calculations of *q*, *w*, *U* and *H* for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions.

Unit II: Chemical Thermodynamics II

Second Law: Limitation of First Law, Concept of entropy, statement of the second law of thermodynamics; mathematical expression of 2^{nd} law, Calculation of entropy change for reversible and irreversible processes, Clausius inequality

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit III: Phase Equilibrium

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, concept of activity and fugacity, phase diagram for one component systems, with applications (H_2O & CO_2)

Phase diagrams for systems of solid-liquid equilibria involving eutectic mixture (Pb-Ag), congruent (Zn-Mg) and incongruent melting points, solid solutions. Three component systems, water chloroform-acetic acid system, triangular plots.

Unit IV: Chemical Equilibrium

Partial molar quantities, Chemical potential-its physical significance, Gibbs-Duhem equation, of ideal mixtures, change in thermodynamic functions in mixing of ideal gases. Criteria of thermodynamic equilibrium, law of mass action, equilibrium constant, factor effecting equilibrium constant, thermodynamic derivation of relations between the various equilibrium constants *Kp*, *Kc* and *Kx*. *Le Chatelier's Principle* (quantitative treatment); Van't Hoff's Isotherm. Coupling of exoergic and endoergic reactions.

Unit V: Ionic Equilibrium

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Reference books

- Puri, Sharma, Pathania; Principles of Physical Chemistry, Vishal Publishing Co.45th Edition (2011)
- Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., OUP (2011).
- Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
- Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
- McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics, Viva Books Pvt. Ltd.: NewDelhi (2004).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S.

Commonly Asked Questions in Thermodynamics, CRC Press: NY (2011).

- Levine, I. N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
- Metz, C. R. 2000 Solved Problems in Chemistry, Schaum Series (2006)

CHEMISTRY
(Major)
(4th Semester)
Course No.:**CHM-DSC-252**
(Inorganic Chemistry -III)
Organometallic and Analytical Chemistry
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

UNIT-1 Organometallic Compounds-I

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands.

Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series.

Ferrocene: Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

UNIT-2 Organometallic Compounds-II

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds.

Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures.

UNIT-3: Reaction Kinetics and Mechanism

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and Kinetic stability, Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.

UNIT-4: Catalysis by Organometallic compounds

Study of the following industrial processes and their mechanism:

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Synthetic gasoline (Fischer Tropsch reaction)
4. Synthesis gas by metal carbonyl complexes

UNIT-5: Principles in Qualitative Analysis

Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

Reference books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J., Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Greenwood, N. N. & Earnshaw, Chemistry of the Elements, Butterworth Heinemann. 1997.
- Cotton, F. A. & Wilkinson, G., Advanced Inorganic Chemistry, Wiley, VCH, 1999.
- Miessler, G. L. & Donald, A. Tarr., Inorganic Chemistry 4th Ed., Pearson, 2010.
- Shriver & Atkins, Inorganic Chemistry 5th Ed.

CHEMISTRY

(Major)

(4th Semester)

Course No.:**CHM-DSC-253**

Practical

(Inorganic, Organic and Physical Chemistry)

Contact Hours: 60; Credits: 04

Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Examination Time: 18 hours (3 days)

Section-A (Inorganic Chemistry)

1. Volumetric Titration: (*any one*) **20 Marks**

i. Determination of oxalic acid using potassium permanganet solution.
ii. Determination of iron (II) using potassium permanganet solution.
iii. Determination of iron (II) using potassium dichromate solution.
iv. Determination of alkali present in soap / detergents
v. Determination of water crystalisation in Mohr's salt by titrating with permanganet solution.

Section-B (Organic Chemistry)

2(a) Organic preparation and reactions (*any one*) **15 marks**

i) Nitration of acetanilide/ nitrobenzene/ salicylic acid
ii) Bromination of phenol/ aniline
iii) Azomethyne
iv) Benzil from benzoin
v) Benzilic acid from benzil
vi) Methyl orange
vii) Iodoform

2(b). Purification of organic compounds (*any one*) **15 Marks**

i) Decolorization of crude sulphanilic acid (recrystallization using animal charcoal)

ii) Recrystallization of benzoic acid from hot water/ ethanol.
iii) Acetanilide from boiling water
iv) Naphthalene/ m-Dinitrobenzene from ethanol
v) Naphthalene/ camphor/phthalic acid (by sublimation)

Section-C (Physical Chemistry)

3. ***Any one experiment out of the following can set in examination*** **20 Marks**

i) To determine the solubility of benzoic acid at different temperature and to determine ΔH of the dissolution process.
ii) Preparation of Sodium acetate-acetic acid buffer of different pH.
iii) Preparation of Ammonium chloride-ammonium hydroxide buffer solutions of different pH.
iv) pH-metric titration of strong acid vs strong base.
v) Determination of Critical Solution Temperature (CST) of Phenol water system.

Internal Assessment

4. Viva-voce **15 Marks**

5. Regularity in maintenance of Lab Note Book **5 marks**

6. Attendance **10 Marks**

Reference Books:

- Vogel, A. I., A Textbook of Quantitative Inorganic Analysis, ELBS.
- Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
- Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
- Vogel, A. I., A Textbook of Qualitative Organic Analysis, ELBS.
- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
- Jadav, J. B., Advance Physical Practical Chemistry, Goel Publishing House, New Delhi (1981)
- Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CHEMISTRY

(Minor)

(4th Semester)

Course No.:**CHM-DSM-251**

Practical

(Inorganic, Organic and Physical Chemistry)

Contact Hours: 45; Credits: 03

Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Examination Time: 12 hours (2 days)

Section-A (Inorganic Chemistry)

1. Qualitative Inorganic Analysis **25 Marks**

Qualitative analysis of inorganic mixtures containing 2 anions and 2 cations without interfering radicals.

Section-B (Organic Chemistry)

2a. Systematic Qualitative Organic Analysis of Organic Compounds possessing mono-functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines). **15marks**

2b. Organic Preparation and purification: **10 marks**

***Organic preparation and reactions* (any one)**

i) Nitration of acetanilide/ nitrobenzene/ salicylic acid
ii) Bromination of phenol/ aniline
iii) Oxime/ 2,4-dinitrophenylhydrazone of aldehyde/ ketone.
iv) Benzil from benzoin
v) Benzilic acid from benzil
vi) Benzoylation of Phenol/ aniline
vii) Iodoform from acetone

Purification of organic compounds

i) Decolorization of crude sulphanilic acid (recrystallization using animal charcoal)
ii) Recrystallization of benzoic acid from hot water/ ethanol.
iii) Recrystallization of Acetanilide from boiling water
iv) Purification of naphthalene/ camphor/phthalic acid (by sublimation)

Section-C (Physical Chemistry)

3. Any *one experiment out of the following can set in examination* 20Marks

i. To determine the surface tension of glycerol/acetic acid Solutions at different concentrations and construction of graph.

ii. To determine the viscosity of glycerol/acetic acid Solutions at different concentrations and construction of graph.

iii. pH-metric titration of strong acid vs strong base.

iv. Conductometric titration of strong acid vs strong base.

v. To determine the solubility of benzoic acid at different temperature and to determine ΔH of the dissolution process.

Internal Assessment

4. Viva-voce **15 Marks**

5. Regularity in maintenance of Lab Note Book **5 marks**

6. Attendance **10 Marks**

Reference Book

i. Vogel, A. I., A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

ii. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

iii. Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.

iv. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CHEMISTRY
(Minor)
(4th Semester)
Course No.: **CHM-DSM-252**
(Fundamentals of Chemistry -II)
Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-I: s- and p- block elements

s-Block Elements (Alkali and Alkaline Earth Metals):

Group 1 and Group 2 Elements: General introduction, electronic configuration, occurrence, anomalous properties of the first element of each group, diagonal relationship, trends in variation of properties (such as ionization enthalpy, atomic and ionic radii), trends in chemical reactivity with oxygen, water, hydrogen and halogens, uses. Preparation and Properties of Sodium Carbonate, Sodium Chloride, Sodium Hydroxide and Sodium Hydrogen carbonate, Biological importance of Sodium and Potassium. Calcium oxide and Calcium Carbonate and their industrial uses, Biological importance of Magnesium and Cacium.

p block Elements:

Group13 Elements: General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group, Boron-physical and chemical properties, some important compounds, Borax, Boric acid, Boron Hydrides, Aluminium: Reactions with acids and alkalies, uses.

Group 14 Elements: General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behavior of first element. Carbon-catenation, allotropic forms, physical and chemical properties; uses of some important compounds: oxides. Important compounds of Silicon and a few uses: Silicon Tetrachloride, Silicones, Silicates and Zeolites, their uses.

Unit II: Chemical Thermodynamics

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature– Kirchhoff's equation.

Unit III: Solutions and Phase Equilibria

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. Distillation of solutions. Azeotropes.

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs

Phase Rule. Phase diagrams of one-component systems (water and sulphur).

UNIT-IV: Aliphatic and Aromatic Hydrocarbons

Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution (Halogenation).

Alkenes: Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkylhalides (Saytzeff's rule). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition(bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis.

Alkynes: Preparation: Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

UNIT-V: Alkyl and Aryl Halides

Alkyl Halides: Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis; Elimination vs substitution.

Aryl Halides: Preparation: (Chloro, bromo and iodo-benzene) from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Puri, Sharma, Pathaniaa; Principles of Physical Chemistry, Vishal Publishing Co.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.

CHEMISTRY
(Major)
(5th Semester)
Course No.: **CHM-DSC-301**
Quantum and Photochemistry
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Unit-1: Quantum Chemistry-I

Introduction to black-body radiation and distribution of energy, photo-electic effect, concept of quantization, wave particle duality (de-Broglie's hypothesis), The uncertainty principle, The wave function: wave function and its interpretation, conditions of normalization and Orthogonality and its significance. Basic idea about operators, Eigen function and values, Postulates of quantum mechanics. Schrodinger equation and application to free-particle and particle in a box, boundary conditions. Extension to two dimensional and three dimensional box wave functions and energies, degeneracy.

Unit-2: Quantum Chemistry-II

Quantitative treatment of simple harmonic oscillator model, setting up of Schrodinger equation and discussion of solution of wave functions. Vibrational energy of diatomic molecules and significance of zero point energy. Rigid rotator model and discussion of application of Schrodinger equation.

Unit-3: Chemical Bonding

Variation theorem, Valence bond and molecular orbital approaches, LCAO-MO treatment of H_2, H_2^+; bonding and anti-bonding orbitals, Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Spin state of two electron system, Singlet and triplet state. Setting up of Schrödinger equation for many-electron atoms (He, Li), Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH), calculation of Bond order.

Unit-4: Hybridization and Shape

Quantum mechanical approach of SP^3, SP^2 and SP hybridization and bond angle. The pi-electron approximation, the Huckel MO approximation. Simple Huckel treatment of ethane, allyl and butadiene system. Huckel's rule of aromaticity, delocalization energy of cyclic system.

Unit-5: Photochemistry

Difference between thermal and photochemical process, Laws of photochemistry: Grothus-Drappers law, Stark-Einstein Law, Jablonski diagram depicting various processes occurring in the excited states, qualitative description of fluorescence, phosphorescence, non-radiative processes of internal conversion, intersystem crossing, quantum yield, example of high and

low quantum yield reaction, Photosensitized reaction, quenching, Chemiluminescence. Kinetics of photochemical reactions ($H_2 + Br_2 \rightleftharpoons HBr$, $2HI \rightleftharpoons H_2 + I_2$),

Reference Books:

- K. Chandra, Introductory Quantum Chemistry Tata McGraw-Hill
- B.K Sen , Quantum Chemistry including Spectroscopy 3rd edition, Kalyani Publishers.
- J. P. Lowe, & K. Peterson, Quantum Chemistry, Academic Press (2005).
- J. E House, Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA.
- D. A., Macqurre, Quantum Chemistry.
- Peter W. Atkins, and Friedman, S. Ronald, Molecular Quantum Mechanics 5th Edition.
- R. Kakkar, Atomic & Molecular Spectroscopy, Cambridge University Press

CHEMISTRY
(Major)
(5th Semester)
Course No.:**CHM-DSC-302**
(Organic Chemistry -III)
Heterocyclic, Biochemistry, Natural products & Photochemistry
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-1: Heterocyclic Compounds

Classification and nomenclature, structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis). Substitution reactions of Furan, Pyrrole, Thiophene, Pyridine; Derivatives of furan: Furfural and furoic acid.

Pyrimidine: Structure elucidation of indole, quinoline and isoquinoline, Synthesis of Indole (Fischer indole synthesis and Madelung synthesis), Quinoline (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner Miller synthesis), Isoquinoline (Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction).

UNIT-2: Amino acids, peptides and proteins

Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis.

Study of peptides: Determination of their primary structures, end group analysis, methods of peptide synthesis.

Proteins: Overview of primary, secondary, tertiary and quaternary structure of proteins. Protein denaturation/ renaturation.

UNIT-3: Enzyme, lipid and nucleic acids

Enzymes: Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance.

Lipids: Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number.

Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

UNIT-4: Alkaloids and terpenes

Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance alkaloids. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine

Terpenes: Occurrence, classification, isoprene rule; Elucidation of stucture and synthesis of Citral, Neral and α-terpineol.

UNIT-5: Photochemistry of Organic Compounds

General concepts, Franck- Condon principle; singlet, triplet states; Norrish type I and II processes, Paterno-Buchi reaction, Barton reaction, photo-oxidation and reduction, rearrangements, photo Fries rearrangement, Di - π methane rearrangement, Photochemistry of conjugated dienes.

Reference Books:

- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.
- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Singh J., Singh, J.; Photochemistry and pericyclic reactions; New Age International Publishers

CHEMISTRY

(Major)

(5th Semester)

Course No.:**CHM-DSC-303**

Practical

(Inorganic, Organic and Physical Chemistry)

Contact Hours: 60; Credits: 04

Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Examination Time: 18 hours (3 days)

Section-A (Inorganic Chemistry)

1. Iodo-/Iodimetric Titration and Gravimetric (*any one*) 20 marks

i) Determination of copper (II) using sodium thiosulphate solution iodimetrically
ii) Determination of available chlorine in bleaching powder iodometrically.
iii) Determination of nickel (II) as $Ni(DMG)_2$ complex gravimetrically.

Section-B (Organic Chemistry)

2. Qualitative Organic analysis 30 marks

i) Detection of elements (N, S and halogens) and functional groups, determination of melting points and preparation of suitable derivatives to identify the given organic compounds

Section-C (Physical Chemistry)

3. *Any one experiment out of the following can set in examination* 20 Marks

i) pH metric titration of mixture of strong and weak acid vs strong base.
ii) To determine the water of crystallization of $FeSO_4.2H_2O$ by titration against standard $KMnO_4$.
iii) Conductometric titration of strong acid vs strong base.
iv) Verification of Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7$ in a solution of unknown concentration.
v) Study of the kinetics of interaction of crystal violet/phenolphthalein with sodium hydroxide.

Internal Assessment

4. Viva-voce **15 marks**
5. Regularity in maintenance of Lab Note Book **5 marks**
6. Attendance **10 marks**

Reference Books:

- Vogel, A. I., A Textbook of Quantitative Inorganic Analysis, ELBS.
- Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
- Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
- Vogel, A. I., A Textbook of Qualitative Organic Analysis, ELBS.
- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
- Jadav, J. B., Advance Physical Practical Chemistry, Goel Publishing House, New Delhi (1981)
- Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CHEMISTRY
(Minor)
(5th Semester)
Course No.: **CHM-DSM-301**
(Fundamental of Chemistry-III)

Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-I: Transition Series Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.
Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit II: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Unit III: Equilibria

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^0, Le Chatelier's principle. Relationships between *Kp*, *Kc* and *Kx* for reactions involving ideal gases.

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

UNIT-IV: Alcohols and Phenols

Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, *alk*. $KMnO_4$, acidic dichromate, conc. HNO_3). Diols: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.
Phenols: (Phenol case): Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Schotten – Baumann Reaction.

UNIT-V: Aldehydes, Ketones & Carboxylic acids

Formaldehyde, acetaldehyde, acetone and benzaldehyde: Preparation: from acid chlorides and from nitriles. *Reactions:* Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol Condensation, Cannizzaro's Reaction, Wittig Reaction, Benzoin Condensation. Clemensen Reduction, Wolff Kishner Reduction, Meerwein-Pondorff Verley Reduction.

Carboxylic acids (aliphatic and aromatic): Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Puri, Sharma, Pathaniaa; Principles of Physical Chemistry, Vishal Publishing Co.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.

CHEMISTRY
(Minor)
(5th Semester)
Course No.: **CHM-DSM-302**
(Fundamental of Chemistry-III)

Contact Hours: 45; Credits: 03
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

UNIT-I: Transition Series Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.
Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit II: Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Unit III: Equilibria

Chemical Equilibrium: Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^0, Le Chatelier's principle. Relationships between *Kp*, *Kc* and *Kx* for reactions involving ideal gases.

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

UNIT-IV: Alcohols and Phenols

Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium,

HX (Lucas test), esterification, oxidation (with PCC, *alk*. $KMnO_4$, acidic dichromate, conc. HNO_3). Diols: (Up to 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.
Phenols: (Phenol case): Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Schotten – Baumann Reaction.

UNIT-V: Aldehydes, Ketones & Carboxylic acids

Formaldehyde, acetaldehyde, acetone and benzaldehyde: Preparation: from acid chlorides and from nitriles. *Reactions:* Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol Condensation, Cannizzaro's Reaction, Wittig Reaction, Benzoin Condensation. Clemensen Reduction, Wolff Kishner Reduction, Meerwein-Pondorff Verley Reduction.

Carboxylic acids (aliphatic and aromatic): Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction.

Reference Books:

- Puri, Sharma, Kalia; Principles of Inorganic Chemistry, Vishal Publishing Co.
- Puri, Sharma, Pathaniaa; Principles of Physical Chemistry, Vishal Publishing Co.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
- Ghosh, Sachin Kumar; Advanced General Organic Chemistry: A Modern Approach (vol 1 & 2), NCBA
- Jain, M. K., Sharma, S. C.; Modern Organic Chemistry; Vishal Publishing Co.

CHEMISTRY
(Major)
(6th Semester)
Course No.: **CHM-DSC-351**
Advance Materials
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit-1: Introduction to Nanoscience

Definition of Nano particle, emergence and challenges of nanoscience and nanotechnology, classifications of nanostructured materials: One dimensional, two dimensional and three dimensional nanostructured materials, quantum dots, nanowires, ultrathin films, multilayered materials, metal oxides, semiconductors, new form of carbon (CNT to Graphene), influence of nano over micro/macro, size effects, large surface to volume ratio, surface effects on the properties, applications of nanomaterials.

Unit-2: Nano synthesis

Top down & bottom-up approaches, *Chemical method:* Sol–gel process, Self-assembly process, Electrodeposition, Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Sonochemical synthesis, *Physical method:* Ball milling, Inert gas condensation technique (IGCT), Thermal evaporation,

Greener Nanosynthesis: Greener Synthetic Methods for Functionalized Metal Nanoparticles, Greener Preparations of Inorganic Oxide Nanoparticles, green synthesis of Metal nanoparticles, Nanoparticle characterization methods.

Unit 3: Composite Materials

Overview of composite materials and their need, reinforcements and matrices, types of reinforcements, *Matrix:* Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Carbon fibre composites, properties of composites in comparison with standard materials, applications of metal, ceramic and polymer matrix composites.

Unit-4: Liquid Crystals and Surfactant

Liquid crystal: Definition, Classification, Thermotropic and Lyotropic Liquid crystal, example, Vapour pressure-temperature diagram, thermography, LCD and seven segment cell, Molecular arrangement in Nematic, Smectic (SmA, SmC), Cholesteric phases, Discotic liquid crystal, Columnar and discotic nematic phase, Application of liquid crystal.

Surfactant: Amphiphiles, example of cationic and anionic amphiphiles, types of Micelles, formation of Critical Micellar Concentration (CMC), factor effecting CMC, solubilisation and emulsification, emulsifier.

Unit-5: Macromolecules

Definition, example, degree of polymerisation, classification of polymer: a) isotactic b) syndiotactic and c) atactic polymers. Number average and Mass-average molar mass, determination of molar mass by viscometry and osmometry, Polymerization reaction, addition and condensation polymerisation Nylon 66, Dacron, Zieglar-Natta Catalysis, electron and ion conducting polymers.

Reference Books:

- Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.
- G. Cao, Nanostructures and Nanomaterials – Synthesis, Properties and Applications, Imperial College Press 2006.
- Nanostructured materials: Processing, Properties and Potential Applications, Edited by Carl. C. Koch, Noyes Publications, 2002.
- Composite materials, Sharma S.C., Narosa Publications, 2000.
- Composite materials, Chawla K.K., Springer, New York, 1998.
- Composite materials: Engineering and Science, Mathews F.L. and Rawlings R.D., Chapman and Hall, London, England, 1st edition, 1994.
- Puri, Sharma, Phathania; Principle of Physical Chemistry, 45th Edition, Vishal Publications.
- Peter Atkins, J. D. Paula; Atkins' Physical Chemistry; 8th edition, Oxford University Press.

CHEMISTRY
(Major)
(6th Semester)
Course No.:**CHM-DSC-352**
Spectroscopy
Theory and Applications
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit-1: Molecular Spectroscopy-I

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

Rotation spectroscopy: Rotational spectra of diatomic rigid rotator, Selection rules, intensities of spectral lines, determination of bond lengths of diatomic molecules, isotopic substitution,

Vibrational spectroscopy: Simple Harmonic Oscillator, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential energy curve, dissociation energies, fundamental frequencies, overtones, Selection rules, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Unit-2: Molecular Spectroscopy-II

Raman Spectroscopy: Rayleigh scattering, Quantum theory of Raman Effect, Stoke and anti-stokes' lines, molecular polarizability, Qualitative treatment of Rotational Raman effect (linear molecule). Qualitative discussion on vibrational Raman spectra of H_2O & CO_2, mutual exclusion rule,

Electronic spectroscopy: Born-Oppenheimer approximation, Franc-Condon Principle, Beer-Lambert law and its application, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation. Determination of composition of metal complexes using Job's method.

Unit 3: UV & IR Spectroscopy

UV Spectroscopy: Chromophores and Auxochromes; Application of Woodward Rules for calculation of λ-max for the following systems: α, β- unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular,

Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers. Applications of UV for identification of simple organic molecules.
IR Spectroscopy: IR absorption positions of O, N and S containing functional groups; Fingerprint region and its significance; application in functional group analysis. Applications of IR for identification of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

Unit 4: NMR Spectroscopy
Basic principles of Proton Magnetic Resonance, shielding and deshielding of protons, TMS, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Interpretation of NMR spectra of simple compounds (Ethyl bromide, toluene, o & p-nitrotoluene, anisole, ethyl alcohol, ethyl acetate, mesitylene, acids and carbonyl compounds). Applications of NMR for identification of simple organic molecules.

Unit 5: Mass Spectroscopy
Mass Spectroscopy: Basic principles, instrumentation, determination of m/e ratio, base peak, molecular ion, nitrogen rule, metastable ions, isotopic peak, daughter ions, Mc–Lafferty rearrangement, RDA, General rules for fragmentation pattern, fragmentation pattern of simple compounds of hydrocarbons, alcohols, amines, aldehyde, ketone, ether, acids, phenols, nitro compounds, alicyclic compounds.

Reference Books:

- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
- B.K Sen , Quantum Chemistry including Spectroscopy 3rd edition, Kalyani Publishers.
- Kapoor K.L, Quantum Chemistry and Molecular spectroscopy vol-4, Laxmi Publications-New Delhi.
- Kemp William, Organic Spectroscopy, 3rd Edition, Palgrave Publisher, 1991.
- J Kalsi P. S., Spectroscopy of Organic Compounds, 5th Edition, New Age International Publishers, 2016.
- Sharma Y. R, Elementary Organic Spectroscopy, 5th Edition, S. Chand & Company, 2013.
- Jag Mohan, Organic Spectroscopy and Applications, Narosa Publishers, 2012.

CHEMISTRY
(Major)
(6th Semester)
Course No.:**CHM-DSC-353**
(Physical Chemistry –III)
Chemical Kinetics and Electrochemistry
Contact Hours: 60; Credits: 04
Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]
Pass Marks = 40 [End Semester Exam (28) Internal Assessment (12)]

Unit -1: Chemical Kinetics-I

Rate of reaction, Order and molecularity of a reaction, rate laws and rate constant in terms of the advancement of a reaction, differential and integrated form of rate expressions and half-life up to second order reactions, experimental methods of the determination of order of a reaction. Effect of temperature on reaction rate, effect of catalyst, Arrhenious equation.

Unit-2: Chemical Kinetics-II

Theories of reaction rate: Collision theory of bimolecular reaction; Activated complex theory, Lindemann theory (qualitative treatment). Equilibrium approximation and steady state approximation; kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations, (iv) Chain reaction.

Unit-3: Conductance

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation. Transport number and their determination using Hittorf and Moving Boundary methods, Conductometric titration, Ostwald's dilution Law, hydrolysis constants of salts.

Unit-4: Electrochemistry-I

Faradays laws of electrolysis, EMF of cell, Standard EMF, rules of oxidation/reduction of ions based on half-cell potentials. Galvanic cell, reversible and irreversible cell, Single electrode potential, thermodynamic of reversible electrode and cell, Nernst equation, standard electrode potential, electrochemical series, determination of activity and activity coefficient.

Unit-5: Electrochemistry-II

Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values using hydrogen/glass electrodes, (iv) solubility product of sparingly soluble salt.

Concentration cells with and without transference, liquid junction potential; discussion of potentiometric titrations (acid-base, redox, precipitation).

Reference Books:

- Puri, Sharma, Phathania; Principle of Physical Chemistry, 45th Edition, Vishal Publications.
- Ball, D. W. Physical Chemistry Cengage India (2012).
- Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
- Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
- Metz, C. R. Physical Chemistry 2nd Ed., Tata McGraw-Hill (2009).
- Laidler, K. J., Chemical Kinetics 3rd Ed., Pearson Education India (2008).
- Kapoor, K. L., A Textbook of Physical Chemistry – Vol. 1 – 6, 2nd Ed., Laxmi Publications-New Delhi (2011).

CHEMISTRY

(Major)

(6th Semester)

Course No.:**CHM-DSC-354**

Practical

(Inorganic, Organic and Physical Chemistry)

Contact Hours: 60; Credits: 04

Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Examination Time: 18 hours (3 days)

Section-A (Inorganic Chemistry)

1. Qualitative Inorganic Analysis **30 Marks**

i) Qualitative analysis of mixtures containing 3 anions and 3 cations. Mixtures should preferably contain one interfering anion or insoluble component or combination of anions.

Section-B (Organic Chemistry)

2. Chromatographic separation **20 Marks**

i) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.

ii) Separate a mixture of o-nitrophenol and p-nitrophenol by TLC technique and identify them on the basis of their Rf values.

iii) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC/ Paper chromatography.

iv) Separation of 2,4-Dinitrophenyl hydrazones of any two carbonyl compounds (e.g., benzophenone and benzyl; p-nitrobenzaldehyde and benzaldehyde) from their mixture and determination of Rf values (By Paper/ Thin layer chromatography)

v) Paper chromatographic separation and determination of Rf values of mixture of any three amino acids from their mixture (alanine, glycine and leucine or any other set). Spray reagent: Ninhydrin.

Section-C (Physical Chemistry)

3. ***Any one experiment out of the following can set in examination*** **20 Marks**

i) Determine the rate constant of hydrolysis of methyl acetate in presence HCl.

ii) To study saponification of ethyl acetate by sodium hydroxide

iii) Conductometric titration of a mixture of strong and weak acid vs strong base.

iv) Determination of equivalent conductances of a strong electrolyte at various dilutions and verification of Onsagar equation.

v) Potentiometric titration of ferrous ammonium sulphate against standard $K_2Cr_2O_7$/$KMnO_4$ and determination of redox potential of Fe(II)- Fe(III) system.

Internal Assessment

4. Viva-voce **15 marks**

5. Regularity in maintenance of Lab Note Book **5 marks**

6. Attendance **10 marks**

Reference Books:

- Vogel, A. I., A Textbook of Quantitative Inorganic Analysis, ELBS.
- Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
- Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
- Vogel, A. I., A Textbook of Qualitative Organic Analysis, ELBS.
- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
- Athawale, V. D. & Mathur, P. Experimental Physical Chemistry, New Age International: New Delhi (2001).
- Jadav, J. B., Advance Physical Practical Chemistry, Goel Publishing House, New Delhi (1981)
- Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

CHEMISTRY

(Minor)

(6th Semester)

Course No.:**CHM-DSM-351**

Practical

(Inorganic, Organic and Physical Chemistry)

Contact Hours: 60; Credits: 04

Full Marks = 100[End Semester Exam (70) Internal Assessment (30)]

Pass Marks = 40 [End Semester Exam (28) Internal Assessment(12)]

Examination Time: 12 hours (2 days)

Section-A (Inorganic Chemistry)

1. Qualitative Inorganic Analysis **25 Marks**

Qualitative analysis of inorganic mixtures containing 2 anions and 2 cations without interfering radicals.

Section-B (Organic Chemistry)

2a. Systematic Qualitative Organic Analysis of Organic Compounds possessing mono-functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines). **15marks**

2b. Organic Preparation and purification: **10 marks**

Organic preparation and reactions

i) Nitration of acetanilide/ nitrobenzene/ salicylic acid
ii) Bromination of phenol/ aniline
iii) Oxime/ 2,4-dinitrophenylhydrazone of aldehyde/ ketone.
iv) Benzil from benzoin
v) Benzilic acid from benzil
vi) Benzoylation of Phenol/ aniline
vii) Iodoform from acetone
viii)

Purification of organic compounds

i) Decolorization of crude sulphanilic acid (recrystallization using animal charcoal)
ii) Recrystallization of benzoic acid from hot water/ ethanol.
iii) Recrystallization of Acetanilide from boiling water
iv) Purification of naphthalene/ camphor/phthalic acid (by sublimation)

Section-C (Physical Chemistry)

3. Any *one experiment out of the following can set in examination* **20Marks**

vi. To determine the surface tension of glycerol/acetic acid Solutions at different concentrations and construction of graph.

vii. To determine the viscosity of glycerol/acetic acid Solutions at different concentrations and construction of graph.

viii. pH-metric titration of strong acid vs strong base.

ix. Conductometric titration of strong acid vs strong base.

x. To determine the solubility of benzoic acid at different temperature and to determine ΔH of the dissolution process.

Internal Assessment

7. Viva-voce **15 Marks**

8. Regularity in maintenance of Lab Note Book **5 marks**

9. Attendance **10 Marks**

Reference Book

i. Vogel, A. I., A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

ii. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

iii. Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.

iv. Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

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