SYLLABUS
&
PROGRAMME STRUCTURE

Integrated Master Degree (IMD)
in
Chemistry

(Effective from the Academic Session 2020-21)

First to Sixth Semester

MAHARAJA BIR BIKRAM UNIVERSITY
AGARTALA, TRIPURA: 799004

IMD PROGRAMME STRUCTURE

UG Structure of Proposed CBCS Syllabus under Integrated Master Degree in Chemistry

(Semester I to Semester VI)

Semester	Core Course (14) Honours	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (8)
I	**C1 (Credit-06) C2 (Credit-06)**	**AECC1: Environmental Studies**			**GE1 (Phy) (Credit-06)** **GE1 (Math) (Credit-06)**
II	**C3 (Credit-06) C4 (Credit-06)**	**AECC2: (Communicative English) (Credit-02)**			**GE2 (Phy) (Credit-06)** **GE2 (Math) (Credit-06)**
III	**C5 (Credit-06) C6 (Credit-06)**		***SEC1** (Basics in Computer Applications/Pesticide Chemistry/ Fuel Chemistry) **(Credit-02) (Assignment-1)**		**GE3 (Phy) (Credit-06)** **GE3 (Math) (Credit-06)**
IV	**C7 (Credit-06) C8 (Credit-06)**		***SEC2** (Analytical Chemistry/ Clinical Biochemistry/ Pharmaceutical Chemistry) **(Credit-02) (Assignment-2)**		**GE4 (Phy) (Credit-06)** **GE4 (Math) (Credit-06)**
V	**C9 (Credit-06) C10 (Credit-06) C11 (Credit-06)**			**DSE1** (Analytical Methods) **(Credit-06)** **DSE2** [Introductory Research Methodology/ Industrial gases & Inorganic Chemicals/ Energy / Spectroscopic methods (IR,NMR & UV-Vis)] **(Credit-06) (Project Work-1)**	
VI	**C12 (Credit-06) C13 (Credit-06) C14 (Credit-06)**			**DSE3** (Industrial Chemistry) **(Credit-06)** **DSE4** (Environmental Chemistry I & II/ Introductory Nano Chemistry / Green Chemistry) **(Credit-06) (Project Work-2)**	

Semester- I
Core Course (CC) – Paper I
INORGANIC CHEMISTRY-I

Total Marks– 100
(Theory – 70, Practical-30)
(Credits: Theory-04, Practical-02)

Theory

Unit-I

Atomic Structure **(10 Lectures)**

Bohr's theory, its limitations, hydrogen spectra, de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Schrödinger's wave equation (only equation), significance of ψ and ψ^*, quantum numbers and their significance, normalized and orthogonal wave functions, Sign of wave functions, radial and angular wave functions for hydrogen atom, radial probability distribution curves, shapes of orbitals.

Unit-II

Periodicity of Elements **(10 Lectures)**

Modern periodic table, classification of elements on the basis of electronic configuration; periodic variation in properties – atomic and ionic radii, oxidation states, ionization potential, electron affinity, electronegativity (Mulliken scale, Pauling's scale and Allred Rochow scale), diagonal relationship, Slater's rule, screening or shielding effect.

Unit-III

Chemical Bonding **(16 Lectures)**

General characteristics, types of bonds, radius ratio, packing fractions, Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, solvation energy, hydration energy, Lewis structure, hybridization & geometry. Bent's rule, Molecular orbital theory (MOT), Molecular orbital diagrams of diatomic and simple polyatomic molecules and their ions (N_2, O_2, C_2, B_2, F_2, CO, NO, HCl, BeF_2, CO_2), formal charge, Valence shell electron pair repulsion theory (VSEPR), bond angle, bond length, bond strength, bond energy, covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules and consequences on polarization, bond moment and dipole moment, van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Hydrogen bonding and its application.

Unit-IV

Redox Reactions and Nuclear Radio Chemistry **(16 Lectures)**

Ion electron method of balancing equations, calculation of equivalent Weights of oxidants and reductants, standard electrode potential, formal potential, electrochemical series; redox potentials and its applications, choice of indicators in redox titrations.

Nuclear Radio Chemistry

Nuclear particles;neutron-proton ratio and its implications, types of radioactive decay; nuclear stability, nuclear binding energy; mass defect and packing fraction; magic number, isotopes, isobars,

isotones and isomers, natural and artificial radioactivity; first order rate equation of radioactive disintegration; radioactive equilibrium; Theory of radioactive disintegration series; measurement of radioactivity, half-life and average life period, group displacement law, unit of radioactivity; nuclear Transmutation, carbon-14 dating, nuclear reactions, types of nuclear reactions, concepts of fusion and fission, spontaneous fission, tracer elements, application of radioactive isotopes, Q value; nuclear forces: n-n, n-p, p-p.

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H. *Concepts & Models of Inorganic Chemistry*, Oxford, 1970
- Atkins, P.W. & Paula, J. *Physical Chemistry*, Oxford Press, 2006.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications 1962.
- Das, A. *Innovative Mnemonics in Chemical Education - A Handbook for Classroom Lectures*, Cambridge Scholars Pub., Lady Stephenson Library, Newcastle upon Tyne, UK, 2019.

Practical-CC I (LAB) (Credits:02)

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference Books:

- Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS.

Semester- I
Core Course (CC) – Paper II
PHYSICAL CHEMISTRY- I

Total Marks– 100
(Theory – 70, Practical-30)
(Credits: Theory-04, Practicals-02)

Theory

Unit-I
GASEOUS STATE (16 Lectures)

Kinetic molecular model of a gas: Postulates 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, calculation of σ from η; 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 Equipartition of energy, degrees of freedom and molecular basis of heat capacities.

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. van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit-II

LIQUID STATE (14 Lectures)

Qualitative treatment of the structure of the liquid state; physical properties of liquids; Liquid- Vapour equilibrium, vapour pressure, surface tension, Surface energy, Contact angle, Determination of surface tension by capillary rise & Drop weight method with their derivations, Excess pressure inside the bubble, Interfacial tension, and coefficient of viscosity, and their determination. Effect of temperature on surface tension, Parachor, Applications of Surface tension, Explanation of cleansing action of detergents, Viscosity & Viscosity coefficient, Measurement of viscosity, Effect of addition of various solutes on surface tension and viscosity. Temperature variation of viscosity of liquids and comparison with that of gases. Rheochor, Qualitative discussion of structure of Liquid.

Unit-III

Electrolysis & Electrolytic Conductance (14 Lectures)

Electrolysis, Factors controlling Electrolysis, Faraday's laws with explanations. Qualitative and quantitative treatment of Faraday's laws. Application of electrolysis in metallurgy and industry. Electrolytic conductance, Conductivity, specific, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Experimental determination of conductance (Specific, equivalent & molar), Kohlrausch law of independent migration of ions and its applications.

Unit-IV
SOLID STATE **(16 Lectures)**

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Structure of Different Ionic Crystal (NaCl, KCl, ZnS,CaF_2, Na_2O, Pervoskite) Radius ratio effect, Packing of Ionic crystal & Voids, Different Stoichiometric & nonstoichiometric defects in crystals. Different Electrical and magnetic properties of solid. Solid with superconductivity.

Reference Books:

- 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).

Practical-CC II (LAB) (Credits:02)

Surface tension measurements

1. Determination of the surface tension by drop number method.
2. Determination of the surface tension by drop weight method.
3. Study the variation of surface tension of detergent solutions with concentration.
4. Determination of concentration of a given solution of acetic acid by measuring the surface Tension of the solution.

Viscosity measurement

5. Determination of viscosity of aqueous solutions of ethanol at room temperature.
6. Determination of viscosity of aqueous solutions of sucrose
7. Determination of viscosity of aqueous solutions of Polymer polystyrene.
8. Determination of concentration of a given solution glycerol/sucrose by measuring the viscosity of the solution.

Conductometry measurement

9. Determination of cell constant.
10. Determination of specific and equivalent conductance of electrolytes.

Reference Books

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry,* 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry,* 3rd Ed.; W.H. Freeman & Co.: New York (2003).
- Advance Physical Chemistry, Gurtu-Gurtu, A Pragati Publication.
- A Text Book of Physical Chemistry, A.S. Negi & S. C. Anand, The New age Publication.
- Physical Chemistry, P.C. Rakhit

Semester – I
Ability Enhancement Compulsory Course

AECC – Paper I
Environmental Studies

TOTAL MARKS – 100
End semester- 80, Internal- 20

Unit 1 : Introduction to Environmental Studies and Natural Resources (Renewable and Non---renewable Resources)

- Multidisciplinary nature of environmental studies;
- Scope and importance; Concept of sustainability and sustainable development.
- Land resources and landuse change; Land degradation, soil erosion and desertification.
- Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.
- Water: Use and over---exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter---state).
- Energy resources: Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

(10 lectures)

Unit 2 : Ecosystems and Biodiversity and Conservation

- What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems :
  a. ***Forest ecosystem***
  b. ***Grassland ecosystem***
  c. ***Desert ecosystem***
  d. ***Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)***
- Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots
- India as a mega---biodiversity nation; Endangered and endemic species of India
- Threats to biodiversity: Habitat loss, poaching of wildlife, man---wildlife conflicts, biologicalinvasions; Conservation of biodiversity : In---situ and Ex---situ conservation of biodiversity.
- Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

(14 lectures)

Unit 3 : Environmental Pollution and Environmental Policies & Practices

- Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution
- Nuclear hazards and human health risks
- Solid waste management: Control measures of urban and industrial waste.
- Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture
- Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity (CBD).

- Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

(15 lectures)

Unit 4 : Human Communities and the Environment

- Human population growth: Impacts on environment, human health and welfare.
- Resettlement and rehabilitation of project affected persons; case studies.
- Disaster management : floods, earthquake, cyclones and landslides.
- Environmental movements :Chipko, Silent valley, Bishnois of Rajasthan.
- Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.
- Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

(8 lectures)

Suggested Readings:

1. *Carson, R. 2002. Silent Spring. Houghton Mifflin Harcourt.*
2. *Gadgil, M., &Guha, R.1993. This Fissured Land: An Ecological History of India. Univ. of California Press.*
3. *Gleeson, B. and Low, N. (eds.) 1999.Global Ethics and Environment, London, Routledge.*
4. *Gleick, P. H. 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.*
5. *Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll.Principles of Conservation Biology. Sunderland: Sinauer Associates, 2006.*
6. *Grumbine, R. Edward, and Pandit, M.K. 2013. Threats from India's Himalaya dams. Science, 339: 36---37.*
7. *McCully, P. 1996. Rivers no more: the environmental effects of dams(pp. 29---64). Zed Books.*
8. *McNeill, John R. 2000. Something New Under the Sun: An Environmental History of the Twentieth Century.*
9. *Odum, E.P., Odum, H.T. & Andrews, J. 1971.Fundamentals of Ecology. Philadelphia: Saunders.*
10. *Pepper, I.L., Gerba, C.P. &Brusseau, M.L. 2011. Environmental and Pollution Science. Academic Press.*
11. *Rao, M.N. &Datta, A.K. 1987. Waste Water Treatment. Oxford and IBH Publishing Co. Pvt. Ltd.*
12. *Raven, P.H., Hassenzahl, D.M. & Berg, L.R. 2012.Environment. 8th edition. John Wiley & Sons.*
13. *Rosencranz, A., Divan, S., & Noble, M. L. 2001. Environmental law and policy in India. Tripathi 1992.*
14. *Sengupta, R. 2003. Ecology and economics: An approach to sustainable development. OUP.*
15. *Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.*
16. *Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.*
17. *Thapar, V. 1998. Land of the Tiger: A Natural History of the Indian Subcontinent.*
18. *Warren, C. E. 1971. Biology and Water Pollution Control. WB Saunders.*
19. *Wilson, E. O. 2006.The Creation: An appeal to save life on earth. New York: Norton.*
20. *World Commission on Environment and Development. 1987.Our Common Future. Oxford University Press.*

First Semester
DSC/ GE for IMD - PAPER –I (Physics)

TOTAL MARKS – 100
(Theory – 70, Practical-30)

Unit-I Vector Calculus (15 Lectures)

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter.
Ordinary Differential Equations: 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients.

Vector Analysis: Review of vector algebra (Scalar and Vector triple products), Gradient, Divergence, Curl and their significance, Vector Integration, Line, Surface and Volumeintegrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors(statement only).

Problems: Simple numerical problems

Unit-II Mechanics (15 Lectures)

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass.
Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets.
Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum.

Problems: Simple numerical problems

Unit-III General Properties of Matter (15 Lectures)

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

Elasticity: Hooke's law, Stress-strain diagram, Elastic moduli, Relation between Elastic constants, Poisson's Ratio, Expression for Poisson's ratio in terms of elastic Constants, Work done in stretching and work done in twisting a wire, Twisting couple on a cylinder, Determination of Rigidity Modulus by static torsion of cylinder(wire), Torsional pendulum, Determination of Rigidity modulus and moment of inertia by dynamical method.

Problems: Simple numerical problems

Unit-IV Oscillations and Relativity (15 Lectures)

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations.

(7 Lectures)

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

(8 Lectures)

Problems: Simple numerical problems

Practical

1. Measurements of length (or diameter) using verniercalliper, screw gauge and travelling microscope.
2. To determine the height of a building using a Sextant.
3. To study the Motion of Spring and calculate (a) Spring constant, (b) **g**
4. To determine the Moment of Inertia of a body about an axis passing through its centre of gravity
5. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Young's Modulus of material of a rod by flexure method.
7. To determine the Modulus of Rigidity of a Wire by Statistical method or dynamical method.
8. To determine the Young's modulus of a material of a wire by Searle's method.
9. To determine the value of g using Bar Pendulum.
10. To determine the value of g using Kater's Pendulum.

11. To determine the Moment of Inertia of a Flywheel.

Reference Books:

- University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison-Wesley
- Mechanics Berkeley Physics course,v.1: Charles Kittel, et. Al. 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
- Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford UniversityPress
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

First Semester
DSC/GE for IMD - PAPER –I
Differential Calculus

TOTAL MARKS – 100
(End Semester-80 Internal-20)

UNIT-I. ε-δ definitionsof limit and continuity.Properties of limit and continuity. Uniform continuity. Types of discontinuities. Differentiability of functions. Successive differentiation, Leibnitz's theorem.

UNIT-II. Rolle's theorem, Mean Value theorems of Lagrange and Cauchy. Statement of Taylor and Maclauriantheorems with Lagrange's and Cauchy's form of remainders. Expansion of functions like e^{ax}, $sinax, cosax$, $e^{ax}sinbx$, $e^{ax}cosbx, \log(1+x)$, $(1+x)^n$ etc. Indeterminate forms,L'Hospital rule and its applications.

UNIT-III. Functions of several variables, their limit and continuity. Partial derivatives, chain rule in partial derivatives. Homogeneous functions. Euler's theorem on homogeneous functions and its converse. Maxima and minima of functions of two variables, stationary points, saddle points.Jacobian and its property.

UNIT-IV. Tangent, subtangent, normal, subnormal,curvature, radius of curvature, different formulae of radius curvature, evolute and involute, asymptotes, envelopes.

References:

1. Differential Calculas -R.K.Ghosh and K.C.Maity, New Central Book Agency.
2. Text book of Differential Calculas-Ahsan Akhtar and Sabiha Ahsan, Prentice Hall of India.
3. Differential Calculus, Santinarayan, P.K. Mittal, S. Chand.
4. Differential Calculus-Das and Mukherjee, U.N.Dhur.

Semester- II

Core Course (CC) – Paper III

ORGANIC CHEMISTRY I

Total Marks– 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory

Unit –I

Basics of Organic Chemistry **(18 Lectures)**

General Introduction: Classification and Nomenclature (acyclic and cyclic)

Bonding and Physical Properties: Hybridization and its applications, orbital pictures of bonding (sp^3, sp^2, sp, C-C, C-N & C-O system), bond lengths, bond angles, bond energy, bond polarity and bond polarizability; inductive, electromeric, resonance, mesomeric and field effects; tautomerism, hyperconjugation, steric inhibition of resonance, dipole moment of organic compounds; organic acids and bases and their relative strength.

Reaction Mechanism and Reactive Intermediates: Homolytic and heterolytic bond fission, homogenic and heterogenic bond formation, curly arrow rules; electrophiles and nucleophiles; introduction to types of organic reactions-addition, elimination and substitution reactions. Reaction kinetics: activation energy and transition state, energy profile diagrams for one-step and two-step reactions, thermodynamic and kinetic control of reactions. Reactive Intermediates: carbocations (carbenium and carbonium ions), carbanions, free radicals, carbenes, nitrene and benzyne: structure and stability.

Unit-II

Stereochemistry-1 **(20 Lectures)**

Types of Stereoisomerism, conformation and configuration; Fischer, Newmann, Sawhorse and flying-wedge projection formulae and their interconversions, optical activity, specific rotation, optical purity and enantiomeric excess, elements of symmetry: rotational axis of symmetry, plane of symmetry, centre of symmetry and alternating axis of symmetry, chirality, asymmetry, stereogenicity, chirotopicity and pseudoasymmetry, enantiomers, distereoisomers, threo, erythro and meso compounds, systems involving 1/2/3-chiral centre (s), racemic mixture, racemization (through cationic, anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation, relative and absolute configuration, D/L and R/S descriptors, geometrical isomerism, cis/trans, syn/anti and E/Z nomenclature, combination of R/S and E/Z isomerisms; elementary idea of stereospecific and stereoselective reactions.

Unit – III

Chemistry of Aliphatic Hydrocarbons **(16 Lectures)**

Carbon-Carbon sigma bond (Alkane): Corey- House synthesis and free radical halogenation of alkanes.

Carbon-Carbon pi bond (Alkenes and Alkynes): Formation of alkenes and alkynes by elimination reactions, E1, E2, E1cb mechanisms, Saytzeff and Hofmann eliminations, *syn* and *anti* eliminations; electrophilic addition mechanism to C=C bonds. Reactions of alkenes with mechanism: regio and chemo selectivity, halogenation, hydrohalogenation, Markownikoff and anti-Markownikoff addition, oxymercuration-demercuration, hydroboration, ozonolysis,

hydrogenation, syn and anti-dihydroxylation, epoxidation, 1,2-and 1,4-addition reactions in conjugated dienes, interconversion of E- and Z-alkenes, allylic and benzylic bromination: use of NBS; Reactions of alkynes: electrophilic and nucleophilic additions, hydration to form carbonyl compounds, Birch reduction of alkynes, reduction by Lindlar's catalyst, reactions of terminal alkynes by exploring its acidity

Unit-IV

Stereochemistry-2 and Aromatic Hydrocarbons **(20 Lectures)**

Stereochemistry-2: Conformation: Nomenclature, eclipsed, staggered, gauce and anti, dihedral and torsion angle, energy barrier of rotation, conformational analysis of ethane, propane, *n*-butane, relative stability of conformation on the basis of steric effect, dipole-dipole interaction, H-bonding; cycloalkanes: stability of cycloalkanes: Baeyer strain theory, concept of angle strain and torsional strain, conformational analysis of cyclohexane and monosubstituted cyclohexane.

Aromatic Hydrocarbons: Aromaticity: Hückel's rule of aromaticity, antiaromatic, nonaromatic and homoaromatic compounds; electrophilic aromatic substitution: arenium ion mechanism, halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation, chloromethylation, Vilsmeier-Haack, Gattermann-Koch and Gattermann reactions, Ipso substitituion, Directive effects of the substituents.

Reference Books:

- Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry, Second edition,* Oxford University Press, 2012.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. *Organic Chemistry, 12th Edition,* Wiley, 2016.
- Sen Gupta, S. *Organic Chemistry, First edition,* Oxford University Press, 2014.
- Smith, J. G. *Organic Chemistry,* Tata McGraw-Hill Publishing Company Limited.
- Kalsi, P. S. *Organic Reactions and Their Mechanisms,* New Age International Private Limited, 2017.
- Morrison, R. N. & Boyd, R. N. *Organic Chemistry,* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nasipuri, D. *Stereochemistry of Organic Compounds,* Wiley Eastern Limited.
- Sen Gupta, S. *Basic Stereochemistry of Organic Molecules, Second Edition,* Oxford University Press, 2018.
- E. L. Eliel, *Stereochemistry of carbon compounds,* Tata-McGraw Hill.
- Kalsi, P. S. *Stereochemistry Conformation and Mechanism, Eighth edition,* New Age International, 2014.
- Finar, I. L. *Organic Chemistry (Volume 1),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Das, A. *Innovative Mnemonics in Chemical Education - A Handbook for Classroom Lectures*, Cambridge Scholars Pub., Lady Stephenson Library, Newcastle upon Tyne, UK, 2019.
- Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds;* Wiley: London, 1994.

Practical-CC III (LAB) (Credits: 02)

1. Separation of the components of a binary solid mixture depending upon solubility by using water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc.

The composition of the mixture may be of the following types: benzoic acid/p-toluidine; *p*-nitrobenzoic acid /*p*-aminobenzoic acid; *p*-nitrotolune/*p*-anisidine; *p*-toluidine/benzophenone; *p*-chlorobenzoic acid/ benzophenone; benzoic acid/benzophenone.

2. Purification of any one of the separated components by crystallization using suitable solvents such As water, alcohol, alcohol-water mixture etc.

3. Determination of the melting points of above purified compounds and other unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

4. Determination of boiling point of the common organic liquid compounds (boiling point of the chosen organic compounds should preferably be less than 160 °C) e.g., ethanol, acetylacetone, ethyl methyl ketone, cyclohexane, cyclohexanone, anisole, crotonaldehyde, mesityl oxide.

Reference Books:

- Vogel, A. I. *Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis,* CBS Publishers and Distributors.
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, Vikas Publishing House Pvt. Ltd.
- Agarwal, O. P. *Advanced Practical Organic Chemistry*, Goel Publishing House
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009).
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).

Semester- II
Core Course (CC) – Paper IV
PHYSICAL CHEMISTRY II

Total Marks– 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory

Unit-I
CHEMICAL THERMODYNAMICS-I (14 Lectures)

Basics of Thermodynamics: Utility of Thermodynamics study, System and Surrounding, isolated, closed and open systems; different processes-isothermal, adiabatic reversible, irreversible, cyclic, etc., Intensive and extensive variables; state and path functions; 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 of molecules and ions 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. Adiabatic flame temperature, explosion temperature.

Unit-II
CHEMICAL THERMODYNAMICS-II (14 Lectures)

Second Law: Need of Second Law of Thermodynamics, Second Law, Carnot Theorem, Application of Carnot cycle, Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Feature of Entropy Change, Calculations of entropy change for reversible and irreversible processes, during phase change.
Third Law: Statement of third law, Nernst Heat theorem, concept of residual entropy, calculation of absolute entropy of molecules.
Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relationship between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Unit - III
IONIC EQUILIBRIA (14 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, Ostwald Dilution law, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, Calculation of pH, Use of pH, dissociation constants of mono-, di-and triprotic acids (exact treatment).

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. Common ion effect, Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.

Unit-IV

Solutions and Colligative Properties (14 Lectures)

Dilute solutions; concept of ideal and non ideal solution, liquid-liquid, liquid-gas solutions, Henrys Law, Cause of positive and negative deviations, lowering of vapour pressure, Raoult's and their applications. Excess thermodynamic functions. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure and amount of solute. Inter relationship between different colligative properties, Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Reference Books

- Peter, A. & Paula, J. de. *Physical Chemistry 9th Ed*., Oxford University Press (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.: New Delhi (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
- Advance Physical Chemistry, Gurtu-Gurtu, A Pragati Publication.
- A Text Book of Physical Chemistry, A.S. Negi & S. C. Anand, The New age Publication.
- Physical Chemistry, P.C. Rakhit
- Thermodynamics principles & Applications, N C Dey, New Central Book Agency(P) Ltd.

Practical- CC IV LAB (Credits:02)

Thermochemistry

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.

4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. Determination of heat of solution of Benzoic acid from solubility measurement.

pH -metry

8. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
9. Preparation of buffer solutions of different pH (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide.
10. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base. (iii) Determination of dissociation constant of a weak acid.

Reference Books

- 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).

Semester – II
Ability Enhancement Compulsory Course

MIL - AECC – 2
English Communication

TOTAL MARKS – 100
(End Semester-80, Internal-20)

Sem.	Paper	Unit	Contents	Ending Session Marks	Internal Marks
II	AECC (MIL) ENGLISH	I	Communication - its different types and modes. Verbal and non-verbal communication; personal, social and business communication. Interpersonal, intra-personal and group communication. Barriers of communication.	**20**	**20** **Based on Language Skills**
		II	Speaking Skills – Monologue and Situational Dialogue; Group Discussion; Interview- its types; Effective Communication; Public Speaking Skills.	**20**	
		III	Reading Comprehension- Close Reading; Comprehension; Summary and Paraphrasing; Analysis and Interpretation.	**20**	
		IV	Writing Skills – Basic tools for writing skill: Vocabulary, use of determiners and prepositions, Construction (Types) of Sentences and conversion of the same, Question Tag ; Report writing- its different types; Making notes; Letter Writing.	**20**	

Suggested Readings:

1. *Verbal and Non-verbal communication, Aman Publications, English, ISBN: 8182040604*
2. *Fluency in English - Part II, Oxford University Press, 2006.*
3. *Business English, Pearson, 2008.*
4. *Language, Literature and Creativity- Orient Blackswan, 2013.*

Second Semester
DSC / GE for IMD - PAPER –II
ELECTRICITY AND MAGNETISM

TOTAL MARKS – 100
(Theory – 70, Practical-30)

Unit-I [15 +2(Intro.+ Recap.) Lectures)]

Electrostatics:
Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem--, Electric field due to point charge, infinite line of charge ,uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential.

Capacitance, capacitor and dielectric medium:
Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field.
Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

Unit-II [15 +2(Intro.+ Recap.) Lectures)]

Magnetism & Magnetostatics:
Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law and its applications in different cases.
Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials. Hysteresis, hysteresis loss and Hysteresis curve. Energy loss per cycle of a Hysteresis curve.

Unit-III [15 +2(Intro.+ Recap.) Lectures)]

Electromagnetic Induction:
Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, Self inductance of a single coil and a solenoid , Mutual inductance of two coils. Energy stored in magnetic field.

Transient currents , AC and AC impedance
Growth and decay of current in LR circuit, Charging and discharging of capacitor through a resistance (CR circuit), current and impedance in— AC LR , CR and LCR circuit, Resonance condition, power factor, wattles current

Unit-IV [15 +2(Intro.+ Recap.) Lectures)]

Maxwell`s equations and Electromagnetic wave propagation:

Equation of continuity of current, Displacement current, Maxwell's equations and their derivation from basic laws of physics , Poynting vector, its measure and average value,

energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, velocity in vacuum and dielectric medium, transverse nature of EM waves, polarization.

N.B: Simple Problems (covering Unit-I, II, III & IV) using formulae of these respective units to be practiced.

Practical

1.To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) Checking electrical fuses.
2.To determine an unknown Low Resistance using Potentiometer.
3. Measurement of current by Potentiometer
4. Determination of resistance per unit length of the meter bridge wire by Carry Foster method and determination of unknown resistance

5. Determination of the end correction of a meter bridge wire and to find the specific resistance ofthe material of the given wire

6.To determine the Temperature coefficient of resistance of a material of a given wire by meter bridge.

7. Determination of Horizontal components of earth magnetic field and magnetic moment of a bar magnet by deflection magnetometer and vibration magnetometer.

8.To verify the Superposition, and Maximum power transfer theorems.
9.To study the characteristics of a series RC Circuit.
10.To study response curve of a Series LCR circuit and determine its (a) Resonant Frequency b)Quality factor Q,
11.To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ.
3. Press.
4. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.12
6. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

Practical Books :
1.) An Advanced Course in Practical Physics , D. Chattopadhyay and P.C. Rakshit.
1. Advanced Practical Physics Vol.I & Vol.II. Dr. Basudev Gosh.
2. A Text Book of Practical Physics, Dr. Basudev Gosh.
3. Advanced Practical Physics Vol.I &Vol.II, K. G. Mazumdar.
4. 5B.Sc Practical Physics, C.L. Arora.

Second Semester
DSC/GE for IMD - PAPER –II
Differential Equations

TOTAL MARKS – 100
(End Semester-80 Internal-20)

UNIT-I. Significance of ordinary differential equation. Formation of a differential equation. Meaning of a solution of ordinary differential equation. Degree and order of a differential equation. Concept of linear and non linear differential equations. Differential equation of first order and first degree. Separable, exact and homogeneous first order differential equations. Integrating factor, rules to find an integrating factor (statement of relevant results only).Linear equations and equations reducible to linear form. Bernoulli's equation. First order higher degree equations solvable for x, y, p.Clairaut'sequation and singular solutions.

UNIT-II. Linear differential equations of second order with constant and variable coefficients: Complementary function, Particular integral and Symbolic operator D. Linear differential equations of second order with variable coefficients. Method of undetermined coefficients. Euler's homogeneous equation and reduction to an equation of constant coefficients.

UNIT-III. Wronskian and its properties. The method of variation of parameters. Simultaneous differential equations. Orthogonal trajectories.Transformation of the equation by changing - the dependent variable and the independent variable.

UNIT-IV. Formation of partial differential equations. Order and degree of partial differential equations. Concept of linear and non-linear partial differential equations, Linear partial differential equation of first order, Lagrange's method of solution.

References:

1. Differential Equation – R.K.Ghosh and K.C.Maity, New Central Book Agency.
2. Advanced Differential Equation- M.D. Raisinghania.
3. Differential Equation- J.G. Chacraborty and P.R.Ghosh,U.N. Dhur.

Semester- III
Core Course – Paper V
INORGANIC CHEMISTRY-II

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory

Unit-I

Metallurgy and Acids and Bases **(16 Lectures)**

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 Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

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

Unit-II

***s* and *p* block elements** **(15 Lectures)**

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, basic beryllium acetate and nitrate.

Unit-III

(15 Lectures)

Preparation, Properties, Structure & Uses of some Compounds of p-Block Elements

Boric acid and borates, boron nitrides, borohydrides (diborane), carboranes, graphitic compounds, silanes, Oxides and oxoacids of nitrogen, P_4, S_8, chlorine, peroxo acids of sulphur, peroxo acids of chlorine, interhalogen compounds, polyhalide ions, pseudohalogens.

Unit-IV

Noble Gases and Inorganic Polymers **(16 Lectures)**

Nobel Gases: 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- XeF_2, XeF_4 and XeF_6), Molecular shapes of noble gas compounds (VSEPR theory).

Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry*, 3rd Ed., John Wiley Sons, N.Y. 1994.
- Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth-Heinemann. 1997.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry,* 4th Ed., Pearson, 2010.
- Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

Practical- CC V (LAB) (Credits:02)

(A) Iodo / Iodimetric Titrations

1. Estimation of Cu(II) using sodium thiosulphate solution (Iodimetrically).
2. Estimation of available chlorine in bleaching powder iodometrically.

(B) Inorganic preparations

1. Cuprous Chloride, Cu_2Cl_2
2. Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
3. Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.
4. Preparation of Borax/Boric acid.

Reference Books:

- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis,* 6th Ed., Pearson, 2009.

Semester- III
Core Course– Paper VI
ORGANIC CHEMISTRY-II

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory

Unit – I

Chemistry of Halogenated Hydrocarbons and Organometallic compounds (16 Lectures)

Alkyl halides: Methods of preparation, chemical reactions, nucleophilic substitution reactions – S_N1, S_N2, S_Ni, S_N1' and S_N2' mechanisms, effect of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles), relative rate and stereochemical features; nucleophilic substitution vs. elimination.

Aryl halides: Methods of preparation, chemical reactions, nucleophilic aromatic substitution: S_NAr and benzyne mechanism.

Organometallic compounds: Preparation and synthetic application of Grignard reagent and organolithium compounds.

Unit – II

Alcohols, Phenols, Ethers and Epoxides (16 Lectures)

Alcohols: Methods of preparation and properties, Bouvaelt-Blanc reduction, dehydration, oxidation (with PCC and PDC); preparation and properties of glycols, oxidation of 1,2-diols by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement.

Phenols: Methods of preparation and properties; acidity of substituted phenols; Cumene hydroperoxide-phenol rearrangement, Reimer–Tiemann and Kolbe–Schmidt reaction, Fries, Claisen and Dienone-Phenol rearrangements, Houben-Hoesch reaction, Lederer-Manasse reaction, Dakin reaction.

Ethers and Epoxides: Methods of formation and reactions with acid, ring opening reaction of epoxides.

Unit – III

Carbonyl Compounds (16 Lectures)

Methods of preparation and chemical reactions, nucleophilic addition to carbonyl groups, Aldol condensations, Claisen ester condensation, Dieckmann condensation, Benzoin condensation, Knoevenagel condensation, Perkin, Cannizaro, Tischenko and Wittig reactions, Benzil-benzillic acid rearrangement, Haloform reaction, Baeyer-Villigar oxidation, Darzen's reaction, Clemmensen and Wolff Kishner reduction, MPV reduction, Oppenauer oxidation, Michael addition, Reformatsky reaction, reduction with lithium aluminium hydride and sodium borohydride.

Unit – IV

Active methylene compounds and Carboxylic Acids and their Derivatives (16 Lectures)

Active methylene compounds: Preparation, properties and synthetic applications of Ethyl acetoacetate and Diethyl malonate.

Carboxylic Acids and their Derivatives: Methods of preparation, physical properties and reactions of monocarboxylic acids, effect of substituents on acidic strength, preparation and typical reactions of succinic, phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; preparation and reactions of acid chlorides, anhydrides, esters and amides; esterification and hydrolysis mechanism ($B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$), Hell-Volhard-Zelinsky reaction, Hunsdicker reaction, Arndt-Eistert reaction.

Reference Books:

- Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry, Second edition,* Oxford University Press, 2012.
- Carey, F.A.; Sundberg, R. J. *Advanced Organic Chemistry, Part: B,* Springer.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. *Organic Chemistry, 12th Edition,* Wiley, 2016.
- Sen Gupta, S. *Organic Chemistry, First edition,* Oxford University Press, 2014.
- Kalsi, P. S. *Organic Reactions and Their Mechanisms;* New Age International Private Limited, 2017.
- Morrison, R. T. & 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).
- McMurry, J.E. *Fundamentals of Organic Chemistry, 7th Ed.* Cengage Learning India Edition, 2013.

Practical- CC VI (LAB) (Credits:02)

Organic preparations:

1. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) using green approach (Zn-dust/Acetic Acid)
2. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, pcresol) by Schotten-Baumann reaction.
3. Oxidation of Ethanol/ Isopropanol (Iodoform reaction).
4. Bromination of Acetanilide using green approach (Bromate-bromide method)
5. Nitration of any one of the following:
    a) Acetanilide by conventional method
    b) Salicylic acid by green approach (using ceric ammonium nitrate).
6. Preparation of phthalimide by condensation of phthalic anhydride with urea.
7. Hydrolysis of amides and esters.
8. Preparation of benzil by oxidation of benzoin.
9. Aldol condensation (preparation of dibenzylidene acetone).

10. Benzil-Benzilic acid rearrangement.

The above derivatives should be prepared using 0.5-1g of the organic compound. The solid samples must be collected and may be used for recrystallization, melting point and TLC.

Reference Books:

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009).
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, Vikas Publishing House Pvt. Ltd.
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

Semester – III
(Skill Enhancement Course) SEC – I
(Honours)

FULL MARKS - 100
(Credits: 02)
Theory: 30 Lectures

(Students are required to choose two topics in their Assignment among SEC-1A / SEC-1B / SEC- 1C)

(SEC-1A / SEC – 1B / SEC – 1C)

(SEC-1A) (Credit:01)
BASICS IN COMPUTER APPLICATIONS

Introduction to Computer Fundamentals
Introduction to Computer, Computer System Hardware, Computer Memory, Input and Output Devices, Interaction between User and Computer, Introduction to Free and Open Source Software, Definition of Computer Virus, Types of Viruses, Use of Antivirus software.

Basics of Operating System
Definition of Operating System, Objectives, types, and functions of Operating systems, Working with Windows Operating System: Introduction, The Desktop, Structure of Windows, Windows Explorer, File and Folder Operations, The Search, The Recycle Bin, Configuring the Screen, Adding or Removing New Programs using Control Panel, Applications in windows (Paint, Notepad, WordPad, Calculator)

Introduction to Business Communication Tools
MS-Word: Introduction, Starting MS-Word, MS-Word Screen and its Components, Elementary Working with MS-Word.
MS-Excel: Introduction, Starting MS-Excel, Basics of Spreadsheet, MS-Excel Screen and Its Components, Elementary Working with MS-Excel.
MS-Power point: Introduction, Starting MS-PowerPoint, Basics of PowerPoint, MS-PowerPoint Screen and Its Components, Elementary Working with MS Power Point.

Introduction to HTML
Introduction to HTML, Working of HTML, Creating and loading HTML page, tags, Structure of on HTML, Document, Stand Alone Tags, Formatting text, Adding Images, Creating hyper Links, Tables, Sending E-mails through Web Page, Sample web pages.

Internet, Internet application and Internet Security
Introduction, Internet evolution, Working of Internet, Use of Internet, Overview of World Wide Web (Web Server and Client), Introduction to Search engine and Searching the Web, Downloading files, Introduction to Web Browsers, Working with E-mail (creation and use of the same), Security, Privacy, Ethical Issues & Cyber Law.

(SEC – 1B) **(Credit:01)**

PESTICIDE CHEMISTRY

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship; synthesis and technical manufacture and uses of representative pesticides in the following classes: organochlorines (DDT, Gammexene); organophosphates (Malathion, Parathion); carbamates (Carbofuran and Carbaryl); quinones (Chloranil); anilides (Alachlor and Butachlor).

Reference Book:

- Cremlyn, R. *Pesticides. Preparation and Modes of Action,* John Wiley & Sons, New York, 1978.
- Melnikov, N.N. *Chemistry of Pesticides*, Springer, 1971

(SEC – 1C) **(Credit:01)**

FUEL CHEMISTRY

Review of energy sources (renewable and non-renewable), classification of fuels and their calorific value.

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, coal gasification (hydro gasification and catalytic gasification), coal liquefaction and solvent refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, refining and different types of petroleum products and their applications. Fractional Distillation (principle and process), cracking (thermal and catalytic cracking), reforming petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.

Petrochemicals: Vinyl acetate, propylene oxide, isoprene, butadiene, toluene and its derivatives xylene.

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting), solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

Reference Books:

- Stocchi, E. *Industrial Chemistry, Vol-I,* Ellis Horwood Ltd. UK (1990).
- Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).

SEC (Assignment 1 & 2): General Information

- Skill Enhancement Course (SEC) is an integral component based on assignment 1 & 2 of IMD Honours in Chemistry the Streams under UGC CBCS UG Syllabi.
- SEC-1 (Assignment-1) will consist of diverse topics/themes of the Earlier Semesters and similarly SEC-2 (Assignment-2) will also consist of diverse topics/themes related to the Later Semesters.
- Topics/Themes must be incorporated in each of two Syllabi of SEC meant for Assignments corresponding to CBCS IMD Honours Programmes. Assignments should be guided in such a way that is prepared by students on different titles & aspects/dimensions of topics/themes/issues incorporated in University approved SEC Syllabi.
- SEC will represent a well mentored and self prepared assignments in terms of systematic answers in written form against four broad type of question/query carrying 20 marks each. It also consists of 20 marks as oral interaction. Assignments may be on Practical issues/topics/experiments.

SEC: Distribution across Streams &Programmes :

- One Paper of SEC finds its place in each of Third and Fourth Semesters under **Honours Curricula** comprising altogether two Papers.
- Same sub topic/theme cannot be opted by a given candidate/student in preparation of Assignments at different Semesters under SEC.

SEC: Marks Distribution For Assignments

- **Assessment of SEC-Assignments will be made on evaluation of the written form of theme consisting of 80 marks (four questions – each question carries 20 marks) and Oral Interaction /Feedback with the students on assignment consisting of 20 marks.**
- The Assignment will follow the University approved Syllabi materials on Subject & Paper specific topics/themes/issues.
- **The word limits of each broad question within the Assignment will be in between 400 to 500.**
- The evaluated Assignments will remain under the custody of the related Departments and the University may ask for the despatch of the Assignments as & when necessitated.
- The total marks on Assignments will have to be transmitted by the College to the University on or before the stipulated date.
- This is a general guideline. The respective department(s) may incorporate or modify as department(s) deem fit.

Semester - III
DSC /GE for IMD - PAPER –III
THERMAL PHYSICS AND STATISTICAL MECHANICS

TOTAL MARKS – 100
(Theory- 70 (60 + Inter: 10), Practical-30 (20 + Inter: 10))
(Credits: Theory-04, Practicals-02)

Unit-1
[15 +2(Intro.+ Recap.+ Problem hints/ Practice) Lectures)]

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP &CV, Work Done during Isothermal and Adiabatic Processes, Compressibility &Expansion Coefficient, Reversible & irreversible processes, Second law of thermodynamics.

Unit-II
[15 +2(Intro.+ Recap.+ Problem hints/ Practice) Lectures)]

Entropy: Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for (CP– CV), CP/CV, TdS equations.

Unit-III
[15 +2(Intro.+ Recap.+ Problem hints/ Practice) Lectures)]

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities andits experimental verification, Mean free path (Zeroth Order), Transport Phenomena:Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy(no derivation) and its applications to specific heat of gases; mono-atomic and diatomicgases.

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of EnergyDensity, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law.

Unit-IV
[15 +2(Intro.+ Recap.+ Problem hints/ Practice) Lectures)]

Statistical Mechanics: Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law, - distribution of velocity ,Quantum statistics, Fermi-Dirac distribution law,- electron gas, Bose-Einstein distribution law, - photon gas, comparison of three statistics.

N.B: ***Simple Problems (covering Unit-I, II, III & IV) using formulae of these respective units to be practiced.***

Reference Books:

1. *Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.*
2. *A Treatise on Heat, MeghnadSaha, and B.N. Srivastava, 1969, Indian Press.*
3. *Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.*
4. *Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill14*
5. *Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears&G.L.Salinger. 1988, Narosa.*
6. *University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.*
7. *Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.*

More Reference Books:

1. *Thermal Physics (Heat and Thermodynamics), A. B. GUPTA and H. RAY, Books and Allied (P) Ltd.*
2. *Heat Thermodynamics And Statistical Physics, BrijLal, N. Subrahmanyam and P. S. Hemne.*

Unit- V

PRACTICAL : PHYSICS LAB-DSC 1C LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne'sconstantflow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle'sApparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom'sMethod.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee andCharlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistancethermometer.
8. To study the variation of thermoemf across two junctions of a thermocouple withtemperature.
9. To record and analyze the cooling temperature of an hot object as a function of timeusing a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-BalanceBridge
11. Determine the boiling point of a liquid by Platinum resistance thermometer
12. To determine the coefficient of increase of volume of air at constant pressure.
13. To determine the coefficient of increase of pressure of air at constant volume.
14. 14.Find the coefficient of linear expansion of solid by Pulinger's method or any method

15. To find the melting point of a wax using Jouli's constant volume air thermometer.

Reference Books:

1. *Advanced Practical Physics for students, B.L.Flint&H.T.Worksnop, 1971, AsiaPublishing House.*
2. *Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4thEdition, reprinted 1985, Heinemann Educational Publishers.*
3. *A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, KitabMahal, New Delhi.*
4. *A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal,985, Vani Publication.*

More Practical Reference Books :

1. *An Advanced Course in Practical Physics ,D. Chattopadhyay and P.C. Rakshit.*
2. *Advanced Practical Physics Vol.I&Vol.II. Dr.Basudev Gosh.*
3. *A Text Book of Practical Physics, Dr.Basudev Gosh.*
4. *Advanced Practical Physics Vol.I&Vol.II, K. G. Mazumdar.*
5. *B.Sc Practical Physics, C.L. Arora.*

Semester - III
DSC / GE for IMD - PAPER –III
REAL ANALYSIS

TOTAL MARKS – 100
(End Semester-80 Internal-20)

Unit – I

Algebraic and Order Properties of R. Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, bounded below sets, bounded sets, unbounded sets. Suprema and infima of a set. The Completeness Property of R, the Archimedean Property of R. Q is Archimedean ordered field but not ordered complete. Density of rational (and irrational) numbers in R.

Unit – II

Intervals. Neighborhood of a point in R,interior point. Open set and its properties.Limit point and isolated point of a set. Closed set and its properties. Exterior point and interior point of a set. Closure and interior of a set. Derived set, dense set.Illustrations of Bolzano-Weierstrass theorem on sets.

Unit – III

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence criteria, Monotone subsequence Theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion.

Unit – IV

Infinite series, convergence and divergence of infinite series, Cauchy criterion. Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Raabe's test, Cauchy's nth root test, Logarithmic test, Kummer's test, Gauss's test, Integral test, Alternating series, Leibniz theorem, Absolute and Conditional convergence.

Reference:

1. *Differential Calculas -M.C.Ghosh and K.C.Maity,Central*
2. *Mathematical Analysis-S.C.Malik and Sabita Arora- New Age International*
3. *Real Analysis – S.K. Mapa, Sarat Book House.*
4. *Mathematical Analysis- SitansuBandyopadhyay, Academic Publishers*
5. *Elements of Real Analysis – Shanti Narayan, M.D. Raisinghania, S.Chand*
6. *Introduction to Mathematical Analysis - Amritabha Gupta, Academic Press.*

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Semester- IV
Core Course-Paper-VII
ORGANIC CHEMISTRY-III

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory

Unit – I

Nitrogen Containing Functional Groups (**16 Lectures**)

Methods of preparation and chemical reactions of nitro, nitriles, isonitriles and amines, basicity of amines, von Richter reaction, carbylamine reaction, Beckmann, Hofmann, Curtius, Lossen, Schmidt and Hofmann-Martius, benzidine and Demjanov rearrangement, diazo coupling reaction, distinction between primary, secondary and tertiary amines using Hinsberg's method; reduction of nitro compounds under different conditions; preparation and synthetic application of diazonium salts; Gomberg, Meerwein and Japp-Klingermann reactions.

Unit – II

Polynuclear Hydrocarbons, Quinones and Sulphur compounds (**16 Lectures**)

Polynuclear Hydrocarbons: Naphthalene, Anthracene and Phenanthrene-structures and synthesis (including Haworth method, Friedel Craft acylations, Elbs reaction, Bardhan-Sengupta synthesis, Bogert-Cook synthesis, Diels Alder reaction, and Pschorr method); reactions of naphthalene, anthracene and phenanthrene, important derivatives of naphthalene such as naphthol, naphthylamine.

Quinones: Introduction, quinones of benzene, naphthalene, anthracene and phenanthrene-structures, synthesis and chemical reactions; Thiele acetylation.

Sulphur compounds: Preparation and reactions of thiols, thioethers and sulphonic acids.

Unit – III

Heterocyclic Compounds (**18 Lectures**)

Classification, nomenclature, structure, aromaticity in five and six membered rings containing one heteroatom; synthesis of furan, pyrrole, thiophene and pyridine (including Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch pyrrole synthesis, Fiest-Benary synthesis, Hantzsch pyridine synthesis) and reactions of furan, pyrrole, thiophene and pyridine. Condensed five and six membered heterocycles: synthesis of indole, quinoline and isoquinoline (including Fischer-Indole synthesis, Madelung synthesis, Reissert synthesis, Bischler-Mohlau synthesis, Skraup synthesis, Doebner-Miller synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Bischler-Napieralski synthesis, Pictet-Spengler reaction, Pomeranz-Fritsch synthesis); reactions of indole, quinoline and isoquinoline.

Unit – IV

Alkaloids, Terpenoids and Dyes (**16 Lectures**)

Alkaloids: Introduction, natural occurrence, Hoffmann's exhaustive methylation, Emde's modification, structure elucidation and synthesis of nicotine. Medicinal importance of nicotine, hygrine, quinine, morphine, cocaine, and reserpine.

Terpenoids: Introduction, occurrence, classification, isoprene rule; structure elucidation and synthesis of citral and α-terpineol.

Dyes: Classification, colour and constitution, mordant, ingrain, disperse and vat dyes; synthesis and applications of methyl orange, congo red, malachite green, rosaniline, phenolphthalein, alizarin and indigotin; edible dyes with examples.

Reference Books:

- Carey, F.A.; Sundberg, R. J. *Advanced Organic Chemistry, Part: B,* Springer.
- Mukherjee, S.M.; Singh, S.P.; Kapoor, R.P.; Dass, R. *Organic Chemistry, Volume-III,* New Age International Private Ltd.
- Bansal, R. K. *Heterocyclic Chemistry,* New Age International Private Ltd.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. *Organic Chemistry, 12th Edition,* Wiley, 2016.
- Sen Gupta, S. *Organic Chemistry, First edition,* Oxford University Press, 2014.
- Kalsi, P. S. *Organic Reactions and Their Mechanisms,* New Age International Private Ltd. 2017.
- Morrison, R. T. & 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).
- Clayden, J.; Greeves, N. & Warren, S. *Organic Chemistry, Second edition,* Oxford University Press, 2012.
- Finar, I. L. *Organic Chemistry (Volume 2),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Das, A. *Innovative Mnemonics in Chemical Education - A Handbook for Classroom Lectures*,
- Cambridge Scholars Pub., Lady Stephenson Library, Newcastle upon Tyne, UK, 2019.
- Jain, M.K.; Sharma, S.C. *Modern Organic Chemistry,* Vishal Publishing Co.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry,* Prajati Parakashan (2010).

Practical- CC VII (LAB) (Credits:02)

Qualitative Analysis of Single Solid Organic Compounds:

Identification of a single solid organic compound through systematic analysis:

1. Determination of the melting point of the given compound.
2. Solubility test.
3. Detection of special elements (nitrogen, sulphur and halogens).
4. Detection of functional groups (─COOH, phenolic –OH, ─CHO, >C=O, ─NH_2, ─NO_2, ─$CONH_2$,>C=C<, anilide).
5. Preparation of suitable derivative of the given sample.
6. Determination of the melting point of the prepared derivative.
7. Literature survey.

List of compounds to be identified:
Cinnamic acid, succinic acid, adipic acid, benzoic acid, salicylic acid, *p*-hydroxy benzoic acid, *o*-chlorobenzoic acid, *p*-nitro benzoic acid, phthalic acid, benzamide, acetamide, phthalimide, acetanilide, benzil, benzoin, benzophenone, glucose, vaniline, urea, sulphanilic acid, *p*-nitroaniline, *p*-amino phenol, resorcinol, β-naphthol, *p*-bromoaniline, anthranilic acid.

Reference Books:

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009).
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, Vikas Publishing House Pvt. Ltd.
- Agarwal, O. P. *Advanced Practical Organic Chemistry*, Goel Publishing House.
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

Semester- IV
Core Course – Paper VIII
PHYSICAL CHEMISTRY-III

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory
Unit – I

Electrochemistry –I **(14 Lectures)**

Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.
Arrhenius theory of electrolytic dissociation. & its Limitations, Debye-Hückel Interionic attraction theory of strong electrolytes, Asymmetric effect, Electrophoretic effect, Wien effect, Debye-Falkenhagen effect, Walden's rules, activity and activity coefficient of electrolyte, mean molality and mean ionic activity of electrolyte, ionic strength, Debye- Hückel limiting law.
Ionic velocities, mobilities and their determinations, Transference numbers and their relation to ionic mobilities, abnormal transference number, determination of transference numbers using Hittorf and Moving Boundary methods.

Unit - II
Electrochemistry-II **(14 Lectures)**

Electrochemical and electrolytic cells, Galvanic Cell, Electrode Potential, Concept of Half Cell, Setting up of simple cells, writing of cell reaction, Types of electrodes, Reversible and Irreversible cells with examples. Electromotive force of a cell and its calculation, Nernst equation and its thermodynamic derivation; Relation between emf and free energy & Cell thermodynamics, Reference Electrodes (Hydrogen electrode, Calomel electrode, Quinhydrone electrode, glass electrode), Electrode potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i, equilibrium constants, and (ii) pH values, using hydrogen, calomel, Quinone-hydroquinone, glass electrodes.(iii) determination of activity coefficients (iv) solubility product (v)dissociation constant of weak acid (vi) Potentiometric titrations (acid-base, redox, precipitation).; Concept and types of Concentration cells with and without transference, liquid junction potential;. Elementary ideas of polarizations and overvoltage-related theories, Tafel equation, Corrosion – types, theories, factors and prevention. Different types of commercial cells -Lead and alkali accumulators.

Unit-III

SYSTEMS OF VARIABLE COMPOSITION & CHEMICAL EQUILIBRIUM
(14 Lectures)

SYSTEMS OF VARIABLE COMPOSITION: Partial molar quantities, Importance of partial molar properties, Chemical potential dependence of thermodynamic parameters on composition; Gibbs Duhem equation and its application, chemical potential of ideal gas mixtures, change in thermodynamic functions in mixing of ideal gases. Chemical potential for real gases and Fugacity.

CHEMICAL EQUILIBRIUM: Law of mass action, Criteria of Chemical equilibrium, Thermodynamic derivations of Equilibrium expressions, Thermodynamic equilibrium constant. relations between the various equilibrium constants K_p, K_c and K_x. Reaction quotient, degree of advancement of reaction, Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient (Van't Hoff Reaction Isotherms). Effect of temperature on equilibrium constant (Van't Hoff equation), Van't Hoff Reaction Isochore, Derivation of K_p, K_c & K_x for different types of reactions using degree of dissociation & partial pressure, Coupling of exoergic and endoergic reactions. Factors influencing Equilibrium state viz. temperature, pressure, catalyst, inert gas and concentration. Le Chatelier principle (quantitative treatment) & application; Le Chatelier principle & Physical Equilibrium.

Unit – IV

Surface & Colloid Chemistry (14 Lectures)

Colloids:
Types of colloids, Classification of Colloids, Lyophilic and lyophobic colloids, Multimolecular Colloids, Associated colloids, Micelle, Critical Micelle Concentration (CMC), CMC and variation different Physical properties, Preparation of Colloids by Chemical process, Bredigs process, peptization, Purification of colloids, Dialysis. Properties of Colloids- General properties, Optical properties, electrical properties, Kinetic properties, Coagulation of Colloids (Hardy-Schulze Rule), Isoelectric point, Electrical double layer and Zeta potential, Protective action of Colloids (Gold number); Emulsion, Types and properties of emulsion, Gels, Classification and properties of Gels. Applications of colloids.

(7 Lectures)

Catalysis:
Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

(3 Lectures)

Surface chemistry:
Adsorption; Nature of adsorbed state, Types of adsorption- Physical adsorption, chemisorption, adsorption isotherms (Freundlich and Langmuir). Surface catalysis, Applications of adsorption phenomenon in nature & industry.

(4 Lectures)

Reference Books:

- Peter Atkins & Julio De Paula *Physical Chemistry*, *10th Ed.*, Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry, 4th Ed.*, Narosa (2004).
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
- Engel, T. & Reid, P. *Physical Chemistry, 3rd Ed.*, Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics*, CRC Press: NY (2011).
- Zundhal, S.S. *Chemistry concepts and applications*, Cengage India (2011).
- 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).
- Advance Physical Chemistry, Gurtu-Gurtu, A Pragati Publication.
- A Text Book of Physical Chemistry, A.S. Negi & S. C. Anand, The New age Publication.
- Physical Chemistry, P.C. Rakhit

Practical- CC VIII (LAB) (Credits:02)

Conductometry

1. Perform the following conductometric titration: Strong acid vs. strong base and determine the strength of acid solution.
2. Perform the following conductometric titration: weak acid vs. strong base and determine the strength of weak acid solution.
3. Perform the following conductometric titration: strong acid vs. weak base and determine the strength of strong acid solution.
4. Perform the following conductometric titration: acetic acid & hydrochloric acid mixture vs. strong base and determine the strength of unknown acid solution.
5. Perform the following conductometric titration: Na_2SO_4/K_2SO_4 solution vs.$BaCl_2$ and determine the strength of salt solution.
6. Perform the following conductometric titration: NaCl/KCl solution vs.$AgNO_3$ and determine the strength of salt solution.

Potentiometry

7. Perform the following potentiometric titrations: Strong acid vs. strong base.
8. Perform the following potentiometric titrations: weak acid vs. strong base.
9. Perform the following potentiometric titrations: Potassium dichromate vs. Mohr's salt

Adsorption

10. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry, 8th Ed.;* McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

Semester – IV
(Skill Enhancement Course) SEC – II
(Honours)

Total Marks– 100
(Credits: 02)

(Students are required to choose two topics in their Assignment among SEC-2A/SEC-2B/SEC- 2C)

(SEC-2A / SEC – 2B / SEC – 2C)

(SEC-2A)

ANALYTICAL CHEMISTRY

(Credit: 01)

Introduction: Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexo metrictitrations, Chelation, Chelating agents, use of indicators

a) Determination of pH of soil samples.
b) Estimation of Calcium and Magnesium ions as Calcium carbonate by complex metrictitration.

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

a) Determination of pH, acidity and alkalinity of a water sample.
b) Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and foodpreservations and adulteration.

a) Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
b) Analysis of preservatives and colouring matter.

Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

a) Paper chromatographic separation of mixture of metal ion (Fe3+ and Al3+).
b) To compare paint samples by TLC method.

Ion-exchange: Column, ion-exchange chromatography etc.
Determination of ion exchange capacity of anion / cation exchange resin (using batchprocedure if use of column is not feasible).

Analysis of cosmetics: Major and minor constituents and their function.

a) Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
b) Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zincoxide and Calcium carbonate by complexometric titration.

Suggested Applications (Any one):

a) To study the use of phenolphthalein in trap cases.
b) To analyze arson accelerants.
c) To carry out analysis of gasoline.

Suggested Instrumental demonstrations:

a) Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
b) Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
c) Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in SoftDrink.

Reference Books:

- Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. *Instrumental Methods ofAnalysis. 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.*
- Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry, 6th Ed.*, Saunders College Publishing, Fort Worth (1992).
- Harris, D. C. *Quantitative Chemical Analysis*, W. H. Freeman.
- Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
- Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India.
- Freifelder, D. *Physical Biochemistry 2nd Ed*., W.H. Freeman and Co., N.Y. USA(1982).
- Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA. 16 (1977).
- Vogel, A. I. *Vogel's Qualitative Inorganic Analysis, 7th Ed*., Prentice Hall.
- Vogel, A. I. *Vogel's Quantitative Chemical Analysis, 6th Ed*., Prentice Hall.
- Robinson, J.W. *Undergraduate Instrumental Analysis, 5th Ed*., Marcel Dekker, Inc., NewYork (1995).

(SEC-2B)

CLINICAL BIOCHEMISTRY

(Credit: 01)

Theory

Basic understanding of the structures, properties and functions of carbohydrates, lipids and proteins:

Carbohydrates: Biological importance of carbohydrates, metabolism, cellular currency of energy (ATP); glycolysis, alcoholic and lactic acid fermentations, Krebs cycle; isolation and characterization of polysachharides.

Proteins: Biological importance of proteins; classification of proteins, primary, secondary and tertiary structures of proteins: α-helix and β- pleated sheets; isolation, characterization, denaturation of proteins.

Enzymes: Nomenclature, classification, characteristics; active site, mechanism of enzyme action, factors affecting enzyme action, stereospecificity of enzyme action, coenzymes and cofactors, enzyme inhibitors; introduction to biocatalysis: importance in green chemistry and chemical industry.

Lipids: Classification; biological importance of triglycerides, phosphoglycerides and cholesterol; lipid membrane, liposomes and their biological functions and underlying applications; lipoproteins, properties and biochemical functions of steroid hormones and peptide hormones.

Nucleic Acids: Structure and nomenclature of the component of nucleic acids; structure of DNA (Watson-Crick model) and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation; introduction to gene therapy.

Biochemistry of disease: A diagnostic approach by blood/ urine analysis

Blood: Composition and functions of blood, blood coagulation; blood collection and preservation of samples; anaemia; regulation, estimation and interpretation of data for blood sugar, urea, creatinine, cholesterol and bilirubin.

Urine: Collection and preservation of samples; formation of urine; composition and estimation of constituents of normal and pathological urine.

Reference Books:

- Devlin, T.M. *Textbook of Biochemistry with Clinical Correlation*, Wiley.
- Berg, J. M.; Tymoczko, J. L.; Stryer, L. *Biochemistry,* W. H. Freeman.
- Satyanarayana, U.; Chakrapani, U. *Fundamentals of Biochemistry*, Books and Allied (P) Ltd.
- Lehninger, A.L; Nelson, D.L; Cox, M.M. *Principles of Biochemistry*, W. H. Freeman.
- Talwar, G.P. & Srivastava, M. *Textbook of Biochemistry and Human Biology, 3rd Ed*., PHI Learning.
- Finar, I. L. *Organic Chemistry* (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Practical

1. Carbohydrates – qualitative and quantitative.
2. Lipids – qualitative.
3. Determination of the iodine number of oil.
4. Determination of the saponification number of oil.
5. Determination of cholesterol using Liebermann- Burchard reaction.
6. Proteins – qualitative.
7. Determination of protein by the Biuret reaction.

Reference Books:

- Wilson, K.; Walker, J. *Principles and techniques of practical biochemistry*, Cambridge University Press.
- Gowenlock. A.H. *Varley's Practical Clinical Biochemistry*, CRC Press.

(SEC- 2C)
PHARMACEUTICAL CHEMISTRY

(Credit: 01)

Theory

Drugs & Pharmaceuticals

Drug discovery, design and development; basic retrosynthetic approach. Synthesis and uses of the representative drugs of the following classes: analgesics, antipyretic and anti-inflammatory agents (Aspirin, Phenacetin, Aminopyrine); antibacterial and antifungal agents (Sulphadiazine, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), antitubercular agents (Isoniazid); CNS agents (Phenobarbital, Diazepam), cardiovascular agents (Glyceryl trinitrate), antilaprotic agents (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation, production of (i) ethyl alcohol and citric acid; (ii) Antibiotics: Penicillin, Cephalosporin, Chloromycetin and Streptomycin; (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Practical

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).
3. Preparation of paracetamol and its analysis.
4. Determination of ascorbic acid in vitamin C tablets by iodometric titration.

Reference Books:

- Patrick, G. *Introduction to Medicinal Chemistry*, Oxford University Press.
- Ahluwalia, V.K. *Drugs*, Ane Books Pvt. Ltd.
- Jain, M.K.; Sharma, S.C. *Modern Organic Chemistry,* Vishal Publishing Co.
- Kar, A. *Medicinal Chemistry*, New Age publications
- Singh H.; Kapoor V.K. *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan.

SEC (Assignment 1 & 2): General Information

- Skill Enhancement Course (SEC) is an integral component based on assignment 1 & 2 of IMD Honours in Chemistry the Streams under UGC CBCS UG Syllabi.
- SEC-1 (Assignment-1) will consist of diverse topics/themes the Earlier Semesters and similarly SEC-2 (Assignment-2) will also consist of diverse topics/themes related to the Later Semesters.
- Topics/Themes must be incorporated in each of two Syllabi of SEC meant for Assignments corresponding to CBCS IMD Honours Programmes. Assignments should be guided in such a way that is prepared by students on different titles & aspects/dimensions of topics/themes/issues incorporated in University approved SEC Syllabi.
- SEC will represent a well mentored and self prepared assignments in terms of systematic answers in written form against four broad type of question/query carrying 20 marks each. It also consists of 20 marks as oral interaction. Assignments may be on Practical issues/topics/experiments.

SEC: Distribution across Streams &Programmes :

- One Paper of SEC finds its place in each of Third and Fourth Semesters under **Honours Curricula** comprising altogether two Papers.
- Same sub topic/theme cannot be opted by a given candidate/student in preparation of Assignments at different Semesters under SEC.

SEC: Marks Distribution For Assignments

- **Assessment of SEC-Assignments will be made on evaluation of the written form of theme consisting of 80 marks (four questions – each question carries 20 marks) and Oral Interaction /Feedback with the students on assignment consisting of 20 marks.**
- The Assignment will follow the University approved Syllabi materials on Subject & Paper specific topics/themes/issues.
- **The word limits of each broad question within the Assignment will be in between 400 to 500.**
- The evaluated Assignments will remain under the custody of the related Departments and the University may ask for the despatch of the Assignments as & when necessitated.
- The total marks on Assignments will have to be transmitted by the College to the University on or before the stipulated date.
- This is a general guideline. The respective department(s) may incorporate or modify as department(s) deem fit.

Semester - IV
DSC / GE for IMD - PAPER –IV
WAVES, FLUIDS, SOUND AND OPTICS

TOTAL MARKS – 100
(Theory- 70 (60 + Inter: 10), Practical-30 (20 + Inter: 10))
(Credits: Theory-04, Practicals-02)

Unit-I

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).
Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequency (Frequency ratio: 1:1, 1:2, 1:3) and their uses.

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

Unit-II

Fluids: Surface Tension:Synclastic and anticlastic surface, Excess of pressure Application to spherical and cylindrical drops and bubbles , variation of surface tensionwith temperature , Jaegar's method. Viscosity: Viscosity , Rate flow of liquid in acapillary tube ,Poiseuille's formula, Determination of coefficient of viscosity of aliquid , Variations of viscosity of a liquid with temperature, lubrication. Physics of low pressure, production and measurement of low pressure, Rotary pump, Diffusion pump Molecular pump , Knudsen absolute gauge , penning and pirani gauge, Detection of leakage.
Sound: Simple harmonic motion ,forced vibrations and resonance ,Fourier's theorem Application to saw tooth wave and square wave Intensity and loudness of sound, Decibels Intensity levels, musical notes musical scale. Acoustics of buildings: Reverberation and time of reverberation Absorption coefficient, Sabine's formula measurement of reverbe-ration time. Acoustic aspects of halls and auditoria.

Unit-III

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front.
Huygens Principle.
Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change onreflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shapedfilms. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness(Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.
Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index and Visibility of fringes.

Unit-IV

Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.
Polarization: Transverse nature of light waves. Plane polarized light, – production and analysis. Circular and elliptical polarization.

N.B: Simple Problems (covering Unit-I, II, III & IV) using formulae of these respective units to be practiced.

Suggested Readings:

1. *Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill.*
2. *Principles of Optics, B.K. Mathur, 1995, Gopal Printing.*
3. *Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication.University Physics. FW Sears, MW Zemansky and HD Young 13/e, 1986. Addison-Wesley.*

More Reference Books:

1. *Principles of Acoustics, B. Ghosh, Sreedhar Publishers, Kolkata.*
2. *A textbook on Oscillations, Waves and Acoustics, M. Ghosh and D. Bhattacharjee, S. Chand & company LTD., New Delhi.*
3. *Vibrations, Waves, and Acoustics, D. Chattopadhya and P.C Rakshit., Books*
4. *N.Subrahmanyam, Brijlal, M.N. AVADHAULU, S.CHAND, New Delhi*
5. *Modern Optics, Books and Allied (P) LTd. Kolkata*
6. *College Physics, Vol. I, A.B. GUPTA, Books and Allied (P) Ltd.*

PHYSICS
PRACTICAL
DSC-PAPER-IV
LAB: WAVES, FLUIDS, SOUND AND OPTICS

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focusing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a given Prism using Mercury Light/ Helium light.
8. To determine the value of Cauchy Constants of a material of a prism.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium & (2) spectrum of Mercury light/ Helium light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photo sensor and laser in diffraction patterns of single and double slits.

Suggested Readings:

1. *Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.*
2. *Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers*
3. *A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,*

More Practical Reference Books :

1. *An Advanced Course in Practical Physics,D. Chattopadhyay and P.C. Rakshit.*
2. *Advanced Practical Physics Vol.I&Vol.II. Dr.Basudev Gosh.*
3. *A Text Book of Practical Physics,Dr.Basudev Gosh.*
4. *Advanced Practical Physics Vol.I&Vol.II, K. G. Mazumdar.*
5. *B.Sc Practical Physics, C.L. Arora.*

Semester - IV
DSC / GE for IMD - PAPER – IV
ALGEBRA

TOTAL MARKS – 100
(End Semester-80 Internal-20)

Unit – I

Complex numbers : Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. Exponential sine, cosine and logarithm of complex number. Direct and inverse circular and hyperbolic functions. Expansion of trigonometric functions. Gregory's series. Summation of series.

Unit – II

Theory of Equations : Polynomials in one variable and the division algorithm. Relations between the roots and the coefficients. Transformation of equations. Descartes rule of signs. Solution of cubic and biquadratic (quadratic) equations.

Unit – III

Group Theory : Group, semi group, quasi group, properties and examples of groups. Subgroup, properties and examples of subgroups. Cyclic group and its property.

Unit – IV

Ring and Field Theory **:** Rings, properties and examples of Rings. Integral domain and its properties. Field, properties and examples of fields. Sub-ring, properties and examples of sub-ring. Sub-field, properties and examples of sub-field.

Reference:

1. *Advanced Higher Algebra : J.G. Chakravorty and P.R. Ghosh, U.N. Dhur*
2. *Algebra : R.M. Khan, Central*
3. *Higher Algebra : Mapa, Ashok Pub.*

Semester- V
Core Course-Paper IX
INORGANIC CHEMISTRY-III

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(Credits: Theory-04, Practicals-02)

Theory

Unit – I

Coordination Chemistry-I **(16 Lectures)**

IUPAC nomenclature of coordination compounds, type of ligands, isomerism in coordination compounds of CN 4 & 6, EAN rule, Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Inner-metallic complexes and their applications in analytical chemistry,Werner's theory, Valence bond theory for coordination numbers 4, 5 & 6 (inner and outer orbital complexes), magnetic properties and spin state of HS and LS coordination compounds for coordination numbers 4, 5 & 6.

Unit – II

Coordination Chemistry-II **(16 Lectures)**

Crystal field theory, crystal field splitting energy (Δo or Δt), spin state and magnetic properties of coordination compounds (CN 4 & 6), CFSE in high spin and low spin octahedral and tetrahedral complexes, pairing energies, factors affecting Δo, trans effect, Jahn-Teller theorem, distorted octahedral geometry, square planar geometry, discrimination between Ligand field theory (LFT) and Molecular orbital theory (MOT), electromagnetic Spectrum and colour of the coordination complexes, homoleptic and heteroleptic complexes, labile and inert complexes.

Unit – III

d and f block elements **(16 Lectures)**

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy),
Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Unit - IV

Bioinorganic Chemistry **(16 Lectures)**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, Introduction to metallo-enzymes, carbonic anhydrase and carboxypeptidase. 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. Iron and its application in bio-systems, Metalloporphyrins, Haemoglobin; Storage and transfer of iron. Structure ,biological function of Chlorophyll and Vitamin B_{12}, Fixation of nitrogen,.

Reference Books:

- Purcell, K.F & Kotz, J.C. *Inorganic Chemistry*, W.B. Saunders Co, 1977.
- Huheey, J.E. *Inorganic Chemistry*, Prentice Hall, 1993.
- Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry,* Panima Publishing Company 1994.
- A. Das, *Innovative Mnemonics in Chemical Education - A Handbook for Classroom Lectures*, Cambridge Scholars Pub., Lady Stephenson Library, Newcastle upon Tyne, UK, 2019.
- Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley-VCH, 1999.
- Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
- Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

Practical- CC IX (LAB) (Credits:02)

Gravimetric Analysis:

1. Estimation of nickel (II) using Dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN
3. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

Inorganic Preparations:

1. Tetraammine copper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
2. *Cis* and *trans* $K[Cr(C_2O_4)_2.(H_2O)_2]$ Potassium dioxalatodiaquachromate (III)
3. Tetraamminecarbonatocobalt (III) ion
4. Potassium tris(oxalate)ferrate(III)

Chromatography of metal ions:

Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

1. Ni (II) and Co (II)
2. Fe (III) and Al (III)

Reference Books*:*

- Mendham, J., A. I. *Vogel's Quantitative Chemical Analysis, 6th Ed.,* Pearson, 2009.

Semester- V
Core Course- Paper - X
ORGANIC CHEMISTRY-IV

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(Credits: Theory-04, Practicals-02)

Theory

Unit-I

Amino Acids, Peptides and Proteins **(16 Lectures)**

Introduction, α-Amino acid-synthesis with mechanistic details (including Strecker, Gabriel Phthalimide, Phthalimidomalonic ester, Erlenmeyer Azlactone and hydantoin synthesis); physical and chemical properties, iso-electric point and its calculations, reactions of α-amino acids, Ninhydrin reaction; peptide synthesis using N-protection and C-protection, Merrifield peptide (solid phase) synthesis; determination of C-terminal and N terminal amino acid residues (Sanger, Edman and dansyl methods); protein classification, primary, secondary, tertiary and quaternary structure of proteins (definitions only), chemical test of proteins.

Unit-II

Nucleic acids and Enzymes **(16 Lectures)**

Nucleic Acids: Structure & nomenclature of the component of nucleic acids, nucleosides and nucleotides, double helical structure of DNA (Watson-Crick model), complimentary base–pairing in DNA.

Enzymes: Introduction, classification and characteristics of enzymes; salient features of active site of enzymes, mechanism of enzyme action (taking trypsin as an example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

Unit-III

Lipids and Energy in Biosystems **(16 Lectures)**

Lipids: Introduction, classification; common fatty acids present in fats and oils, hydrogenation of fats and oils. Analysis of fats and oils: saponification value, acid value, iodine number; reversion and rancidity, trans-esterification.

Energy in Biosystems: Cells obtain energy by the oxidation of foodstuff (organic molecules); introduction to metabolism (catabolism, anabolism); ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change; agents for transfer of electrons in biological redox systems: NAD+, FAD; conversion of food to energy: outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle; overview of catabolic pathways of fat and protein; caloric value of food, standard caloric content of food types.

Unit-IV

Drugs and Pesticides (16 Lectures)

Drugs: Introduction, classification; structure, synthesis and therapeutic uses of antipyretics and analgesics: Paracetamol, Phenacetin, Ibuprofen; antibacterial agents: Sulphaguanidine, Sulphanilamide; antimalarials: Chloroquine; antibiotics: Chloramphenicol; CNS agents: Diazepam; anaesthetics: Benzocaine. Medicinal values of curcumin (haldi), azadirachtin (neem), lycopene, vitamin C and antacid (ranitidine).

Pesticides: Introduction, classification, preparation and uses of DDT, endrin, parathion, baygon and melathion; uses of plant insecticides: nicotine, pyrethrum, rotenone and limonene; adverse effect of pesticides, LD_{50} (Lethal Dose, 50%) and toxicity.

Reference Books:

- Mukherjee, S.M.; Singh, S.P.; Kapoor, R.P.; Dass, R. *Organic Chemistry, Volume-III,* New Age International Private Ltd.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. *Organic Chemistry, 12th Edition,* Wiley, 2016.
- Finar, I. L. *Organic Chemistry (Volume 1 and volume 2),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Jain, M.K.; Sharma, S.C. *Modern Organic Chemistry,* Vishal Publishing Co.
- Berg, J.M.; Tymoczko, J.L. & Stryer, L. (2006) *Biochemistry. 6th Ed.* W.H. Freeman and Co.
- Nelson, D.L.; Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IV Edition.* W.H. Freeman and Co.
- Murray, R.K.; Granner, D.K.; Mayes, P.A. & Rodwell, V.W. *Harper's Illustrated Biochemistry. XXVIII edition.* Lange Medical Books/ McGraw-Hill, 2009.

Practical- CC X (LAB) (Credits: 02)

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Estimation of aniline by (Bromate-Bromide) method
5. Determination of saponification value of an oil or a fat.
6. Determination of Iodine number of an oil/ fat.

Reference Books:

- Arthur, I. V. *Quantitative Organic Analysis,* Pearson.
- Vogel, A.I. *Quantitative Organic Analysis, Part 3,* Pearson (2012).
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, Vikas Publishing House Pvt. Ltd.
- Agarwal, O. P. *Advanced Practical Organic Chemistry*, Goel Publishing House.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry,* 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

Semester- V
Core Course-Paper-XI
PHYSICAL CHEMISTRY-IV

TOTAL MARKS – 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practicals-02**)

Theory

Unit – I

Phase Equilibria – I **(14 Lectures)**

Clausius-Clapeyron equation and its applications to solid-liquid,Distribution Law, Solvent Extraction, Equilibrium constant from Distribution Law, Nernst distribution law: its derivation and applications. Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems;
liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, water, carbon di oxide & sulpher, with applications. Enantiotropy & Monotropy.
Two component system- Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and ncongruent melting points,
Salt solution (KI-Water system, $FeCl_3$- water system, NaCl-water system, Na_2SO_4, 10 H_2O-water system) Cryohydric point

Unit-II

Chemical Kinetics **(14 Lectures)**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, 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 (steady-state approximation in reaction mechanisms) (iv) chain reactions.
Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Unit – III

Physical Properties & Molecular structure **(14 Lectures)**

Additive and constitutive properties, molar refraction (Lorenz-Laurentz equation) Optical activity, Specific and molar rotation, Optical rotator dispersion, (ORD) and circular dichroism(CD) Basic ideas of electrostatics, Electrostatics of dielectric media, dielectric constant, induced and orientation polarization, Clausius-Mosotti equation, Debye equation, , Dipole moment and molecular polarizabilities and their measurements (Temperature and refractivity method). Magnetic rotation, Magnetic properties-diamagnetism, paramagnetism and ferromagnetism, origin of magnetism, magnetic moment, magnetic susceptibility and its measurement, Ascertaining the structure of different molecules and ions using above properties..

Unit - IV

Macromolecules (14 Lectures)

Defination, types, properties and uses of macromolecules. Degree of polymerization, number average and weight average molecular weight, Distribution of molar mass & poly dispersity index, Determination of molar mass by viscometry, osmometry, light scattering, Ultra centrifuge, Types of polymerization reaction, mechanism & kinetics of polymerization recation, Stereo chemistry of macromolecules(conformation & configuration) Crystallinity of macromolecules, Difference between ordinary and macomolecular crystal, factors influencing cryatallinity, experimental determination of cryatallinity of macromolecules.

Reference Books:

- Atkins, P.W & Paula, J.D. *Physical Chemistry, 10th Ed.*, Oxford University Press (2014).
- Castellan, G. W. *Physical Chemistry, 4th Ed.*, Narosa (2004).
- Mortimer, R. G. *Physical Chemistry, 3rd Ed.,* Elsevier: NOIDA, UP (2009).
- Barrow, G. M., *Physical Chemistry, 5th Ed.,* Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. *Physical Chemistry, 3rd Ed.*, Prentice-Hall (2012).
- Rogers, D. W. *Concise Physical Chemistry*, Wiley (2010). 29
- Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. *Physical Chemistry, 4th Ed.*, John Wiley & Sons, Inc. (2005).
- Advance Physical Chemistry, Gurtu-Gurtu, A Pragati Publication.
- A Text Book of Physical Chemistry, A.S. Negi & S. C. Anand, The New age Publication.
- Physical Chemistry, P.C. Rakhit

PRACTICAL
Core Course – Paper – XI (LAB) (Credits:02)

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Determination of partition coefficient of iodine in water and chloroform.
3. Distribution of distribution co-efficient of ammonia between between water and chloroform.
4. Determination of partition coefficient of benzoic acid between water and nonpolar organic solvent.
5. Determination of rate constant and study of hydrolysis of ester by HCl/NaOH at room temperature.
6. Study of kinetics of saponification of ethyl acetate and determination of rate contant.
7. Study of the kinetics of Iodide-persulphate reaction.
8. Determination of Equilibrium Constant of $KI + I_2 = KI_3$ by partition method.

Reference Books:

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

Semester - V
DSE – Paper – I (Honours)
ANALYTICAL METHODS

TOTAL MARKS – 100
(Theory – 70, Practical 30)
(Credits: Theory-04, Practicals-02)

(UNIT-I)

Qualitative and quantitative aspects of analysis:
Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Optical methods of analysis-I:
Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

(UNIT-II)

Optical methods of analysis-II:
Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution. Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(UNIT-III)

Thermal methods of analysis:
Theory of thermogravimetry (TG), basic principle of instrumentation.
Techniques for quantitative estimation of Ca and Mg from their mixture.

Electroanalytical methods:
Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

(UNIT-IV)

Separation 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.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents.
Chiral chromatographic techniques using chiral columns (GC and HPLC).
Role of computers in instrumental methods of analysis.

Suggested Readings:

1. *Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.*
2. *Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.*
3. *Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.*
4. *Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.*
5. *Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.*
6. *Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.*
7. *Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.*
8. *Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.*

PRACTICAL
DSE – Paper - I (LAB)
ANALYTICAL METHODS (Credits:02)

Separation Techniques

1. Chromatography:

a. Separation of mixtures.
   i. Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.
   ii. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

b. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.

c. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

2. Solvent Extractions:

i. To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni2+ DMG complex in chloroform, and determine its concentration by spectrophotometry.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, Li in cola drinks and fruit juices using fame photometric techniques.

5. Analysis of soil:

i. Determination of pH of soil.
ii. Total soluble salt
iii. Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:

i. Determination of exchange capacity of cation exchange resins and anion exchange resins.
ii. Separation of metal ions from their binary mixture.
iii. Separation of amino acids from organic acids by ion exchange chromatography.

Suggested Readings:

1. *Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.*
2. *Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.*
3. *Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.*
4. *Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.*
5. *Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.*
6. *Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.*
7. *Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.*
8. *Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.*

SEMESTER - V

DSE – Paper – II (Honours)

Introductory Research Methodology/ Industrial gases & Inorganic Chemicals/ Energy & Environment / Spectroscopic methods (IR, NMR & UV-Vis)

TOTAL MARKS – 100

(Credits: Theory + Tutorial = 04+02=06)

(PROJECT-1)

(UNIT-I)

INTRODUCTORY RESEARCH METHODOLOGY

Literature Survey:

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

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

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Methods of Scientific Research and Writing Scientific Papers:

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

(UNIT-II)

INDUSTRIAL GASES AND INORGANIC CHEMICALS

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

(UNIT-III)

ENERGY & ENVIRONMENT

***Sources of energy*:** Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc.

***Nuclear Pollution*:** Disposal of nuclear waste, nuclear disaster and its management.

(UNIT-IV)

SPECTROSCOPIC METHODS (IR, NMR & UV-VIS)

Ultraviolet and Visible spectroscopy: Introduction, theory, instrumentation and solvent effects, characteristic absorption of organic compounds, application of rules for calculation of λ_{max} polyenes and dienones.

Infrared Spectroscopy: Introduction, theory, instrumentation, characteristic group frequencies of organic molecules, factors affecting group frequencies.

Proton NMR spectroscopy: Introduction, theory, deuterated solvents, chemical shift and factors influencing it, spin-spin coupling, charactersistic chemical values of different kind of protons. Application of UV, IR and NMR in structure elucidation of organic molecules.

Practical :

1. Percentage of available chlorine in bleaching powder.
2. Preparation of borax/ boric acid.
3. Preparation of Potash alum [Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$].
4. Preparation of Chrome alum [Chromium(III) potassium sulfate, $KCr(SO_4)_2$].

Suggested Readings:

1. Suresh Chandra and Mohit Kr. Sharma, Research Methodology, 2nd Edition, 2019, Narosa Pub.
2. J. M. Lehn, Supramolecular Chemistry, Concepts and Perspectives, VCH, 1995.
3. H. Dodziuk, Introduction to Supramolecular Chemistry, Kluwer Academic, 2002.
4. F. Vogtle, Supramolecular Chemistry, An Introduction, John Wiley & Sons, 1991.
5. J. W. Steed, J. L. Atwood, Supramolecular Chemistry, A Concise Introduction, John Wiley, 2000.
6. A. Bianchi, K. B. James, E. G. Espana, Supramolecular Chemistry of Anions, Wiley-VCH, 1997.
7. M. Fujita, Molecular Self-assembly, Organic Versus Inorganic Approaches, Springer, 2000.
8. J. L. Atwood, J. E. D. Davies, D. D. MacNicol, F. Vogtle, J. M. Lehn, Comprehensive Supramolecular Chemistry, Pergamon, 1996.
9. Jag Mohan, Organic Spectroscopy: *Principles and Applications* , Second Edition, 2018, Narosa Pub
10.P.S. Kalsi, Spectroscopy of Organic Compounds, New Age International, 2007.
11. S.K.Agarwal and Keemti Lal, Advanced Inorganic Chemistry, Pragati Prakashan, 17th Ed. 2019.

(DSE - II & IV): General Information for Projects

- **A Project must consist of the following 8 components:**
  1. **Title of the project**
  2. **Abstract**
  3. **Key-words**
  4. **Introduction**
  5. **Methodology**
  6. **Results and Discussion**
  7. **Conclusion**
  8. **References**

- The Project will follow the University approved Syllabi materials on Subject & Paper specific topics/themes/issues.
- The Project must also consist of all the basic features including Cover Page, Preface, Certification by Guide and Contents etc. apart from main components.
- **The word limits of a Project will be in between 2500 to 3500.**
- **The project will be assessed in the following way :**

Assessment Profile of a Project		
Sl. No.	**Assessment Aspects**	**Assigned Marks (100)**
01	Nature of Project Theme	20
02	Schedule and Consistency of Analysis.	20
03	Knowledge and skill in the project	20
04	Quality of the project and Management	20
05	Oral Feedback (Power point presentation)	20

- Both the evaluated/ assessed Projects will remain under the custody of the related Departments and the University may ask for the despatch of the Projects as & when necessitated.
- The total marks on Projects will have to be transmitted by the College to the University on or before the stipulated date.
- This is a general guideline. The respective department may incorporate or modify as department deem fit.

Some proposed topics for project work :

1. *Preparation of some useful Inorganic Chemicals*
2. *Management of alternative sources of energy*
3. *Solving of problems related to society*
4. *Review of literature on burning issues*
5. *Analysis of food products/food adulteration*
6. *Analysis of Fertilizers and Pesticides*
7. *Medicinal plants and uses*
8. *Liquid crystals- an overview*
9. *Analysis of Drug and Pharmaceuticals*

Semester - VI
Core Course – Paper – XII
INORGANIC CHEMISTRY-IV

Total Marks– 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practical-02**)

Theory

Unit-I

Analytical Chemistry **(12 Lectures)**

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.

Unit-II

Organometallic Compounds-I **(16 Lectures)**

Organometallic Compounds: Definition, classification and nomenclature of organometalllic compounds, hapticity (η) of organometallic ligands, examples of mono-, tri- and penta hapto cyclopentadienyl complexes.
Metal carbonyls: EAN and 18 electron rule of 3d block elelments (mononuclear & polynuclear metal carbonyls), General methods of preparation of mono and binuclear carbonyls of 3d series (direct combination, reductive carbonylation, thermal and photochemical decomposition), structures of mononuclear and binuclear carbonyls (Cr, Mn, Fe, Co and Ni) using VBT, synergic effect and use of IR data to explain extent of back bonding, Zeise's salts (preparation, structure & bonding), Ferrocene (preparation, structure & reactions).

Unit-III

Organometallic compounds – II **(16 Lectures)**

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), Grignard reagent (synthesis and reactivity), Industrial processes and their mechanism: Alkene hydrogenation (Wilkinsons Catalyst), Hydroformylation, Wacker Process, Fischer Tropsch reaction.

Unit – IV

Reaction Kinetics and Mechanism **(16 Lectures)**

Introduction to inorganic reaction mechanisms, substitution reactions in square planar complexes, trans- effect, mechanism of nucleophilic substitution in octahedral and square planar complexes, thermodynamic and kinetic stability, kinetics of octahedral substitution, ligand field effects and reaction rates.

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis, 7th Edition*, Prentice Hall,1996.
- Cotton, F.A.G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.*;Wiley India,
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.*, Harper Collins 1993, Pearson,2006.
- Sharpe, A.G. *Inorganic Chemistry, 4th Indian Reprint*, (Pearson Education) 2005
- Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry, 3rd Ed.*, John Wiley and Sons, NY, 1994.
- Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements, 2nd Ed.*, Elsevier 1997.
- Lee, J.D. *Concise Inorganic Chemistry, 5th Ed.*, John Wiley and sons 2008.
- Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
- Shriver, D.D. & P. *Atkins, Inorganic Chemistry, 2nd Ed*., Oxford University Press,1994.
- Basolo, F. & Pearson, R. *Mechanisms of Inorganic Reactions: Study of Metal Complexes in Solution, 2nd Ed.*, John Wiley & Sons Inc; NY.
- Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
- Miessler, G. L. & Tarr, D.A. *Inorganic Chemistry, 4th Ed.*, Pearson, 2010.
- Collman, J. P. et al. *Principles and Applications of Organotransition Metal Chemistry*, Mill Valley, CA: University Science Books, 1987.
- Crabtree, R. H. *The Organometallic Chemistry of the Transition Metals*, New York, NY: John Wiley, 2000.
- Spessard, G. O. & Miessler, G.L. *Organometallic Chemistry*, Upper Saddle River, NJ: Prentice-Hall, 1996.

Practical-CC XII (LAB) (Credits:02)

Qualitative semimicro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested:
CO_3^{2-}, NO_2^-, S^{2-}, SO_3^{2-},$S_2O_3^{2-}$, CH_3COO^-, F^-,Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, PO_4^{3-}, $NH4^+$, K^+,Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+},„ Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+},Sr^{2+}, Ca^{2+},Mg^{2+}

Mixtures should preferably contain one interfering anion, **or** insoluble component (BaSO4, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3) **or** combination of anions e.g. $CO_3^{2-}$and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, $Br^-$and I^-, $NO3^-$ and Br^-, $NO3^-$ and I^-.

Spot tests should be done whenever possible.

1. Preparation of acetylacetanato complexes of Cu^{2+}/Fe^{3+}. Find the λmax of the complex.
2. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2002.
2. Marr & Rockett Practical Inorganic Chemistry, John Wiley & Sons 1972.

Semester - VI
Core Course – Paper -XIII
ORGANIC CHEMISTRY-V

Total Marks– 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practical-02**)

Theory

Unit-I

Organic Spectroscopy (**20 Lectures**)

UV Spectroscopy: Types of electronic transitions, λmax, chromophores and auxochromes, bathochromic and hypsochromic shifts, intensity of absorption; application of Woodward-Fieser rules for calculation of λ_{max} for polyenes and enones; relative positions of λmax considering conjugative effect, steric effect, solvent effect; distinction between cis and trans isomers.

IR Spectroscopy: Introduction; modes of molecular vibrations (fundamental and nonfundamental), IR active molecules, application of Hooke's law, significance of fingerprint region, overtone bands; characteristic group frequencies of organic molecules, factors affecting group frequencies.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it, equivalent and non-equivalent protons, significance of the terms: upfield/downfield, shielded and deshielded protons, spin–spin coupling and coupling constant (1^{st} order spectra), anisotropic effects in alkene, alkyne, aldehydes and aromatics; relative intensities of first-order multiplets, chemical and magnetic equivalence in NMR, NMR peak area.

Application of IR, UV and NMR for identification of simple organic molecules.

Unit-II

Pericyclic reactions and Organic Photochemistry (**16 Lectures**)

Definition and Classification, electrocyclic reactions: FMO approach, thermal and photochemical reactions (4π and 6π electrons); cycloaddition reactions: FMO approach, Diels-Alder reaction, photochemical [2+2] reactions, Paterno-Buchii reaction; sigmatropic rearrangement: FMO approach, sigmatropic shifts and their order, [1,3] and [1,5] hydrogen shift, [3,3] shift with reference to Claisen and Cope rearrangement, [2,3] sigmatropic rearrangement; chelotropic reaction; photochemical reactions of carbonyl compounds: Norrish type I and II reactions; photochemistry of olefins: cis-trans isomerism.

Unit-III

Carbohydrates (**16 Lectures**)

Monosaccharides: Intoduction, occurrence, classification and nomenclature, constitution and absolute configuration of glucose and fructose, Fischer's proof of configuration of (+)-glucose, epimers and anomers, mutarotation, cyclic structures, pyranose and furanose forms, determination of ring size of glucose and fructose, Haworth projections and conformational structures, anomeric effect (including stereoelectronic explanation), configuration and conformational analysis of monosaccharides, reactions: osazone formation, oxidation and reduction of aldoses, bromine-water oxidation, HNO_3 oxidation, Fischer glycosidation, reactivity of different hydroxyl groups, selective protection-deprotection, Lobry de Bruyn-van Ekenstein rearrangement, ascending (Kiliani-Fischer method) and descending (Ruff's and Wohl's methods) of aldoses, interconversions of aldoses and ketoses.

Unit-IV

Polymers **(16 Lectures)**

Introduction, classification of polymer, synthetic and natural polymers, types of polymerization, addition, condensation, co-ordination and ring opening polymerization; polymerisation reactions-addition and condensation; mechanism of polymerization: cationic, anionic and free radical addition polymerization, Ziegler-Natta polymerisation of alkenes; stereo chemistry of polymerization, preparation and applications of plastics–thermosetting (phenol-formaldehyde, polyurethanes) and thermosoftening (PVC, polythene); fabrics–natural and synthetic (acrylic, polyamido, polyester); rubbers–natural and synthetic: Buna-S, Chloroprene and Neoprene; vulcanization; polymer additives; introduction to liquid crystal polymers and biodegradable and conducting polymers with examples.

Reference Books:

- Kemp, W. *Organic Spectroscopy,* Palgrave.
- Kalsi, P. S. *Spectroscopy of Organic Compounds;* New Age International Private Ltd. 2016.
- Fleming**, I.,** Williams**,** D. *Spectroscopic Methods in Organic Chemistry;* Springer.
- Sharma, Y. R. Elementary *Organic Spectroscopy;* S. Chand, 2013.
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry,* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Carey, F.A.; Sundberg, R. J. *Advanced Organic Chemistry, Part: A,* Springer.
- Carey, F.A.; Sundberg, R. J. *Advanced Organic Chemistry, Part: B,* Springer.
- Singh, J.; Singh, J. *Photochemistry and Pericyclic Reactions,* New Age International Private Ltd.; Third edition, 2012.
- Dinda, B. *Essentials of Pericyclic and Photochemical Reactions;* Springer, 2017.
- Mukherjee, S.M.; Singh, S.P.; Kapoor, R.P.; Dass, R. *Organic Chemistry, Volume-III,* New Age International Private Ltd.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. *Organic Chemistry,* 12th Edition, Wiley, 2016.
- Finar, I. L. *Organic Chemistry (Volume 1),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Clayden, J., Greeves, N. & Warren, S. *Organic Chemistry, Second edition,* Oxford University Press, 2012.
- Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. Polymer Science, New Age International (P) Ltd. Pub.
- Billmeyer, F. W. Textbook of Polymer Science, John Wiley & Sons, Inc.

Practical-CC XIII (LAB) (Credits:04)

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of methyl orange.
4. Preparation of urea formaldehyde.
5. Estimation of glucose by Fehling's/Benedict's solution.
6. Chromatography:
   - **a)** Chromatography: Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
   - **b)** Separation of a mixture of two sugars by ascending paper chromatography
   - **c)** Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)
   - **d)** TLC separation of a mixture of dyes (fluorescein and methylene blue)

Reference Books:

- Vogel, A.I. *Quantitative Organic Analysis, Part 3,* Pearson (2012).
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education(2009)
- Vishnoi, N.K. *Advanced Practical Organic Chemistry*, Vikas Publishing House Pvt. Ltd.
- Agarwal, O. P. *Advanced Practical Organic Chemistry*, Goel Publishing House.
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry,* 5th Ed., Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000).

Semester VI

Core Course Paper - XIV
PHYSICAL CHEMISTRY V

Total Marks– 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practical-02**)

Theory

Unit-I

Phase Equilibria - II: (14 Lectures)

Binary alloy: solid solutions (Au-Ag system), (Pb-Ag system), (Cu-Ni system), (Mn-Cu system), (Cu-Ag system), (Pb-Sn system).
Binary solutions:Liquid-Liquid phase system (Phenol- water, Water- Trimethyl amine, Water-nicotine system etc.) Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Three component systems, water-chloroform-acetic acid system, Pb-Bi-Sn System, Triangular plots.

Unit - II
Quantum Chemistry (16 Lectures)

Black Body radiation, Photo-electric effect, De-broglie's hypothesis, Heisenburg's Uncertainty principle, Postulates of quantum mechanics. Quantum mechanical Operators and different types of operators (Momentun, linear,Laplacian, Hamiltonion Hermition etc), wave functions(angular and radial) probability distribution functions, nodal properties, Eigen value & eigen function, Observables, Commutation rules, Schrödinger equation, transformation of Schrödinger equation to spherical polar coordinates. Separation of variables.and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy, Extension to two and three dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion. Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Angular momentum: quantization of square of total angular momentum and z-component.Rigid rotator model of rotation of diatomic molecule.

Unit-III

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Statistical Thermodynamics & Photochemistry (16 Lectures)

Statistical Thermodynamics: Limitations of classical thermodynamics, Macro, and Micro state, Ensamble, Starling approximation, The concept of distribution of energy, Thermodynamic entropy & probability, Maxwell distribution law, Maxwell- Boltzman statictics, Bose- Einstein statistics, Fary-Dirac statistics, Boltzn, Boson and fermion.
Partition function and its significance, Different partitional functions – Translational, Rotational, vibrational, electronic; relationship between thermodynamic function and partition function, derivation of different thermodynamic function in terms of partition function(enthalpy, free energy, entropy, heat capacity, equilibrium constant), Sackur – Tetrode Equation & its derivations.

Photochemistry: Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the

differential rate of photochemical reactions, photosensitised reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence

Unit-IV
Molecular Spectroscopy-I: (16 Lectures)

Interaction of electromagnetic radiation with matter and various types of energy viz. translational, rotational, electronic energy in molecules and their corresponding spectra; Born- Oppenheimer approximation; Franck-Condon principle, types of spectra – absorption and emission , atomic or line spectra & molecular and band spectra,

Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical equation of vibration, Hook's law, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Reference Books:

- Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy, 4th Ed.*, Tata McGraw-Hill: New Delhi (2006).
- Chandra, A. K. *Introductory Quantum Chemistry*, Tata McGraw-Hill (2001).
- House, J. E. *Fundamentals of Quantum Chemistry*, 2nd Ed., Elsevier: USA (2004).
- Kakkar, R. *Atomic & Molecular Spectroscopy: Concepts & Applications*, Cambridge University Press (2015).
- Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).
- *Polmer Chemistry, Gwarikor.*

CHEMISTRY PRACTICAL
Core Course Paper - XIV (LAB)
PHYSICAL CHEMISTRY V (Credits:02)

1. Draw the calibtation curve (absorbance at λ_{max} vs. concentration) for $CuSO_4$ solution at various concentration and estimate the concentration in the given solution of copper sulphate.
2. Draw the calibtation curve (absorbance at λ_{max} vs. concentration) for $KMnO_4$ solution at various concentration and estimate the concentration in the given solution of $KMnO_4$.
3. Determination of composition of Fe^{+3} – salicylic acid complex by Jobs method.
4. Determine the amount of iron present in a sample using 1,10-phenathroline spectrophotometrically.
5. Verify Lambert-Beer's law and determine the concentration of $K_2Cr_2O_7$ in a solution of unknown concentration.
6. Verify Lambert-Beer's law and determine the concentration of $KMnO_4$ in a solution of unknown concentration.
7. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$.
8. Determine the dissociation constant of an indicator by spectroscopic method.

Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry, 8th Ed.*; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry, 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

Semester - VI
DSE – Paper – III (Honours)
INDUSTRIAL CHEMISTRY

Total Marks– 100
(Theory – 70, Practical-30)
(**Credits: Theory-04, Practical-02**)

Theory

(UNIT-I)

Silicate Industries:
Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass.

Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre.

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

(UNIT-II)

Fertilizers:
Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.
Surface Coatings:
Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

(UNIT-III)

Batteries:
Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.
Alloys:
Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorisation) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

(UNIT-IV)

Catalysis:
General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.
Chemical explosives:

Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

Reference Books*:*

- E. Stocchi, *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau, *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann, *Introduction to Ceramics*, Wiley Publishers, New Delhi.
- J. A. Kent, *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- P. C. Jain, M. Jain, *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan, *Engineering Chemistry*, Vikas Publications, New Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

Practical
DSE – Paper – III (Honours) (Credits:02)
INDUSTRIAL CHEMISTRY

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

Reference Books:

- E. Stocchi, *Industrial Chemistry, Vol-I*, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau, *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann, *Introduction to Ceramics*, Wiley Publishers, New Delhi.
- J. A. Kent, *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- P. C. Jain, M. Jain, *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan, *Engineering Chemistry*, Vikas Publications, New Delhi. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).

Semester – VI

DSE – Paper – IV (Honours)

ENVIRONMENTAL CHEMISTRY I & II/ INTRODUCTORY NANO CHEMISTRY/ GREEN CHEMISTRY

Total Marks– 100

(Credits: Theory + Tutorial = 04+02=06)

(PROJECT-02)

Theory

(UNIT-I)

Environmental Chemistry-I

***Air Pollution*:** Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution. Pollution by SO_2, CO_2, CO, NO_x, H_2S and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

(UNIT-II)

Environmental Chemistry-II

***Water Pollution*:** Hydrological cycle, water resources, aquatic ecosystems, sources and nature of water pollutants, techniques for measuring water pollution, impacts of water pollution on hydrological and ecosystems, water purification methods, effluent treatment plants (primary, secondary and tertiary treatment), industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal, industrial waste management, incineration of waste, water treatment and purification (reverse osmosis, electro dialysis, ion exchange), water quality parameters for waste water, industrial water and domestic water.

(UNIT-III)

Introductory Nano Chemistry

Nano and Nature, Nanoscopic colours (Butterfly wings), Bioluminescence (Fireflies), Tribology (Geckos Sticky feet, lotus-leaf effect etc.) in nature, the development of nanoscale science: Size scale, Nanotechnology timeline, pre-18th Century; 19th Century, 20th Century, 21th Century.

Classification of Nanomaterials, OD, 1D, 2D and 3D types of nanomaterials (Quantum dots, Quantum wires, Carbon Nano Tubes, Bucky balls, Fullerences etc.) Quantum confinement (Quantum size effect).

Synthesis of nanomaterials-Bottom-up Top-down Approach: Co-precipitation, Ultrasonication, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition.

Characterization Techniques: Electron Microscopy,Spectroscopy, XRD. Properties of nanomaterials:Size-effect: melting point, electrical properties, optical properties, magnetic properties, catalytic properties. Few selective examples of recent emerging applications: Solar cell, Nano-medicine, nanoecotoxicology. Applications of nanomaterial in catalysis, electronics &environmental field).

(UNIT-IV)

Green Chemistry

Definition, twelve principles of Green Chemistry, need for Green Chemistry, goals of Green Chemistry, atom economy, environmental factor; green solvents: water as a solvent, solvent free reactions, supercritical carbon dioxide, ionic liquids; microwaves and ultrasonic energy in green processes; green reagents; Green chemistry in sustainable development.

Reference Books:

- E. Stocchi, *Industrial Chemistry, Vol-I*, Ellis Horwood Ltd. UK.
- R.M. Felder, R.W. Rousseau, *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- J. A. Kent, *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara, *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
- A. K. De, *Environmental Chemistry*, New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, *Environmental Pollution Analysis*, Wiley Eastern Ltd, New Delhi.
- E. Stocchi, *Industrial Chemistry, Vol-I*, Ellis Horwood Ltd. UK.
- R.M. Felder, R.W. Rousseau, *Elementary Principles of Chemical Processes*, Wiley Publishers, New Delhi.
- J. A. Kent, *Riegel's Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara, *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. New Delhi.
- K. De, *Environmental Chemistry*, New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, *Environmental Pollution Analysis*, Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
- G.T. Miller, *Environmental Science 11th edition*, Brooks/ Cole (2006).
- A. Mishra, *Environmental Studies. Selective and Scientific Books*, New Delhi (2005).
- S.K.Agarwal and Keemti Lal, *Advanced Inorganic Chemistry*, Pragati Prakashan, 17th Ed. 2019.
- W.R. Fahmer, *Nano technology and Nano electronics*
- P.Mani, G. Ranganath, R.N. Jayaprakash, *Materials Science*
- Bharat Bhusan, *Hand Book of Nanotechnology*
- Mark Ratner, Daniel Ratner, *Nanotechnology*
- Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers.
- Anastas, P.T. & Warner, J.K.. *Green Chemistry - Theory and Practical*, Oxford University Press.
- Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington.
- Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*, American Chemical Society, Washington DC (2002)
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph*, International Publishing House Pvt Ltd. New Delhi.
- Gurtu, J. N., Gurtu, A. *Introductory Green Chemistry*, Pragati Prakashan
- *Monograph on Green Chemistry Laboratory Experiments*, Green Chemistry Task Force Committee, DST.

Chemistry Practical:

I. Air pollution

1. Estimation of SPM in air samples.
2. Estimation of CO in air samples
3. Estimation of NO and NO_2 in air samples
4. Estimation of SO_2 in air samples

II. Water Pollution

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO3 and potassium chromate).
5. Estimation of total alkalinity of water samples (CO32-, HCO3-) using double titration method.
6. Measurement of dissolved CO2.

III. Nano Chemistry

1. Synthesis of Iron based nanomaterials by co-precipitation method.
2. Synthesis of Manganese based nanomaterials by co-precipitation method.
3. Synthesis of Titanium based nanomaterials by Suitable method
4. Synthesis of Silver Nanoparticles.
5. Synthesis of Gold nanoparticles.

IV. Green Chemistry

1. Green synthesis of adipic acid.
2. Tranesterification reaction: Synthesis of biodiesel.
3. Diels-Alder cycloadditon reaction in water.
4. Surfactants for carbon dioxide – Replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
5. Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
6. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

(DSE - II & IV): General Information for Projects

- **A Project must consist of the following 8 components:**
  1. **Title of the project**
  2. **Abstract**
  3. **Key-words**
  4. **Introduction**
  5. **Methodology**
  6. **Results and Discussion**
  7. **Conclusion**
  8. **References**
- The Project will follow the University approved Syllabi materials on Subject & Paper specific topics/themes/issues.
- The Project must also consist of all the basic features including Cover Page, Preface, Certification by Guide and Contents etc. apart from main components.
- **The word limits of a Project will be in between 2500 to 3500.**
- **The project will be assessed in the following way :**

Assessment Profile of a Project		
Sl. No.	**Assessment Aspects**	**Assigned Marks (100)**
01	Nature of Project Theme	20
02	Schedule and Consistency of Analysis.	20
03	Knowledge and skill in the project	20
04	Quality of the project and Management	20
05	Oral Feedback (Power point presentation)	20

- Both the evaluated/ assessed Projects will remain under the custody of the related Departments and the University may ask for the despatch of the Projects as & when necessitated.
- The total marks on Projects will have to be transmitted by the College to the University on or before the stipulated date.
- This is a general guideline. The respective department may incorporate or modify as department deem fit.

Some proposed topics on the project

1. *Analysis of Air samples*
2. *Analysis of Water samples*
3. *Analysis of soil samples*
4. *Green methods for synthesis of important compounds*
5. *Synthesis of Nanoparticles*
6. *Designing of molecules using software*
7. *Minor synthesis having potential applications*
8. *Synthesis and characterization of natural and synthetic dyes & polymers*
9. *Synthesis and characterization of mixed ligand transition metal complexes*

SYLLABUS

Integrated Master Degree (IMD) in

Chemistry

(Effective from the Academic Session 2023-24)

Seventh to Tenth Semester

MAHARAJA BIR BIKRAM UNIVERSITY

AGARTALA, TRIPURA: 799004

Curriculum Structure

SEMESTER – VII

Course Code	Course name	L	T	P	C
ICH 701C	Inorganic Chemistry-VI	**4**	**0**	**0**	**4**
ICH 702C	Physical Chemistry-VI	**4**	**0**	**0**	**4**
ICH 703C	Organic Chemistry-VI	**4**	**0**	**0**	**4**
ICH 704C	Inorganic chemistry Lab	**0**	**0**	**4**	**4**
ICH 705E (DSE 05)	Basic Statistics & Computer Skill	**4**	**0**	**0**	**4**
	SEMESTER TOTAL:	**16**	**0**	**04**	**20**

SEMESTER – VIII (Min: 20 credits)

Course Code	Course name	L	T	P	C
ICH 801C	Inorganic Chemistry-VII	**4**	**0**	**0**	**4**
ICH 802C	Physical Chemistry-VII	**4**	**0**	**0**	**4**
ICH 803C	Organic Chemistry-VII	**4**	**0**	**0**	**4**
ICH 804C	Physical Chemistry Lab	**0**	**0**	**4**	**4**
ICH 805E (DSE 06)	Biomolecular Chemistry	**4**	**0**	**0**	**4**
ICH 806E (DSE 07)	Chemistry of Surface	**4**	**0**	**0**	**4**
	SEMESTER TOTAL:	**20**	**0**	**04**	**24**

SEMESTER – IX

Course Code	Course name	L	T	P	C
ICH 901C	Inorganic Chemistry-VIII	**4**	**0**	**0**	**4**
ICH 902C	Physical Chemistry-VIII	**4**	**0**	**0**	**4**
ICH 903C	Organic Chemistry-VIII	**4**	**0**	**0**	**4**
ICH 904C	Organic Chemistry Lab	**0**	**0**	**4**	**4**
ICH 905C	Chemistry Project - 3	**4**	**0**	**0**	**4**
	SEMESTER TOTAL:	**16**	**0**	**04**	**20**

SEMESTER – X (Min: 20 credits)

Course Code	Course name	L	T	P	C
ICH 1001C	Chemistry Project - 4	**0**	**0**	**8**	**8**
ICH 1002E (DSE 08)	Supramolecular and Nano chemistry	**4**	**0**	**0**	**4**
ICH 1003E (DSE 09)	Medicinal chemistry and Forensic science	**4**	**0**	**0**	**4**
ICH 1004E (DSE 10)	Advanced Organic Chemistry	**4**	**0**	**0**	**4**
ICH 1005E (DSE 11)	Advanced and Industrial Materials	**4**	**0**	**0**	**4**
ICH 1006E (DSE 12)	Chemistry and Society	**4**	**0**	**0**	**4**
	SEMESTER TOTAL:	**20**	**0**	**08**	**28**

Semester VII

Paper Code: ICH 701C

Paper Name: Inorganic Chemistry – VI

Credit: 04

Full Marks: 100 (70 +30)

Course outcome:

This course aims to impart to the student, knowledge of:

- Fundamental aspects of classifying molecules based on various symmetry elements, point groups and constructing character table.
- Understand symmetry, group theory, and Stereochemistry
- Understand Metal-Ligand bonding involved in Coordination compounds
- Utilize this knowledge for complex formation in research interest.
- Magnetic and Phtochemical behavior of metal complexes, metal carbonyls and photo induced chemical reactions.

Learning outcome:

On completion of the course, students should be able to:

- Recognize symmetry elements, identify point groups of molecules, construct and explain character table for simple molecules.
- Categorize molecules based on their symmetry properties and predict their molecular properties.
- Combine, evaluate and interpret information from the various spectroscopic techniques in determination of molecular structures.
- Demonstrate the magnetic property of metal complexes
- Explain photochemical properties of inorganic compounds.

Unit I: Molecular symmetry and group theory

Symmetry elements and operations, symmetry groups, equivalent symmetry elements and equivalent atoms, point groups with examples, Group of very high symmetry, systematic procedures for symmetry classification of molecules and illustrative examples, symmetry point groups for compounds having coordination number 2 to 9, molecular dissymmetry and optical activity. Brief representation of theory of groups, Historical development of Evariste Galois theory of groups, matrix representation of groups, reducible and irreducible representation of point groups, definition of classes and character, the "Great Orthogonality Theorem", character tables, concept of character projection operator, symmetry adapted linear combination, vibrational modes as bases for group representation, symmetry selection rules for IR and Raman spectra, orbital Symmetry and Chemical reactions –Woodward and Hoffman rules for electrocyclic and cycloaddition reactions.

Unit II: Bonding and stereochemistry in main group elements

Born-Oppenheimer approximation, Hartree-Fock method, Brillouin theorem, Koopman's theorem, Roothan's equations, models of chemical bonding - Molecular orbital (MO) and Valence bond (VB) theories, application to diatomic molecules such as, H_2, H_2^+, N_2, O_2, and CO. Hybridization and MOs of H_2O, NH_3 and CH_4, Introduction to the SCF method; the use of outer d-orbitals; dπ-pπ bond; LCAO-MO theory for homo-nuclear diatomic molecules; hetero-nuclear diatomic molecule; polyatomic molecules; orbital symmetry and overlap; molecular shapes in terms of molecular orbitals; Walsh Diagrams, non-covalent interactions.

Unit III: Magneto chemistry

Magnetic susceptibility, types of magnetic materials, contribution of magnetic properties and their origin, magnetic moment, measurement of magnetic susceptibility (Gouy and Faraday methods), sources of para-magnetism, diamagnetic susceptibility, derivation of Curie equation for magnetic moment, Curie and Curie-Weiss law, quenching of orbital moments, Magnetic behavior of multi-electron system, orbital coupling, spin-coupling, spin-orbit coupling (Russel Saunder's coupling), spin-orbit coupling constant, j-j coupling, micro-states and term symbols, Lande interval rule, temperature dependence of magnetism, thermal energy and magnetic moment, ferrimagnetism andanti-ferromagnetism and its exchanged pathways; molecular field theory of ferromagnetism, magnetic sub-lattice.

Unit IV: Inorganic Photochemistry

Introduction to inorganic photochemistry, photophysical and photochemical process, characteristics of the electronically excited states of inorganic compounds, quantum yield, transfer of excitation energy under conditions of weak interaction and strong interaction, exciplex formation**,** ligand field states, charge transfer states; Photochemical processes: Selection rules, Jablonski diagram, Fluorescence and phosphorescence, delayed fluorescence, Photochromism, Photosensitization, Photochemical reactions: Prompt and delayed reactions, substitution reaction, photooxidation and reduction, d–d and charge transfer reactions redox reactions of Cr(III), Ru(II) and Ru(III) complexes; Photochemistry of $Cr(CO)_6$, $Mn_2(CO)_{10}$ and $Fe(CO)_5$; photochemical reactions of $[Ru(bipy)_3]^{2+}$ and $[Fe(bipy)_3]^{2+}$; Application of inorganic photochemistry: Molecular recognition, Sensing, Dye sensitized solar cells; Excited states of metal complexes in visible light driven organic synthesis and photovoltaics: Water photolysis and carbon dioxide reduction. Solar energy conversion and storage

Recommended books:

1. F. A. Cotton, Chemical applications of Group Theory Adaptation; Wiley (2020).
2. Von H. H. Jaffe und M. Orchin, Symmetry in Chemistry; John Wiley & Sons, Inc., (1965).
3. P. K. Bhattacharya, Group Theory and its Chemical Applications; Himalaya, New Delhi (2010).
4. Robert L. Carter, Molecular Symmetry and Group Theory; Wiley (1997).
5. James E Huheey, E. A. Keiter, R. L. Keiter, O. K.Medhi, Inorganic Chemistry: Principles of Structure and Reactivity; 4th Edition, Pearson (2006).
6. H. J. Emeleus and A. G. Sharpe, Modern Aspects of Inorganic Chemistry; 4th Edition, John Wiley & Sons, Inc., New York (1973).
7. Bodie E. Douglas, Darl H. McDaniel and. John J. Alexander, Concepts and Models of Inorganic Chemistry; 3rd Edition, John Wiley and Sons (1994).
8. A.B.P. Lever, Inorganic Electronic Spectroscopy; Elsevier (1968).
9. R. L. Carlin, Magneto-chemistry, Springer Verlag (1986).
10. K. K. Rohatgi- Mukherjee, Fundamentals of Photo chemistry, New Age International Publishers.
11. A.W. Adamson & P. D. Fleischauer, Concepts of Inorganic Photochemistry, John Wiley & Sons.

Paper code: ICH 702C
Paper name: Physical Chemistry – VI
Credit: 04
Full Marks: 100 (70+30)

Course Outcome:

The aim is to motivate and enable a comprehensive knowledge to the students on principles of molecular spectroscopy. By introducing this course student will be able to understand about the –

- Molecular spectroscopy in advanced level
- The rotational and vibration spectroscopy.
- Calculation of bond length and bond energies
- About the Raman Effect and rotational vibrational Raman spectra etc.
- Student will learn about the polymer chemistry and about the different polymerization techniques

Learning Outcome:

- On successful completion of this lesson the student should have understand the Microwave spectroscopy, Infrared spectroscopy, Raman spectroscopy and Electronic spectra of diatomic molecule.
- Students will understand and get clear concepts on Polymer chemistry with detailed variation of thermodynamic parameter and role of additives in polymerization process.

UNIT I: Advanced Molecular Spectroscopy-I

Characterization of electromagnetic radiation, energy quantization, atomic and molecular spectra, emission and absorption spectra; Fourier transformed spectroscopy, Lasers. Microwave spectroscopy, rotation spectra of di – and poly- atomic molecules; Stark effect; Applications of microwave spectra; Vibrational spectra of diatomic molecules; Rotation-vibration spectra of diatomic molecules; Vibrational spectra of diatomic and ploy atomic molecules; Classification of molecules, rigid rotor

model, effect of isotopic substitution on transition frequencies & intensities non rigid rotor, breakdown of Born-Oppenheimer approximation; Electronic spectra of diatomic and polyatomic molecules. Applications of Micro wave Spectroscopy, Fermi resonance.

Infrared Spectroscopy: Linear harmonic oscillator, vibrational energies of diatomic molecules, zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy; Basic Instrumentation, Selection rules, normal modes of vibration, group frequencies, overtones, Fermi resonance, hot bands, factors affecting the band positions and intensities. FTIR and NIR; applications

UNIT II: Advanced Molecular Spectroscopy-II

Raman spectroscopy: Rayleigh scattering, Raman Scattering. Polarizability, Polarization of Raman lines, Rule of mutual exclusion, Instrumentation and applications Electronic Spectroscopy: Electronic states of diatomic molecules, Molecular term symbols, selection rules for diatomic molecules, Franck-Condon principle and intensities of electronic spectra; Electronic spectra of polyatomic molecules, Absorptions due to ethylenic and carbonyl chromophore, solvent effects on electronic spectra.

Fluorescence Spectroscopy: Fluorescence, and phosphorescence, fluorescence quenching concentration quenching, quenching by excimer and exciplex emission, fluorescence resonance energy transfer between photoexcited donor and acceptor systems (FRET). Stern-Volmer relation

UNIT III: Introduction of Polymer

Historical Background, Basic Nature and Classification, Concept of Macromolecules, Monomer, Oligomers, Repeating Units, Degree of polymerization, Copolymer- random, alternating, graft, block, Tacticity, Polymerization Process- Addition Polymerization, Chain, Kinetic and Mechanism, Cationic and Anionic Polymerization, Radical Chain Polymerization, Step Polymerization, Living and Non Living Polymerization, Coordination Polymerization, Copolymerization, Ring Opening Polymerization, Molecular Weight Distribution, Static and Dynamic Methods, Degree of Crystallinity, Light Transition and GPC, Glass Transition and Crystalline Melting, X ray Diffraction, Thermal Analysis of Polymer, Spectroscopy of Polymer, Rheology.

UNIT IV: Polymer Thermodynamics and Additives

Thermodynamics, Flory-Huggins equations, Chain Dimension, Solvation and swelling, Polymer Structure, Polymer Additives, Class of polymer additives, Fillers- effects and types of fillers, Coloration of Polymers, Plasticizer, Conducting Polymer, Liquid Crystalline polymer, Polymer Composite, Photoresponsive and Photorefractive Polymer, Polymer in optical lithography, Electrical Properties of Polymer

Recommended Books:

1. R. S. Drago, Physical Methods in chemistry, W. B. Saunders Company, Philadelphia, London. G. M. Barrow, Introduction to Moelcular Spectrsocopy: McGraw Hill
2. C. N. Banwell, Fundamentals of Molecular Spectroscopy, Tata Mcgraw
3. R. Chang, Basic Principles of Spectroscopy, McGraw Hill.
4. G. S. Misra, Introductory Polymer Chemistry, Wiley Eastern Ltd, (1993)
5. S. F. Sun, Physical Chemistry of Macromolecules, 2nd Edition, Wiley, (2004)

Paper code: ICH 703C
Paper name: Organic Chemistry – VI
Credit: 04
Full Marks: 100 (70+30)

Course outcome:

The course helps the students

- To understand the concept of chirality in acyclic and cyclic compounds
- To know how to do conformational analysis in both cyclic and acyclic systems
- To understand the art of inducing asymmetric synthesis
- To familiar with advanced organic reaction mechanism
- To know the different aspects of pericyclic and photochemical reactions with special reference to orbital symmetry
- To know the nature, generation and reactivity of reactive intermediates

Learning outcome:

- Advanced stereochemistry course will enable the students to realise the deep understanding of stereochemical structure and reactivity of various acyclic and cyclic systems. Additionally the flavor of asymmetric synthesis will help them to learn the techniques for introducing chiral induction in achiral molecules.
- Organic reaction mechanism course will make the students competent enough to understand the reactivity pattern of different molecules in different reaction conditions.
- The pericyclic and photochemical reaction course will help the students to explore the newer routes for these types of reaction by virtue of orbital symmetry. Additionally, the students will familiarize with various reactions and their applications in organic synthesis.
- Neutral reactive intermediate in organic synthesis course enable the students to learn the nature, structure and reactivity of short-lived reactive intermediates and their versatile application in organic reactions.

Unit I: Advanced stereochemistry

Chirality, interconversion of Fischer, Newman and Sawhorse and Flying-wedge formula, R-S nomenclature, conformation of acyclic systems, compounds with asymmetric carbons in branched chains; symmetry elements and point groups; prochirality, topicity and prostereoisomerism; conformational analysis of cyclic compounds: cyclobutane and cyclopentane, mono and disubstituted cyclohexanes, fused ring systems- decalins, hydrindane, perhydroanthracene, perhydrophenanthrene; axial and planar chirality: stereochemistry of allenes, atropisomerism, biphenyls and spiro compounds, ansa compounds and cyclophanes, helicity; allylic strains, alkylketone effects, haloketone rule; methods of resolution, principles of asymmetric synthesis: Crams rule, Felkin-Anh model, Prelog's rule, asymmetric induction, enantio and diastereoselective synthesis; stereospecific synthesis, optical purity, determination of enantiomeric and diastereomeric excess, effect of conformation on reactivity.

Unit II: Organic reaction mechanism

Concept of hard and soft acids and bases and its application in organic chemistry, primary and secondary isotope effects for determination of reaction mechanism, Linear free energy relationship, Hammett equation, σ–ρ relationship, Hammand principle, Curtin-Hammett principle,. General reaction mechanism: S_N1, S_N2, mixed S_N1 and S_N2 and S_Ni reaction, SET reaction, S_E1, S_E2, S_Ei mechanism, S_NAr, SRN_1 mechanism, reactivity, effect of substrate, solvent, leaving group and attacking nucleophile, elimination reaction, E1 E2 and E1cb; neighboring group participation reactions and anchimeric assistance.

Unit III: Pericyclic and organic photochemical reactions

Basic concept of pericyclic reaction and orbital symmetry; electrocyclic and cycloaddition reactions, sigmatropic rearrangements, Claisen and Cope rearrangements, Somelett-Hauser rearrangements, Chelotropic reactions, 1,3-dipolar cycloaddition reactions, FMO analysis and Woodward-Hoffmann selection rules for [2+2] cycloaddition reaction, correlation diagrams, Dewer-Zimmermann approach, Mobius and Huckel systems.

Photochemical reactions of carbonyl compounds, Norrish type I and II reactions; photochemistry of olefins, cis-trans isomerism; photochemistry of arenes; di-pi-methane rearrangement, Photo-Fries rearrangement of ethers and anilides; Paterno-Buchi reaction, Hoffmann-Loefller-Freytag Reaction, Barton reaction; singlet oxygen photochemistry, visible light induced energy transfer reaction in organic synthesis.

Unit IV: Neutral reactive intermediate in organic synthesis

Carbenes: Generation, structure, classification, stability and reactions of carbenes and carbenoid.

Nitrenes: Generation, structure and reactions of nitrenes.

Arynes: Generation, structure and stability; benzyne mechanism for aromatic nucleophilic substitution (cine substitution); rearrangement and cycloaddition reactions of arynes, synthetic applications.

Enamines: methods of preparation, structure and stability of enamines; synthetic applications.

Free radicals: Generation, structure and stability of radicals, radical initiator, radical scavenger; persistent radical; tributyl tin hydride mediated radical reactions, exo and endo cyclisation, endiyne cyclisation (Bergman cyclisation) and applications.

Recommended books

1. D. Nasipuri, Stereochemistry of Organic Compounds, Wiley Eastern Limited.
2. S. Sen Gupta, Basic Stereochemistry of Organic Molecules, 2nd Edition, (2018).
3. P. S. Kalsi, Stereochemistry Conformation and Mechanism, Eighth edition, New Age International (2014).
4. E. L. Eliel and S H Wilen, Stereochemistry of Organic Compounds, Wiley: London (1994)
5. R. O. C. Norman and J. M. Coxon, Principles of organic synthesis, 3rd Edition, CRC Press (2017).
6. J. Clayden, N. Greeves and S. Warren, Organic Chemistry, 2nd Edition, Oxford University Press (2012).
7. P. S. Kalsi, Organic Reactions and Their Mechanisms, New Age International Pvt. Ltd.(2017).
8. F. A. Carey and R J Sundberg, Advanced Organic Chemistry, Part A & B, Springer.
9. R. N. Morrison, and R N Boyd, Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.
10. J. Singh and J. Singh, Photochemistry and Pericyclic Reactions, New Age International Private Ltd.; 3rd Edition (2012).
11. B. Dinda, Essentials of Pericyclic and Photochemical Reactions; Springer (2017).

Paper Code: ICH 704C
Paper name: Inorganic chemistry Lab
Credit: 04
Full Marks: 100 (70 +30)

Course Outcome
This laboratory course provides opportunities for hands on laboratory experiences related to qualitative and quantitative analysis in inorganic chemistry.

Learning Outcome:
After completion of the course, a student will be

- Skilled for Systematic qualitative analysis of mixtures containing 06 (six) radicals with an interfering radical.
- Able to gain knowledge about safety and handling of laboratory glassware, equipment's, and chemical reagents.
- Prepare Inorganic Complexes with various organic ligands.
- Able to quantify the presence of metal ions in a sample and estimation hardness of water.

Course Contents:

I) **Inorganic analysis**

Semi micro qualitative analysis of Inorganic salt mixtures containing (06) six radicals including W, Mo, V, Ti, U, Th, Zr, Ce and at least one interfering radical (F^- /PO_4^{3-} /BO_3^{3-}).

II) **Chromatography of metal ions:**

Separations of the following metal ions from their mixtures by Paper chromatographic:

a) Ag (I) and Pb(II)
b) Fe (III) and Al(III)
c) Ni (II) and Co(II)

III) **Inorganic preparation**

Preparation of the following inorganic compounds and characterization by IR, UV-Vis, conductivity & magnetic susceptibility measurements:

a) Tris (acetyl acetonato)manganese (III)
b) Tris (acetyl acetonato)iron (III)
c) Linkage isomer of nitro & nitrido pentammine Cobalt (III) Chloride
d) Tris (Ethylene diammine) Nickel (II) Chloride dehydrate

IV) **Inorganic estimation**

Oxidation-ReductionTitrimetry

a) Estimation of Fe(II)/Fe(III) by $KMnO_4$ solution.
b) Estimation of Fe(II)/Fe(III) by $K_2Cr_2O_7$ solution

GravimetricTitrations

a) Estimationof Nickel(II) using DMG.
b) Estimation of SO_4^{2-} by using $Bacl_2$ method.

Complexometry Titrations

a) Estimation of Ca^{2+} Using EDTA
b) Determination of total hardness of water.

Recommended books:

1. G. Svehla, Vogel's Qualitative Inorganic Analysis, Revised by 7th Edition, Pearson Education.
2. A. K. Nad, B. Mahapatra, A. Ghoshal, An Advanced Course In Practical Chemistry, New Central Book Agency Pvt. Ltd. (2022).
3. S. C. Das, Advanced Practical Chemistry, 3rd Edition, , Kolkata quality printing (2003).
4. G. N. Mukherjee, Advanced Experiments in Inorganic Chemistry, U. N. Dhur & Sons Pvt. Ltd.
5. V. V. Ramanujam, Inorganic Semi Micro Qualitative Analysis, 3rd edition, National Publishing Company (1974).

Paper code: ICH 705E Credit: 04 (compulsory elective, DSE 05),
Paper name: Basic statistics and Computer skill

Course outcome:

On completion of this course the students will be able to understand:

- Importance statistics and statistical data
- Statistical Data Analysis,
- Computer Programming Basics (FORTRAN)
- Python modules, Python Library and Multi-Threading in Pytho.

Learning outcome:

- On completion of the course, students should be able to interpret:
  Interpret various object-oriented language like as FORTRAN, helpful for fast calculations.
  Students will be able to do array/matrix/calculations without the need for loops.
- Know interpreted language link Python**,** writing a script very quickly that "does the job".
- Make out statistical data analysis which will be helpful in their research.

Unit I: (Basic statistics)

Basics of Statistics: Descriptive and Inferential Statistics, Parameters and Statistics, Steps in Statistical data analysis, Variables, scales and organization of the data, Describing data by tables and graphs, Qualitative variable, Quantitative variable, Sample and Population Distributions, Measures of center (Mode, Median, Mean), Measures of variation (Range, Interquartile range, Standard deviation), Probability Distributions, Mean and standard deviation of random variable, Normal distribution, Sampling distributions, Estimation, Point estimation, Point estimators of the population mean and standard deviation, Confidence interval, Hypothesis testing, Scatterplot and correlation coefficient.

Unit II: (Basic statistics)

Statistical Data Analysis: Gaussian Distribution and Errors in Measurement and their effect on data sets. Descriptive Statistics using Excel, Statistical Significance Testing, the T test and the F test, F test of predictors, t tests for estimating mean (μ_1), mean (μ_2), independent samples.

Unit III: (Computer skill)

Computer Programming Basics (FORTRAN): Basic Elements of FORTRAN, FORTAN Language, FORTRAN Keywords and commands, Logical and Relational Operators, iteration, Array variables, Matrix addition and multiplication.Function and Subroutine.

Unit IV: (Computer skill)

Introduction to Python: Features of Python, Python Character Set, Token & Identifiers, Keywords, Literals, Delimiters, and operators. Comments: (Single line & Multiline/ Continuation statements), Clarity & Simplification of expression. Knowledge of data types and Operators & types: Binary operators1Arithmetic, Relational operators, Logical Operators, Augmented Assignment operators.

Exceptional Handling in Python

File handling: open and close a file, read, write, and append to a file, standard input, output, and error streams, relative and absolute paths.

Introduction to Python modules: Importing math module (pi, e, sqrt, ceil, floor, pow, fabs, sin, cos, tan); random module (random, randint,randrange), statistics module (mean, median, mode).

Object-Oriented (OO) Programming in Python

Python Library(Pandas, Numpy, Plotting with Pyplot etc)

Multi-Threading in Pytho.

Recommended books:

1. Jarkko Isotalo, Basics of Statistics.
2. G. M. Clarke & D. Cooke, A Basic course in Statistics; Arnold (1998).
3. T. W. Anderson & S. L. Sclove, Introductory Statistical Analysis; Houghton Mifflin Company (1974).
4. R.A. Johnson & G.K. Bhattacharyya, Statistics: Principles and Methods; 2nd Edition. Wiley (1992).
5. D. Moore, & G. McCabe, Introduction to the Practice of Statistics; 3rd Edition. Freeman (1998).
6. N. A. Weiss, Introductory Statistics; Addison Wesley (1999).
7. D. C. Harris, Quantitative Chemical Analysis; 6th Ed., Freeman (2007).
8. Martin C. Brown, Python The Complete Reference; Tata McGraw-Hill Education, India.
9. Python Pocket Reference: Python in Your Pocket (Greyscale Indian Edition), Publisher: O'Reilly.
10. V. Rajaraman, Computer Programming in FORTRAN 77; Prentice Hall (1997).
11. Martin Cwiakala, Schaum's Outline of Programming with FORTRAN 77 (1995).

Semester VIII
Paper code: ICH 801C
Paper name: Inorganic Chemistry – VII
Credit: 04
Full marks: 100 (70+30)

Course outcome:

The course is aimed to demonstrate

- X-ray crystallographic data analysis and solid state chemistry
- The chemistry of inorganic polymers
- The understanding of the basic principle of all kinds of spectroscopic techniques used in organic chemistry for structural elucidation of inorganic compounds.
- To explain the basic concept behind NMR spectroscopy and its application for the structure elucidation.
- To understand the chemical shift and coupling constant in relation to stereo-chemical structure of the inorganic compound.
- To know the basic concept of Ultraviolet and Visible Spectroscopy, C13-NMR spectroscopic techniques and IR spectroscopy.
- To apply various spectroscopic techniques discussed above for solving/determining the structure of compounds

Learning outcome:

On completion of the course, the student should be able to:

- Analyze crystallographic data
- Acquainted knowledge of inorganic polymer and their properties
- Combine information from experimental NMR, IR, UV, and MS spectra and elucidate the structure of unknown inorganic compounds.
- Argue for a suggested molecular structure from analysis of the spectral data.
- Predict the NMR, IR, UV-Vis and MS spectra from a given molecular structure.

Unit I: X-ray crystallography and Diffraction

Lattice points, Reciprocal Lattice, Unit Cells; Geometry of Crystals; Classification of unit cells, Crystal systems, Herman-Mauguin notation, Bravais Lattices, Distinction between trigonal and hexagonal systems, Crystal planes and indices; Law of rational indices.

Space groups and equivalent positions: Screw axis, Glide planes, Space groups, Relationship between space groups, point groups, Equivalent positions, Special positions,

X-ray diffraction: Principles of X-Ray Diffraction, X-Ray Diffraction Methods, Bragg's law; Crystal systems and symmetry, stereographic projection of 32 point groups and space groups-Hermann–Mauguin notations, Primitive and non-primitive unit cells; Symmetry elements: isogonal symmetry groups and reciprocal lattice.; X-ray-instrumentation- Basics of X-Rays, Production and Detection of X-Rays, Data collection, data reduction, refinement and structure solution, Intensity of Diffracted Beams**;** Determination of Crystal structures, Precise Lattice Parameter Determination, Phase Diagram Determination, Ordered Disordered Transformation, Qualitative and Quantitative Phase Analysis, Effect of Crystal Size on Diffracted X-Ray, Intensity Determination of Single Crystal.

Unit II: Inorganic Polymers

Classification of inorganic polymer, inorganic polymerization reactions, comparison with organic polymers, B-O & B-N polymers, Silicones, Coordination polymers, S-N & S-N-F, P-N compounds, Chalcogen cluster - binary and multi component systems, homolytic inorganic systems; Polysiloxanes, polysilanes, polyphosphazenes, polymeric sulfur – synthesis, structure, properties & applications; Co-ordination polymers and organometallic polymers; definition and classification of coordination polymers, design strategies, network topologies, supramolecular isomerism, interpretation, porous coordination polymers, properties, and applications

Unit III: Spectroscopy of inorganic molecules – I

Infrared and Raman Spectroscopy: Brief review of basic principles of IR and Raman spectroscopy; application of vibrational spectroscopy in investigating - Symmetry and shapes of simple AB_2, AB_3 and AB_4molecules.Structural elucidation (by IR & Raman spectra) of co-ordination compounds containing the common ligands such as: NH_3, H_2O, OH^-, NO^{3-}, SO_4^{2-}, ClO_4^-, CN^-,SCN^-,N_3^-, H^-, PR_3, OPR_3, halides, dioxygen, $-COO^-$.

Electron Spin Resonance Spectroscopy - Electron Paramagnetic Resonance Spectroscopy: Principle, instrumentation, representation of EPR spectrum, X-band and Q-band spectra, line width, hyperfine splitting, magnetically equivalent and nonequivalent sets of nuclei, g-anisotropy, spectra of simple organic free radicals: expected number of lines, intensities. Spectra of transition metal complexes(d^1 - d^9 ions in cubic and tetrahedral fields) , metal hyperfine anisotropic spectra, zerofield splitting, Kramers degeneracy, application: determination of oxidation state of metal ion in samples

Mossbauer spectroscopy: Principles, isomer shift, quadruple effect of magnetic field, application to iron and tin compounds.

Unit IV: Spectroscopy of inorganic molecules - II

Nuclear Magnetic Resonance Spectroscopy - Basic principle, Relaxation time-spin lattice and spin–spin relaxation, Chemical shift, factors that affect chemical shift. Use of chemical shifts and spin-spin couplings for structural determination; Application of ^1H, ^{13}C, ^{19}F ,^{31}P and ^{119}Sn in the structural assignment of selected inorganic compounds.

Mass Spectroscopy: Basic principle of mass spectrometry, concept of metastable ions and transition, recognition of the molecular ion peak, Application to metal compounds containing ligand such as carbonyl/ nitrosyl/ alkyl/ cyclopentadienyl and acetyl acetonate; Interpretation of mass spectra for structural characterization; Effect of isotopes on the appearance of mass spectrum.

R**ecommended books:**

1. E. A. V. Ebsworth, David W. H. Rankin, Stephen Cradock, Structural methods in Inorganic Chemistry; 2nd Edition, Blackwell (1991).
2. Kazuo Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A: Theory and Applications in Inorganic Chemistry; 6th Edition, Wiley Online Library (2008).
3. F. A. Cotton, Progress in Inorganic chemistry; Vol., 8, Wiley (2009).
4. Richard L. Carlin, Transition Metal Chemistry - A Series of Advances; Volume-3, Marcel Dekker, Inc, NY (1966).

5. R. V. Parish. Ellis Horwood, Chichester, NMR, NQR, EPR and Mössbauer spectroscopy in inorganic chemistry; (1990).
6. Clive Whiston, X Ray Methods; John Wiley & Sons (1987).
7. B. Douglas, D. McDaniel, J. Alexander, Concepts and Models of Inorganic Chemistry; 3rd ed., John Wiley (2001, 2005).
8. Donald L. Pavia, Gary M. Lampman, George S. Kriz and James R. Vyvyan, Introduction to Spectroscopy, 5th Edition, Cengage Learning (2013).
9. Veda Ramaswamy, Characterization of Polycrystalline Catalytic Materials using Powder X-Ray Diffraction, Narosa (2016).
10. Roger De Jaeger, Mario Gleria, Inorganic polymer, Nova Science Publishers (2007).
11. P. B. Saxena, Inorganic polymer, Discovery Publishing House (2007).

Paper code: ICH 802C
Paper name: Physical Chemistry – VII
Credit: 04
Full Marks: 100 (70+30)

Course Outcome:

- To introduce the advanced quantum chemistry
- Provide knowledge on the Kinetic theory of gases
- Discussion on solid state chemistry,
- To interrelate the chemical structure and the properties in the design of advanced materials.
- To identify the specific synthetic methodologies of materials of interest.

Learning Outcome: After completion of this course, students will learn about variables and wave functions, postulates of quantum mechanics, Hamiltonian operators, kinetic theory of gases, collison theory, diffusion in gases;To recognize advanced materials of current interest of both organic and inorganic nature and to identify the involvement of Chemistry in the development of advanced materials.

UNIT I: Kinetic Theory and Transport Properties of Gases

Derivation of Maxwell's distribution law for molecular velocity and its applications in calculating molecular speeds: Most probable, average and root mean square. Intermolecular collisions, frequency of collision, Molecular collision and mean free path. Collision theory of reaction rates; Transport process: Thermal conductivity, kinetic theory of thermal conductivity of gases, viscosity, flow rate of fluids, measurement of viscosity of gases, relation between viscosity and mean free path of gases, effect of temperature on viscosity of gas; Diffusion of gases.

Unit II: Solid State Chemistry

Crystal lattice: Unit Cell, Miller indices and planes, X–ray diffraction method, molecular solids, hydrogen bonding, metallic, covalent and ionic solids; structural classification of binary and tertiary compounds, determination simple structure, spinel and perosvskite structures; Band theory, conductors, semiconductors and insulators, energy bands, intrinsic and extrinsic semiconductors; Perfect and imperfect crystals, intrinsic and extrinsic defects, point–, line– and plane– defects;

Vacancy, Schottky and Frenkel defects. Schottky and Frenkel defect formation Solid State Reactions: Types; sintering; nucleation; Factors influencing the reactivity of solids; Precursors to solid state reactions; Tammann and Hedvall mechanism; Wagner's Diffusion theory of reaction; Material transport in solid state reaction—counter diffusion, Kirkendall effect; Huttig's mechanism; Kinetic model: Reaction in powder compact, parabolic rate law, Jander'srate equation.

Structural transformation of solids: Solid solutions, Hume–Rothery rules, substitutional solid solutions and interstitial solid solutions, solid solution mechanism, experimental methods for studying solid solutions (X–ray powder diffraction and density measurements). Alloy systems: Phase diagrams, two and three component systems, study of alloy systems, steels with reference to iron, carbon systems and copper– zinc system.

UNIT III: Quantum Chemistry

Classical mechanics, black body radiation, uncertainty principle and wave particle duality, wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions, one dimensional wave equation, separation of variables for solving wave equation, general solutions to wave equations, two dimensional wave equations. Postulates of quantum mechanics, Wave function of a particle - Schrödinger equation, Eigen value problem, linear operator's classical mechanical quantities in quantum mechanics, wave function normalization, Particle in one dimensional and three dimensional box, Harmonic oscillator

Rigid rotor, energy levels of a rigid rotor, spherical harmonics, Schrödinger equation for the hydrogen atom – solutions, s orbitals, p orbitals, energy levels of a hydrogen atom in magnetic field, Schrödinger equation for Helium atom. Perturbation theory, Variational methods, Hartree-Fock equations, Self-consistent field methods for solving Hartree-Fock equations, Born-Oppenheimer approximation-molecular Hamiltonian operators, Valence bond treatment for chemical bonding in molecules, molecular orbitals, molecular orbital theory for different diatomic molecular systems, photoelectron spectra, SCF-LCAO-MO wave functions, electronic states of diatomic molecules, sp, sp2 and sp3 hybrid orbitals, molecular term symbols, Hückel molecular orbitals, bonding in polyatomic molecules.

Unit IV: **Molecular Mechanics and Molecular Dynamic Simulation Methods**

Introduction, microscopic and macroscopic properties, time scale of chemical/biological process, the Morse potential model, harmonic oscillator model, force fields development, various energy terms and non-covalent interactions included in force fields, Lennrad-Jones type and truncated Lennard-Jones potentials, commonly used force fields, parameterization, advantages and limitations of Force Field Methods, molecular dynamics methods, neighbour searching, Trotter decomposition, cut-offs, temperature and pressure coupling methods, integration algorithms: Verlet algorithm, Leap-frog algorithm, Velocity Verlet, Beeman's algorithm, Constraint algorithms: shake, lincs, etc., topology files, energy minimization: steepest descent method, conjugate gradient method, L-BFGS. Solvent models, Solvation, implicit and explicit solvation, heating dynamics, equilibration dynamics, production dynamics, trajectory analysis, particle mesh Edward dynamics, boundary conditions, Exclusions and 1-4 interactions, replica exchange method, conformational analysis, normal mode analysis, free energy calculation: free energy perturbation method, thermodynamic integration method,

thermodynamic cycles for free energy calculations, determination of hydration/solvation free energy, protein folding free energy, protein-ligand binding free energy etc. Software packages for performing Molecular dynamic simulation as well as for visualization and analysis trajectories

Recommended Books:

1. P. C. Rakshit, Physical Chemistry, Seventh Edition, Sarat Book Distributors, Kolkata, (2004)
2. I. N. Levine, Physical Chemistry, Fifth Edition, Tata McGraw Hill Pub. Co. Ltd., New Delhi
3. T. Engel and P. Reid, Physical Chemistry, First Edition, Pearson Education, Noida (2007).
4. Lesley E. Smart and Elaine A. Moore Solid State Chemistry-An Introduction, Taylor and Franchis, third edition (2005).
5. D. K. Chakrabarty, Solid State Chemistry, New Age International 2nd edition
6. A. Gurtu and J.N. Gurtu, Solid State Chemistry, Pragati Prakashan, 4th edition (2019)
7. Van Vlack, H. Lawrence, "Elements of Material Science and Engineering", 6th edition, New York Addison, Wesley, (1989).
8. S. Chawla, "A Textbook of Engineering Chemistry", Dhanpat Rai & Co, Delhi, (2001)
9. Ira N. Levin, Quantum Chemistry, 6th Edition, Prentice Hall (2008).
10. R. K. Prasad, Quantum Chemistry, New Age Publication Pvt. Ltd.
11. Peter Atkins, Roald Friedman, Molecular Quantum Chemistry, 4th Edition
12. A. K. Chandra, Introductory Quantum Chemistry, 4th Edition, Tata McGraw Hill (1997).
13. M. P. Allen, D. J. Tildesley, Computer Simulations of Liquids, Oxford: Oxford Science Publications. (1987).
14. D. Frenkel, B. Smith, Understanding Molecular Simulation: From Algorithms to Applications, 2nd Edition, Academic Press, San Diego, (2002).
15. K. I. Ramachandran, G. Deepa and K. Nimboori, Computational Chemistry and Molecular Modelling: Principles and Applications, Springer-Verlag, Berlin, Germany, (2008).
16. F. Jensen, Introduction to Computational Chemistry, 2nd Edition, John Wiley & Sons Ltd, (2007).

Paper code: ICH 803C
Paper name: Organic Chemistry – VII
Credits: 04
Full Marks: 100 (70 + 30)

Course outcome:

The course helps the students

- To know the retrosynthetic analysis and disconnection approach and its application in organic synthesis.
- To understand how to design reactions to achieve target molecules.
- To familiarize with modern reagents and their applications in organic reactions.
- To know the important name reactions that are frequently used in organic synthesis with special reference to their applications in different reaction conditions.

Learning outcome:

- After learning the strategies in organic synthesis course students will able to apply the techniques of obtaining the target molecules by following retrosynthesis and disconnection

protocols. They will also be able to do protection and deprotection of different functional groups in critical synthesis.

- After knowing the selective organic reagents (including oxidizing and reducing agents), the students will be able to apply their use in different reaction conditions for doing various organic transformations.
- After learning organic name reactions and rearrangement reactions the students will understand the behavior of specific class of compounds in a particular reaction condition. They will also be able to use the concept of these reactions to achieve target molecules.

Unit I: Strategies in organic synthesis

Designing of organic synthesis; reversal of dipoles (umpolung of reactivity) and it's applications; Retrosynthetic and Disconnection approach-Retrosynthetic analysis: Basic concepts of retrosynthetic analysis, synthons, synthetic equivalent, donor and acceptor synthons, linear and convergent synthesis; analysis of one group disconnection approach for alcohol and keto compounds, functional group interconversions, protection and deprotection strategy in alcohols, carbonyls, acids, amines and amino acid chemistry; Applications of quaternary ammonium salts and crown ethers as phase transfer catalyst.

Unit II: Selective organic reagents and named reaction

Uses of the following reagents in organic synthesis: chloranil, DDQ, hypervalent iodine reagents, NBS, K-selecteride and L-selecteride, sodium cyanoborohydride, super hydrides, 9-BBN, Mukaiyama reagent, LDA, dicyclohexylcarbodimide, Corey-Nicolaou reagent, baker's yeast, peracids, CBS reagents; organo-Copper and organo-zinc reagents.

Named Reaction: Henry reaction, Wittig reaction and Horner-Wordwoth-Emmons reaction; Stobbe reaction, Nazarov cyclization, Passerini reaction, Ugi reaction, Peterson's synthesis, McMurry olefination, Julia olefination, Shapiro reaction, Baylis-Hillman Reaction, Staudinger Reaction, Suzuki and Negishi coupling, Heck reaction, Mitsunubo reaction.

Unit III: Organic oxidation and reduction

Oxidation of alcohols to aldehydes/ketones/carboxylic acids:Transition metal-based oxidants: Jones reagent, Collins Reagent, PCC, PDC, $KMnO_4$, MnO_2, $Mn(OAc)_3$, $RuCl_3/NaIO_4$ (RuO_4).

Metal free oxidation: Dimethyl sulfoxide based oxidation- Moffatt-Pfitzner Oxidation, Corey-Kim Oxidation, Swern Oxidation, Dess-Martin reagent, TEMPO, TPAP.

Oxidation of alkenes/alkynes: $KMnO_4$, OsO_4, Prévost dihydroxylation, Woodward dihydroxylation, epoxidation by peroxy acids and related reagents

Other oxidation processes: Allylic oxidation by SeO_2, Oxidation of aldehydes/ketones by SeO_2, cleavage of 1,2-diols, Sharpless epoxidation reaction

Reduction: Catalytic hydrogenation and dehydrogenation, dissolving metal reduction, reduction of functional groups, Meerwein-Pondrof-Verley reduction, hydroboration and related reaction, reaction of alkyl borane, non-metallic reducing agents such as diimide; aluminium and boron based reducing reagents

Unit IV: Rearrangement reaction involving electron deficient center

Pinacol rearrangement, Wagner-Meerwein rearrangement Demzanov rearrangement, dienone-phenol rearrangement, Favorskii, Wolff rearrangement, Hofmann, Curtius, Lossen, Schmidt rearrangement,

Beckmann rearrangement, Bamberger Rearrangement, Baker–Venkataraman Rearrangement, Baeyer-Villiger oxidation, Stevens rearrangement, benzidine rearrangement, Orton rearrangement, Fries rearrangement, Wittig rearrangement, Claisen rearrangement,

R**ecommended books**

1. S. Warren, Organic Synthesis, Disconnection Approach, Wiley Interscience, NY (1982).
2. R. O. C. Norman and J. M. Coxon, Principles of organic synthesis, 3rd Edition, CRC Press
3. W. Carruthers, Some Modern Methods of Organic Synthesis, Cambridge University Press
4. H. O. House, Modern Synthetic Reactions, Benjamin Publishing Co., 3rd Edition (1992).
5. J. Clayden, N. Greeves and S. Warren, Organic Chemistry, 2nd Edition, Oxford University Press (2012).
6. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part: A, Springer.
7. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part: B, Springer.
8. P. S. Kalsi, Organic Reactions and Their Mechanisms, New Age International Private Limited
9. R. N. Morrison and R. N. Boyd, Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.
10. F. A. Carey and R. J. Sundberg, Advanced Organic Chemistry, Part: B, Springer.

Paper code: ICH 804 C

Paper name: Physical Chemistry Lab

Credit: 04

Total Marks: 100 (70 + 30)

Course Outcome: This laboratory course on physical chemistry would expose students to the skills of performing and comprehending various physical chemistry experiments such as potentiometric, surface chemistry, thermodynamics, spectrophotometry, optical etc.

Learning Outcome:

On completion of course, the students will be able to:

- Develop their skills for qualitative and quantitative estimation samples
- Estimate the order of chemical reactions and solubility product
- Demonstrate conduct metric and potentiometric titrations
- Find out specific rotation of cane sugars and verification of Beer's law
- Estimate CMC of surfactants

Course Content

1. Measurement of specific rotation of glucose/sucrose at a number of concentrations and hence determination of unknown concentration of glucose/sucrose in given solution by optical measurements.
2. Potentiometric titration of Co(II) by $K_3[Fe(CN)_6]$and determination of concentration of Co(II) in a solution.
3. Conductomectric titration of triple mixture containing KCl, NH_4Cl and HCl by $AgNO_3$ and by NaOH solution.
4. Verification of Beer's law and determination of concentration of unknown solution spectrophotmetrically
5. Determination of pH of buffer solutions and hence to calculate the E^0 of quinhydrone electrode
6. Spectrophotometric determination of pKa of an indicator in micellar and microemulsion media.

7. Determination of rate constant and order of the reaction between $KBrO_3$ and KI in acid medium.
8. Kinetic study of decomposition of $K_2S_2O_8$ by KI and effect of added salt.
9. Determinaton of formula of cupro-ammonium ion.
10. Determination of composition and stability constant of Ferric-salicylic acid complex by Job's method.
11. Determination of critical miceller concentration (CMC) of sodium lauryl sulphate from the measurement of conductivities at different concentrations.
12. Determine critical solution temperature of phenol and water in presence of (a) 1% NaCl (b) 0.5% naphthalene and (c) 1% succinic acid
13. Determination of relative strengths of acetic acid and monochloroacetic acid by conductometric method.
14. Determination of dissociation constant of an indicator (e.g. methyl red) by spectrophotometric method.

Recommended Books:

1. J. B. Yadav, Advanced Practical Physical Chemistry, Krishna Prakashan, Meerut (2015).
2. D. P. Shoemaker, C. W. Garland & J. W. Nibler. *Experiments in Physical Chemistry* (5^{th}edn.), McGraw Hill (1989)
3. Findlay's Practical Physical Chemistry, 9^{th} Ed. Revised by B.P. Levitt, Longman.1973.
4. V. D. Athawala& P. Mathur. *Experimental Physical Chemistry*, New Age InternationalPublishers (2001).

Paper code: ICH 805E (optional elective, DSE-06)
Paper name: Bio-molecular Chemistry
Credit: 04
Full Marks: 100 (70+30)

Course outcome:

The course will help the students

- To provide concept about the trace and essential metals in biological systems and their importance.
- To know the different types of chelation therapy in metal ion detoxification and role of metals in biological systems
- To know the properties and synthesis of amino acids and peptides
- To understand the structures of proteins, properties of enzymes and their mode of action.
- To familiarize with the process of enzyme catalyzed reactions.
- To understand the importance of essential fatty acid and their biological as well biological importance of prostaglandins

Learning outcome:

On completion of the course, students should be able to:

- Appreciate how nature acquires and places trace elements for use in life processes.

- Understand the application of specialized methods used to study bioinorganic molecules.
- Define importance of inorganic elements in vital systems.
- Understand list some medical applications of inorganic compounds.
- Identify the main toxicological mechanisms of metals and the biological defenses against the toxic effects.
- The students will able to do the synthesis of amino acids and peptides.
- The students will also have the deep understanding of protein structures.
- After learning the course in Enzyme, the students will be able to know the mechanism of enzyme action and how the enzymes do catalysis in different biochemical reactions.

Unit 1 (Bio-inorganic chemistry)

Calcium in biology: Biochemical role of calcium, Storage and transport of calcium, Role of Ca^{2+} in muscle contraction, Blood clotting mechanism, Biological calcification.

Iron in biological process: Ferritin, Transferrin, bio–mineralization and Siderophores, Peroxidase, Catalase, Hemerythrin, Cytochromes, Cytochrome P-450, Iron sulphur proteins, Rubredoxins, Ferredoxins.

Metallo-enzymes and metalloproteins of copper and zinc: Blue-copper proteins, Ceruloplasmin, Hemocyanin, Cytochrome-c oxidase, Superoxide dismutase, Carbonic anhydrase, Alcohol dehydrogenase, Carboxy peptidase, Metallothionein, inter changeability of Zn and Co in enzymes.

Biochemical role of Co, Mo and Mn: B_{12}coenzyme, Cobalamines, Xanthine oxidase, Sulphite oxidase, Nitrite reductase, Arginase, Mn-SOD, Chlorophyll, Photosystem I and II, cleavage of water.

Unit II (Bio-inorganic chemistry)

Metals in medicines: Chelation therapy, Chelation therapy in metal ion detoxification, Chelation therapy in the treatment of human stones, Different types of chelation therapy in metal ion detoxification, Metal-Metal detoxification, Plasma mobilizing index (PMI), Toxic effects of drugs, Metals in diagnosis and Chemotherapy, Metal complexes as drugs, LD_{50} Value, Different correlations between LD_{50} Values of toxic elements and their different chemical parameters, Metal ions in carcinogenesis and in Anticancer battle, The role of metal complexes in anticancer battle (Pt, Rh, Au, Cu, Co), Alkylating agents as anticancer drugs, Antibacterial, Antiviral and Antifungal activity metal complexes and chelating agents, Anti-inflammatory effects of Zn and Cu Compounds, Biochemical basis of pharmacological uses of Zinc and Copper in some diseases, Gold therapy in rheumatoid arthritis and its side effects.

Unit III (Bio-organic chemistry)

Structure of amino acids and physical and chemical properties, method of synthesis (including resolution and asymmetric synthesis) of amino acids, peptides synthesis (both solution and solid phase) naming of polypeptides chain, hydrolysis of peptides by both chemical and enzymatic (carboxy peptidase, trypsin, chrymotrypsin and Lys C); use of cyanogen bromide in peptide degradation, amino acid sequence determination (N-terminal and C-terminal), structure of protein (Helical and pleated structure), coagulation and denaturation of protein.

Enzymes: Mechanism of enzyme action and models, kinds of reactions catalyzed by enzymes, cofactors, co-enzyme chemistry; Enzyme catalytic organic reactions – Oxidation, reduction, isomerization, epimerization, hydrolysis, phosphorylation, acylation, methylation, decarboxylation, dehydration.

Unit IV (Bio-organic chemistry)

Prostaglandins and related compounds: Classification of lipids, biological importance of fatty acids and lipids, essential fatty acids: ω-3and ω-6 fatty acids; polyunsaturated fatty acid, Structure, sources and functions of prostaglandins and thromboxanes, biosynthesis of prostaglandins, inhibition of prostaglandin synthesis; Different approaches of the synthesis of prostaglandins (PGE_1, PGE_2, PGE_3; $PGF_{1\alpha}$, $PGF_{2\alpha}$and $PGF_{3\alpha}$)

Recommended books:

1. G. N. Mukherjee and Arabinda Das, Elements of Bio-Inorganic Chemistry; 4th Ed., U. N. Dhur & Sons Private Limited (2016).
2. A. K. Das, A Text Book on Mediclinical Aspects of Bio-Inorganic Chemistry; 1st Edition, Cbs Publishers and Distributors, Delhi (1990).
3. I. Bertini, H. B. Gray, S. J. Lippard, and J. S. Valentine, Bioinorganic Chemistry; Viva Books Pvt. Ltd., (2004).
4. S. J. Lippard, and J. M. Berg, Principles of Bioinorganic Chemistry; University Science Book, Mill Valley (1994).
5. J. A. Cowan, Inorganic Biochemistry- An Introduction; Wiley- VCH, (1997).
6. R. W. Hay, Bioinorganic Chemistry, Ellis Hollwood, (1984).
7. S M Mukherjee, S P Singh, R P Kapoor, R Dass, Organic Chemistry, Volume-III, New Age International Private Ltd.
8. T W G Solomons, C B Fryhle and S A Snyder, Organic Chemistry, 12th Edition, Wiley (2016).
9. J M Berg, J L Tymoczko and L Stryer, Biochemistry, W.H. Freeman and Co., 6th Ed. (2006)
10. D L Nelson, M M Cox and A L Lehninger, (2009) Principles of Biochemistry. W.H. Freeman and Co., 4th Edition.
11. R. K. Murray, D. K. Granner, P. A. Mayes and V. W. Rodwell, Harper's Illustrated Biochemistry

Paper code: ICH 806E (optional elective, DSE-07)

Paper name: Chemistry of Surface

Credit: 04

Full Marks: 100 (70+30)

Course outcome

The course will motivate and encouraged the students in the following directions-

- Isotherms, LB film, membrane equilibrium and micellisation.
- In designing a process to removal of toxic compounds from industrial wastewater.
- Learn and understand adsorption process and its mechanisms on the surfaces.
- Able to analyze understanding the types of adsorption isotherms and its applications in real fields
- Equipped to work in the field of Surface science.
- Acquire the detailed information about the paints and paint technology, pigments dyes and extenders,
- Gathered knowledge about paint formulation, manufacture and application techniques, colour technology, paint properties.
- Able to analyze about quality control in paint Industries.
- Equipped students to proceed with the advanced studies related paint industry or seek a job in the related fields.

On completion of course, the students will be able to understand:

- Different adsorption isotherms
- Thermodynamics of adsorption isotherms.
- Effect of added electrolytes on surface excess
- Different types of mixed micelle
- CMC of mixed micelle. Counter ion binding
- Clint's equation for cmc
- Solubilization and emulsification by surfactants
- Applications of microemulsions
- Students will skilled for industrial oriented job

UNIT - I: Surface Chemistry – I

Surface Phenomena, Gibbs adsorption isotherm, types of adsorption isotherms, solid-liquid interfaces, contact angle and wetting, solid-gas interface, physisorption and chemisorption, Freundlich, derivation of Langmuir and BET isotherms, surface area determination; Kinetics of surface reactions involving adsorbed species, Langmuir-Hinshelwood mechanism, Langmuir-Rideal mechanism, Rideal-Eley mechanism.

UNIT – 2: Surface Chemistry – II

Surface Films, Langmuir-Blodgett films, self-assembled mono layers, collapse pressure, surface area and mechanism of heterogeneous catalysis, phase transfer catalysis. Chemical analysis of surfaces: Surface preparations - spectroscopic surface characterization methods, electron spectroscopy, ion scattering spectrometry, secondary ion scattering microscopy (SIMS) - Auger electron spectroscopy - instrumentation and application. Electron stimulated micro analysis, scanning probe microscopes.

UNIT – III: Surface Science and Coating Technology -I

Introduction of paints and surface adhesion, classification- paints, varnishes and lacquers, their components and functions, binders, pigments, extenders, and additives, global picture of paint industry Chemical modifications of vegetable oils - monoglyceride preparation, thermal polymerization, dehydration of the oil, oxidation, iodination, hydrolysis, alcoholysis, acidolysis, saponification, sulfonation, epoxidations. Preparation of alkyd resins, acrylic polymers, phenolics, amino resins, epoxy resins, polyurethane resins and polysiloxanes; Curing parameters and properties of these resins.

UNIT – IV: Surface Science and Coating Technology -II

Pigments: classifications (organic, inorganic pigments), purification and surface modification of pigments, properties of pigments; extenders, fillers and nano fillers; solvents, thinners and diluents, paint additives, physical chemistry of paint formations:wetting, dispersion, stabilization, adsorption, flocculation, rheology; particle size analysis.

Industrial process for making paints-three roll mill process; ball and pebble mills; sand, bead and short mills, high speed disc dispenser, testing and analysis of paints, general industrial paints, problems of paints and coatings. Coating Driers: composition, mechanism of drier action; manufacture of driers; evaluation of driers; combination of driers; drier dosage; drier related paint film defects; driers for water based coatings.

Recommended books

1. W. M. Morgan, 'Outline of Paint Technology', John Wiley sons, 1990.
2. Australian OCCA, 'Surface Coating Technology Volume 1', Chapman and Hall, 1974.

3. H. Y. Payne, 'Organic Coating Technology Vol, 1 & 11', John Wiley & Sons, 1954.
4. L. S. Pratt, 'Physics & Chemistry of Organic Pigments', Wiley, 1947.
5. Swaraj Paul -Surface Coatings: Science and Technology (Second Edition) by CBS publishers.
6. P. E. Philip and A Schweitzer - Paint and Coatings: Applications and Corrosion resistance
7. Dright G. Welden, Failure Analysis of Paints and Coatings, Wiley, 2009.
8. D. P. Woodruff and T. A. Delchar, Modern Techniques of Surface Science, Cambridge University
9. W. Adamson, Physical Chemistry of Surfaces, John Wiley & Sons, New York, 1990.
10. H. J. Butt, K. Graf and M. Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, 2003.
11. J. H. Clint, Surface Chemistry, Blackie and Son Ltd, 1992.
12. M. M. Rieger and L. D. Rheis (Eds), Surfactants in Cosmetics, Marcel Dekker Inc, New York,
13. A. W. Adamson, A. P. Gast, Physical Chemistry of Surfaces, 6th Ed, Wiley India, New Delhi.
14. D. J. Shaw, Introduction to Colloid and Surface Chemistry, 4th Ed, Butterworths Heinemann.
15. H. K. Moudgil, Textbook of Physical Chemistry, PHI Learning, New Delhi (2010).

SEMESTER IX

Paper code: ICH 901C
Paper name: Inorganic Chemistry – VIII
Credit: 04
Full Marks: 100 (70+30)

Course outcome:

On completion of this course the students will be able to understand:

- Crystal Field and Ligand Field theory of transition metal complexes. Magnetic, Optical and kinetic properties of metal complexes. Stability of metal complexes.
- Metal cluster compounds as well as Metal π- complexes with respect to their classification, synthesis, structure, bonding, properties, and reactions.
- Chemistry of rare earth elements and six platinum group metals.
- Focuses on recent promising research and novel trends in the field of cross-coupling reactions.

Learning outcome:

On completion of the course, students should be able to:

- Know about the typical physical and chemical properties of transition metal complexes, their structure and magnetic behavior.
- Understand metal cluster, metal carbonyl cluster compounds, synthesis of dinuclear and polynuclear metal carbonyls and their structural elucidation, bonding with the help of Vibrational spectra.
- Know lanthanide chemistry in the light of their different oxidation states, magnetic properties, radii, and Reactions. Know uses of lanthanide (III) complexes in the medical field such as optical spectroscopy, microscopy, and in MRI. Know chemistry of Pd, Pt, Rh and Ir metals.

Unit I: Chemistry of transition metal complexes

Electronic structure and spectra of transition metal complexes: Spectroscopic states, Crystal Field Theory, Orgel and Tanabe-Sugano diagrams, selection rules, Spectrochemical and Nephelauxetic series, molecular orbital theory of complexes (including complexes with and without π bonding), MO

diagrams for octahedral and tetrahedral complexes, Jahn-Teller effect, Charge-transfer spectra and optical properties of metal complexes.

Magnetic properties of transition metal complexes: Types of magnetic behaviour: dia-, para-, ferro- and anti-ferromagnetic compounds, spin-orbit coupling, temperature independent paramagnetism, application of Crystal Field Theory to explain magnetic properties, spin-crossover. Thermodynamic effects-hydration, ligation, lattice energy.

Reaction Mechanism of inorganic complexes: Stepwise and overall formation constants. Kinetic and thermodynamic stability of metal complexes; Factors affecting the stability of metal complexes, chelate effect, inert and labile complexes, kinetics of substitution in octahedral complexes, acid hydrolysis and base hydrolysis. Dissociative, associative and interchange mechanism, electron-transfer reactions, trans-effect and fluxional molecules.

Unit II: Metal clusters and Metal π complexes

Metal cluster compounds: Classification, synthesis, structure and properties; Metal carbonyls, Preparation of carbonyls, Reaction in carbonyls, Structure and bonding in mono-nuclear carbonyls, binuclear carbonyls, trinuclear, higher nuclear carbonyls, and higher polynuclear carbonyls using VBT. Vibrational spectra of Metal Carbonyls for elucidation of bonding and structure; Metal nitrosyl complexes, preparation, reaction in nitrosyls, bonding and structure; Complexes containing NO^+, Complexes containing NO^-. Metal complexes with terminal nitrosyl, bridging nitrosyl, terminal as well as bridging nitrosyl; Metal dinitrogen complexes, preparation, bonding, structure, reactions. Metal dioxygen complexes, preparation, bonding, structure of mononuclear and binuclear metal-dioxygen complexes, reactions.

Unit III: Lanthanide and Platinum metals

Lanthanide: Electronic configurations, Occurrence of lanthanides, Separation of lanthanides, Properties of lanthanides at different oxidation states, Magnetic properties of lanthanides, Lanthanide contractions, Reactions, Uses of lanthanide (III) complexes in optical spectroscopy, microscopy and in MRI.

Platinum metals: Platinum group metals, Differentiation in mechanical properties of six platinum metals, Uses of platinum metals, Chemistry of palladium and platinum, Rhodium and iridium; Ruthenium and osmium.

Unit IV: Transition metal based Organometallics

General- Ligands, bonding, haptonumber, synthesis and reactivity; Uses of Organo-transition metal reagents of chromium, cobalt, iron, nickel, rhodium and palladium; sandwich compounds and their reactivity; Synthesis and reactions of cyclopentadienyl metal carbonyls, η^6-arene-chromium tricarbonyl in organic synthesis; Metal carbenes (alkylidene complexes)-Schrock and Fischer carbenes, Tebbe's reagent, oxidative addition-reductive elimination, β-hydride elimination; Olefin metathesis and ring closing metathesis

Palladium catalyzed C–C coupling reactions: The Heek reaction, Suzuki-Miyaura coupling, Sonogashira coupling, Stille coupling, Kumada coupling, Negishi coupling and their catalytic cycles.

List of recommended books

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, and O. K. Medhi, Inorganic Chemistry: Principles of Structure and Reactivity; 4th Edn., Pearson Education (2006).
2. F. A. Cotton, G. Wilkinson, C. A. Murillo, and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn., John Wiley (2007).
3. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements; 2nd Edn., Pergamon Press.
4. R. L. Carlin, Magnetochemistry, Springer Verlag (1986).

5. Ioannis D. Kostas, Transition Metal Catalyzed Cross-Coupling Reactions; Special Issue Published in Catalysts, MDPI, Switzerland.
6. B. C. Roy and S. Das, General and Inorganic Chemistry, Vol-II, NCBA Pub. (2017).
7. S. K. Agarwal and Keemti Lal, Advanced in Inorganic Chemistry, 15th Edition, Pragati Prakashan (2015).
8. S. G. Davies, Organotransition Metal Chemistry: Applications to Organic Synthesis, Pergaman
9. Anil Elias, B. D. Gupta, Basic Organometallic Chemistry, Universities Press; 2nd edition

Paper code: ICH 902C
Paper name: Physical Chemistry – VIII
Credits: 04
Full Marks: 100 (70+30)

Course outcomes

- The objectives of the Chemical Kinetics course are to acquire and consolidate the fundamental concepts of kinetic, stoichiometry and reaction mechanisms as well as homogenous kinetics and heterogeneous catalytic kinetic.
- Developing of general understanding how physical laws govern biological processes.
- Acquire basic knowledge about how physical methods can be applied to understand biological processes.
- Introduces the concept of entropy production - where it comes from and how it can be use
- Introduction of application of group theory in advanced area.

Learning Outcomes

On completion of the course the students will be able to:

1. Learn and understand the chain reactions with their characteristics and thereby derive kinetic rate expressions and explain several consequences.
2. Acquire knowledge and understanding on the oscillatory chemical reactions with examples and explain the cause behind such behaviors along with other characteristics of such reactions.
3. Comprehend the fundamentals of the theories of unimolecular reactions, fast reactions,
4. Gathered the knowledge about protein, nucleic acid and cell membrane.
5. Learn the technique to study the structure & function of proteins and nucleic acids.
6. Construct SALC's and use in calculating π MO's under the Hückel approximations different molecules.
7. Learn and indentify the symmetry elements and operations and hence the point group of an object, construct representations and hence character table of a point group

UNIT – I: Chemical Kinetics II

Collision theory & activated complex theory; ionic reaction, kinetic salt effect; steady state kinetics, kinetic & thermodynamic control of reactions; unimolecular reactions; chain reactions, Basic principles of fast kinetics, Flow and stopped flow techniques, Relaxation methods, Flash photolysis; Chain reactions and chain length; Effect of ionic strength on reaction rate & derivation of Brönsted-Bjerrum equation; Mechanism of specific and general acid-base catalysis.

UNIT –II: Biophysical Chemistry

Structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition. Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP,

synthesis of ATP from ADP. Statistical Mechanics in Chain configuration of macromolecules, statistical distribution end-to-end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem. Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibrium and various types of binding processes in biological systems. Hydrogen ion titration curves. Structure and functions of cell membrane, ion transport through cell membrane, Nerve conduction.

UNIT –III: Irreversible & Non-equilibrium Thermodynamics

Introduction to non-equilibrium thermodynamics: Basic concept of entropy production and uncompensated heat and their relation to various thermodynamic functions, Entropy production in closed and open systems, entropy balance in continuous and discontinuous systems, transformation properties of fluxes and forces, coupled and uncoupled reactions and conditions, relaxation process. Curie-Prigogine principle - statement and proof using one scalar and one vector forces, Onsager theory and reciprocal relations, Onsager's formalism of non-equilibrium thermodynamics for multicomponent diffusion-Fick's law of diffusion, conductivity of electrolyte solutions, Onsager's formalism for transport phenomenon in electrochemical systems.

UNIT –IV: Advance Group Theory

Statement and interpretation of The Great Orthogonality Theorem, proof of important corollaries; construction of character tables, cyclic groups and construction of their character tables, direct product groups, direct product representations, projection operators (without derivations) and vanishing of integrals, invariance of the Hamiltonian operator and eigen functions of Hamiltonian operator (H) as 24 bases of irreducible representations, SALCs and their use in calculating π MOs under the Hückel approximations for some simple systems, outlines of symmetry aspects of molecular spectra.

Recommended books

1. S. C. Rakshit, Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
2. V. Heine, Group Theory in Quantum Mechanics: An Introduction to Its Present Usage, Dove Publication, New York, 1991.
3. D. M. Bishop, Group Theory and Chemistry, Oxford University Press, Oxford, 1993.
4. A. K. Mukherjee and B. C. Ghosh, Group Theory in Chemistry: Bonding and Molecular Spectroscopy, Universities Press (India) Private Ltd., Hyderabad, 2018.
5. A. Vincent, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
6. F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn, John Wiley & Sons, New York.
7. G. W. Castellan, Physical Chemistry, 3rd Edn, Narosa Publishing House, New Delhi, 1995.
8. R. S. Berry, S. A. Rice and J. Ross, Physical Chemistry, Oxford University Press, Oxford, 2000.
9. L. P. Hammett, Physical Organic Chemistry, McGraw-Hill Book Company, New Delhi, 1970.
10. K. J. Laidler, Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 1988.
11. M. R. Wright, Fundamental Chemical Kinetics, Horwood Publishing, 1999.
12. I. Prigogine, Introduction to Thermodynamics of Irreversible Processes, Interscience Publishers.
13. D. A. McQuarrie and J. D. Simon, Molecular Thermodynamics,University Science Books, California.
14. James P. Allen, Biophysical Chemistry, Interscience Publishers, 2003
15. A. Upadhyay, K. Upadhyay and N. Nath, Biophysical Chemistry - Principles and Techniques, International (P) Ltd New Age Publishers, 2004.

16. P S Kalsi,N. Mahanta, Biophysical Chemistry 1st Edn. by New Age International (P) Ltd Publishers, 2017.
17. Jaidev Kumar, Biophysical Chemistry, Publisher: Nation press 2001

Paper code: ICH 903C
Paper name: Organic Chemistry – VIII
Credits: 04
Full Marks: 100 (70+30)

Course outcome:

The course helps the students

- To learn the advanced method of analytical techniques for separation and purification of organic compounds with special emphasis on instrumentation of modern analytical equipments.
- To understand the method of optical microscopy such as optical rotatory dispersion and circular dichroism.
- To know about hetereocycles and heterocyclic compounds of special interests.
- To know the important medicinal use of these heterocycles.
- Steroids and steroidal hormones with representative examples, transformations in steroids and hormones.
- To know about steroidal oral contraceptives.
- To learn about macrocylic compounds

Learning outcome:

At the end of the course the students will be able understand about the

- heterocyclic systems having more than one heteroatoms, their reactivity etc.
- different methods of heterocyclic synthesis of small ring heterocycles
- the modern techniques of separation and purification of organic compounds.
- the basic instrumentation of chromatography devices.
- The students will understand the method of optical microscopy such as optical rotatory dispersion circular dichroism.
- various steroids and steroidial hormones
- Macrocyclic compounds and their importances.

Unit I: Chromatography and optical microscopy

Basic concept of chromatographic separation – adsorption and partition chromatography, theory and handling of different chromatographic techniques – thin-layer chromatography (with different developing agents), column chromatography, and paper chromatography; Gas chromatography (GC): Basic principle, instrumentation, types column and column selection; detectors (FID, TCD, ECD, NPD); sample separation and applications; principle of GC-MS. High performance liquid chromatography (HPLC): Instrumentation - basic equipment; pumping and injection system, column and its packing materials, normal and reverse phases; detectors, sample separation and application; elementary idea of HPTLC, principle of LC-MS. Ion-exchange chromatopraphy, Gel permeable (filtration) chromatography, Size exclusion chromatography, Gel electrophoresis.

Optical microscopy: Chirality, absorption and dispersion of light, Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD); Cotton effect and Cotton effect curve;Spectroscopic Methods for determination of absolute configuration, octant rule for ketones-halo ketone rule.

Unit II: Heterocyclic chemistry

Introduction to heterocyclic compounds, Hantzsch-Widman nomenclature for monocyclic, fused and bridged heterocycles; Basicity and aromaticity of heterocycles;

Non-aromatic heterocycles: Synthesis, properties and reactions (ring openings & heteroatom extrusion) of 3-membered heterocycles (aziridines, oxiranes and thiiranes), 4- membered heterocycles (azetidine, oxetanes and thietanes);

Heterocyclic compounds containing two or more hetero atoms: Synthetic methods and reactivity of azoles (imidazole, pyrazole, oxazole, isoxazole, thiazole, isothiazole and their benzo derivatives) and azines (6- membered heterocycles with two hetero atoms -pyridazines, pyrimidines and pyrazines), benzo-diazines, heterocyclic compounds containing one nitrogen atom and an oxygen or sulphur atom (oxazine, phenoxazine and thiazine derivatives), triazoles, triazines and tetrazines.

Caffeine; theobromine and theophylline.

Unit III: steroids and steroidial hormones

Steroids: Introduction and Nomenclature of steroids, Blanc's rule, Barbier Wieland degradation, Oppenauer oxidation, Diel's hydrocarbon, Chemistry of Cholestrol, Ergosterol, Vitamin-D, Stigmasterol and bile acids.

Steroidal hormones: Chemistry of Oestrone, esterdiol, estriol and their chemicalrelationship. Progesterone, androsterone and testosterone - Structure and Synthesis of Cortisone, Cortisol and Aldosterone; Transformations in steroids and hormones; Steroidal oral contraceptives.

Unit IV: Macrocyclic compounds

Structure, functions and synthesis of some macrocyclic compounds; polyunsaturated macrocyclic compounds and their aromatic character; Sources, synthesis and different strategies adopted in the synthesis of exaltone, civetone and muscone; asymmetric synthesis of R-muscone: chiral auxiliary strategy, ring closing metathesis strategy; macrolactonisation strategy, introduction of macrocyclic lactone based antibiotics: their use and mode of action.

Recommended books

1. R. K. Bansal, Heterocyclic Chemistry, New Age International Private Ltd.
2. J. A. Joule, K. Mills and G. F. Smith, Heterocyclic chemistry, Chapman and Hall.
3. T. L. Gilchrist, Heterocyclic Chemistry, Pearson Education.
4. G. D. Christian, Analytical Chemistry, John Wiley & Sons, New York, 6th Edition (2004).
5. D. C. Harris, Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
6. S. M. Khopkar, Basic Concepts of Analytical Chemistry, New Age International Publisher.
7. R. V. Ditts, Analytical Chemistry, Methods of separation, van Nostrand (1974).
8. G. R. Chatwal Natural Products Chemistry Vol-I & II. (Himalaya) 1990.
9. O. P. Agarwal (Goel), Chemistry of Natural Products – Vol-I & II –1985.
10. I. L. Finar, Organic Chemistry, Vol-I & II- (Longmann ELBS London), 2000.
11. N. R. Krishnaswamy, Chemistry of Natural Products: A Unified Approach- (University Press).
12. Sujata V. Bhat, B. A. Nagasampagi, Meenakshi Sivakumar, Chemistry of Natural Products- (Springer-Narosa) 2005.

Paper code: ICH 904C
Paper name: Organic Chemistry Lab
Credit: 04

Course outcome:

The course enables the students

- To know the separation, purification and identification techniques of the compounds of binary solid mixture.
- To identify organic liquid compounds by distillation followed by systematic qualitative analysis.
- To learn how to accomplish more than one step synthesis or multicomponent reactions by hands on experiment.
- To estimate various organic compounds in solution.

Learning outcome:

- After learning the course, the students will be able to separate the components from binary mixture, can do purification and ultimately identify the components.
- The students will be able to distill the organic liquid compound to find out the boiling point and identify the compound by systematic qualitative analysis.
- The students will be able to do more than one step or multicomponent reactions to synthesized desired product.
- After learning the course, the students will be able to estimate glucose, glycine, formic acid acetic acid and proteins accurately.

List of experiments:

1. Separation, purification and identification of compounds of binary solid mixtures by systematic qualitative analysis using simple separation techniques.
2. Identification of organic liquid compounds by distillation followed by systematic qualitative analysis.
3. Organic preparation involving rearrangement reaction, condensation, nucleophilic substitution, heterocycles synthesis and multicomponent reactions.
4. Organic estimations:
   i) Estimation of glucose; ii) Estimation of glycine; iii) Estimation of formic acid;
   iv) Estimation of acetic acid in vinegar; v) Estimation of proteins by Lowry's method.

Recommended books:

1. V. Arthur, Quantitative Organic Analysis, Pearson.
2. A. I. Vogel, Quantitative Organic Analysis, Part 3, Pearson (2012).
3. N. K. Vishnoi, Advanced Practical Organic Chemistry, Vikas Publishing House Pvt. Ltd.
4. O. P. Agarwal, Advanced Practical Organic Chemistry, Goel Publishing House.
5. F. G. Mann and B C Saunders, Practical Organic Chemistry, Pearson Education(2009)
6. V. K. Ahluwalia and R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).

SEMESTER X

Paper code: ICH 1001C

Paper Name: Chemistry Project-4

Credit: 08

Course outcome:

This course enables the students

- To know about the chemical research,
- To learns about different techniques like monitoring reaction condition, purification and drying of solvents.
- Spectral interpretation and identification of compounds.
- How to handling of sophisticated instruments like IR, TGA, UV.
- An ability to write project report and can present it.

Learning outcome

At the end of the course, the students will be able to

- Analyze the existing problems for which research can provide solutions and select the problem for research
- Know the various chemical publishers, journals and perform literature survey.
- Synthesize new chemical compounds through various methods.
- Characterize the compounds using various analytical and spectroscopical studies

Project topics and process of evaluation

Student will be assigned a topic for the project under the supervision of the guide. The student is expected to complete the major literature on assigned topic and present a tentative research plan to the Department through the guide for approval. The candidate will do the experimental/theoretical work on the approved plan of work and submit the results in the form of a thesis at the end of Semester X. The project will be evaluated as the prescribed norms as decided by the Department.

Paper code: ICH 1002E

(Optional elective, DSE-08)

Paper name: Supramolecular and Nano chemistry

Credit: 04

Total marks: 100 (70+30)

Course outcome:

The course enables the students

- To understand the basic concepts of molecular and supramolecular chemistry.
- To understand the underlying principles of molecular recognition of various receptors like crown ethers, cyclophanes, cyclodextrins etc.
- To familiarize with self-assembly techniques
- To familiarize with molecular scale mechanical devices etc.
- To learn about nano-particles, nano-materials, nano-devices etc.
- Students can get motivation to go for the advanced courses or career related to nanotechnology and nanomedicine.

Learning Outcomes:

- Supramolecular chemistry course provides detailed information about the theories and concepts of supramolecular chemistry.
- Students get to learn about the processing of energy and signals by molecular and supramolecular systems, molecular recognition and molecular scale mechanical devices.
- The students will also get knowledge about the nano-materials that have versatile biomedical applications, development of sensors and devices.
- The students learn about the synthesis, properties, characterization and bio-functionalization of nano-materials.

Unit I (Supramolecular Chemistry-I**):**

Concepts and Languages of supramolecular chemistry - molecular to supramolecular chemistry: Molecules, super molecules; Factors leading to strong binding (non-covalent interactions); Types of supramolecular interactions (Hydrogen bonding, Vander Waal's interaction, π-π-stacking, CH-π, anion-π interaction; molecular receptors – design and principles; supramolecular aggregation, Bottom-up approach and Top-Down Approach for the synthesis of macromolecules.

Supramolecular chemistry in inorganic perspective: Inorganic crystal engineering and design, principle of metal organic framework (MOF) and inorganic-organic hybrid material.

Types of interactions between host and guest molecules; Metal guided self-assembly reactions, molecular knot with double helical complexes, Self-assembly of polynuclear metal complexes;

Thermodynamics of host-guest complexation; Enthalpy and entropy contributions, complexation free energies;

Unit II (Supramolecular Chemistry-II**):**

Molecular recognition – factors involved; Molecular receptors – for alkali metal ions, ammonium ions, anions and neutral molecules; Crown ethers, cryptands, spherands, siderophores and ionophores; Creation of rotaxanes, catenanes and cyclophanes, cyclodextrin and their application in specific recognition processes.; Supramolecular catalysis- Catalysis by Reactive Macrocyclic Cation Receptor Molecules; Application of supramolecular chemistry in catalysis, drug delivery, recognition/sensing and material science; Dendrimers as multi-electron storage devices; Spontaneous mechanical like motions, Allosteric movements, Tweezers and Harpoons, Anatural proton pump, Twisters, Tweezers, Threading-Dethreading movements, Ring switching processes in Rotaxanes and Catenanes.

Uni III (Nano chemistry - I**):**

Background to Nano-science and Technology - Implications for Physics, Chemistry, Biology and Engineering - Classifications of nanostructured materials - nano particles - quantum dots, Nanowires, nano-tubes – ultra – thinfilms – multilayered materials; Typical syntheses of nano particles, oxide nano tubes and fibres, metal nano particles; Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties.

Synthesis of nanoparticle: Bottom-up Synthesis -Top-down Approach: Precipitation, Mechanical Milling, Colloidal routes, Self-assembly, sol-gel, Langmuir-Blodgett (LB) technique, electrochemical methods (cathodic and anodic processes), and ballmilling, lithography.

Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

Characterization of nano particles- X-ray diffraction technique, Scanning Electron Microscopy - environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques, Raman XPS and EDAX

Unit IV (Nano chemistry - II**):**

Properties and applications of nano materials: Electrical, optical, mechanical, chemical and magnetic properties of nanomaterials; Surface Plasmon resonance – Fluorescence Resonance energy transfer (FRET). Carbon Clusters: Synthesis, properties and biomedical applications of Fullerenes, Carbon nanotubes and Graphenes; Quantum Dots, wells and wires (metallic and semiconducting) - Preparation, properties and biomedical applications. Dendrimeric structures and their applications; Bio-functionalisation of nanomaterials - Noncovalent Assembly - Covalent assembly –Biofunctional Nanomaterials - Semiconductor Nanoparticles - Magnetic Nanoparticles Applications of Biofunctional nanomaterials – Optical and Electrochemical Sensing; nanomaterials and drug delivery, Nanomedicine, Nanotechnology for sustainability, Environmental, health, and safety issues

List of recommended books

1. Ariga Katsuhiko and Toyoki Kunitake, Supramolecular Chemistry - Fundamentals and Applications: Advanced Textbook, Springer (2006).
2. Steed Jonathan & Jerry Atwood, Supramolecular Chemistry; 2nd ed, Wiley India Pvt Ltd (2017).
3. Asim Das and Mahua Das, An Introduction to Supramolecular Chemistry, CBS Pub. (2020).
4. Geoffrey A. Ozin, Andre C. Arsenault, and Ludovico Cademartiri, Nanochemistry: A chemical approach to nanomaterials; 2nd Edition, RSC (2008).
5. Geoffrey A. Ozin, Andre C. Arsenault, Ludovico Cademartiri, Geoffrey A. Ozin, And Jean-Marie Lehn, Concepts of Nanochemistry; 1st Edition, Wiley-VCH (2009).

Paper code: ICH 1003E (Optional elective, DSE-09)

Paper name: Medicinal chemistry and Forensic science

Credit: 04

Total marks: 100 (70+30)

Course outcome:

The course will help the students

- To understand the physicochemical properties of drug and its metabolic pathways, adverse effect and therapeutic value of drugs.
- To know the role of enzymes and vitamins in biological action.
- To understand the chemistry of various drugs with respect to their pharmacological activity
- To know about different National and International Investigative Agencies and their working mechanism.
- To know the difference between IPC and CRPC.
- To know about different branches of Forensic and allied Sciences.
- To know about Advanced Forensic Chemistry, Toxicology and its related branches.

Learning outcome:

At the end of course the students will be able-

- To learn the basics of drug design, their structure, activity relationship and mode of action.
- They will also learn the classification of drugs and the different routes for the synthesis of drug molecules.
- The students will also know the concept of antibiotics and their synthesis.
- They will also understand the basic principles of toxicology and explosives.
- They will get to know the basic understanding of criminal justice system in relation to forensic science.
- They will be able to know instrumental technique related to forensic science.

Unit I (Medicinal Chemistry - I)

Introduction, concepts of drugs, classification, analogues and pro-drugs, theories of drug action, assay and metabolism of drugs; agonist, antagonist, Drug design, theory of drug design, structure activity relationship (SAR), Quantitative structure activity relationship (QSAR); prodrugs and soft drugs; ADME; Partition coefficient, dissociation constant, hydrogen bonding, ionization, drug shape, surfaceactivity, complexation, protein binding, molar refractivity, bio-isosterism–stereo chemicalaspects of drug action. drug metabolism pathways, Drug potentiation, drug antagonism and drug resistance; History of the use of natural products as therapeutic agents, medicinal plants, active principle; Medicinal agents belonging to alkaloids, steroids, polypeptides, modified nucleic acid bases,sulphonamide and sulpha drugs, antibacterials - sulpha drugs, substituted sulphonamides,anticonvulsants, anticoagulants, antiamoebic agents, antihelmintic agents, anti-malarialagents, diuretics and cardio vascular agents, , medicinal agents affecting CNS, analgesics,antipyretics, antiseptics and disinfectants, Histamine and anti-histaminic agents;Infectious and non-infectious.

Unit II (Medicinal Chemistry - II)

(i) Synthesis and uses of the following drugs of different pharmacological activities:

a) Antimalerials: Quinine, chloquine, Trimethoprim
b) Analgesic & Antipyretics: Paracetamol, Meperidine, methadone, Aminopyrine.
c) Anti-inflammatory:Aspirin, Ibuprofen, Diclophenac, Indomethacin, coxib
d) Antitubercular and antileprotic: Ethambutol, Isoniazide&Dapsone
e) Anaesthetics: Lidocaine, Thiopental.
f) Antihistamines: Phenobarbital, Diphenylhydramine.
g) Tranquilizers: Diazepam, Trimeprazine
h) Cardiovascular: Synthesis of diltiazem, quinidine, methyldopa, atenolol, oxyprenol

(ii) Antibiotics: Definition, mode of action, semi-synthetic penicillin and its significance, Gram-positive and gram-negetive bacteria, β-lactum antibiotics, conversion of penicillin into cephalosporin, synthesis of chloramphenicol (diastereo-selective and enantio-selective) general account of tetracycline & macrocyclic antibiotics (no synthesis).

Unit III (Basics of Forensic Sciences):

National Investigative Agencies, Research and Analysis Wing, Intelligence Bureau, Narcotic Control Bureau, Bureau of Police Research and Development (BPR&D), Central Bureau of Investigation (CBI), Criminal Investigation Department (CID), National Crime Records Bureau (NCRB), National Institute of forensic Science (NICFS), Federal Bureau of Investigation (FBI), Central Investigation Agency (CIA), IPC and CRPC.

Questioned Document, Handwriting, Characteristics of Handwriting, Forgeries, Currency Note examination (FICN), Instrumentation and Photography of Documents (VSC, UV, IR), Crime Scene Management, Forensic Ballistics, Forensic Biology and Serology, Forensic Criminology, Computer Forensics, Cyber Forensic, Forensic Toxicology, Forensic Pharmacology, Clinical Toxicology, Forensic Genetics and Advanced DNA Forensics.

Unit IV (Forensic Chemical Sciences):

Advanced Forensic Chemistry

Explosives: Definition of Explosives, Definition as per Indian Explosive Acts. History of Explosives, Chemistry of explosives, Deflagration and Detonation phenomenon (Redox Chemistry, KineticsMolecular Theory of gases & Gas Laws), Characteristics of high and low explosives, Dust

explosion, Gas/vapour explosion, BLEVE, Effect of blast wave on structures & human and Pyrotechnics.

Improvised Explosive Device: Definition of IED, Components of IED, Explosives Initiation (Explosive Trains); Types (Molotov cocktail, Letter bomb, Pipe bomb, VBIED and CBRN), Detection of Hidden Explosives.

Analysis of Explosive: Pre-blast and Post blast residue collection, Systematic examination of explosives and explosion residues in the laboratory using chemical and instrumental techniques and interpretation of results.

Bomb Scene: Specific approach to scene of explosion, Reconstruction of sequence of events, Evaluation and assessment of scene of explosion.

Advanced Forensic Toxicology: Classification in Toxicology, Introduction and history of clinical toxicology, Toxidrome, Management of the poisoned or overdosed patient, Laboratory principles, Pharmacokinetics and Toxicokinetics overview, Administration, liberation, and absorption of toxicants, Prevention of absorption from the gastrointestinal tract, Elimination of toxicants, Enhancement of elimination of toxicants, Inorganic poisons (cations and anions), Neutral poison (organic non volatile), Types of Antidotes in poisoning cases, Qualitative Descriptions of Toxicity Exposure Limits Determination of LD50 and ED50.

Recommended books:

1. Kar, Medicinal Chemistry, New Age publication (2020).
2. T. Nogrady and D. F. Weave, Medicinal Chemistry-A Molecular and Biochemical Approach, Oxford University Press.
3. Burger, Medicinal Chemistry and Drug Discovery, Vol-1, Ed. M. E. Wolff, John Wiley (1994).
4. Pandeya and J. R. Dimmock, Introduction to Drug Design, New Age International.(2000).
5. Graham and Patrick, Introduction to Medicinal Chemistry, OUP, 3rd edition (2005).
6. S. K. Ghosh and K. F. Rustomji, Encyclopedia of police in India.
7. R. K. Raghavan, Indian police.
8. S Allem, Women in Indian Police.
9. R Prasher, Police Administration.
10. A. R. Huber and A M Headrick, Handwriting Identification: Facts and Fundamentals CRC LLC (1999).
11. D. Ellen, The scientific examination of Documents, Methods and techniques, Taylor & Francis Ltd., 2nd edition (1997).
12. O. Hilton, The Scientific Examination of Questioned Document, Elsevier North Holland Inc., NY (1982).
13. Kirk Vehicular Accident investigation and reconstruction (2000).
14. M. Jauhri, Monograpnh on Forensic Ballistics, Govt. of India Publication, New Delhi (1980).
15. D. Maio, Gunshot Wounds (1987).
16. Kumar, Forensic Ballistics in Criminal Justice (1987).
17. I. Dunsford and C Bowley, Blood Grouping Techniques, Oliver & Boyd, London (1967).
18. K. E. Boorman, B. E. Dodd and P. J. Lincoln (1988) Blood group serology, Churchill Livingstone Edinburgh, 6th edition.
19. R. Li Forensic Biology, Taylor & Francis Group LLC (2008).

20. M. T. Britz Computer Forensics and Cyber Crime: An Introduction, (2003).
21. R. C. Newman Computer Forensics: Evidence, Collection and Management (2007).
22. J. J. Fenton Toxicology A Case-Oriented Approach (2002).
23. Kirby, DNA Fingerprinting Technology.
24. J. M. Butler Forensic DNA Typing: Biology, Technology, and Genetics of STR Markers Academic Press (2005).
25. J. Yinon, Forensic and Environmental Detection of Explosives.
26. Y Jitrin, Modern Methods & Application in Analysis of Explosives, John Wiley & Sons, England (1993).
27. Casarett and Doll Toxicology The Basic Science of poisons (2003).
28. M. E. Johll Investigating Chemistry: A Forensic Science Perspective (2009).

Paper code: ICH 1004E (optional elective, DSE-10)
Paper name: Advanced Organic Chemistry
Credit: 04
Total marks: 100 (70 + 30)

Course outcome
This course aimed to provide knowledge to the learner to
Understand the advanced organic synthesis using special reagents involving silicon, phosphorous, boron and their applications in organic synthesis. The course also aimed to focus to establish the structure of structure of organic compounds based on their spectral data.
Learning outcome
After completion of the course students will be competent on the learning about

- Special reagents in organic synthesis
- Mechanistic aspects of various name reactions in synthetic organic chemistry.
- The principle and instrumentation of NMR and mass spectroscopy.
- Elucidate the structures of compounds using ^{1}H and ^{13}C NMR and mass spectral data.
- Understand the reaction mechanisms using NMR and mass spectral data.

Unit I (Advanced organic synthesis-I):

Silicon, Phosphorous and Sulful in organic synthesis:
Organosilicon: Synthetic applications of trimethylsilyl chloride dimethyl-t-butylsilyl chloride, trimetthylsilyl cyanide, trimethylsilyl iodide and trimethylsilyl triflate, synthetic applications of silyl carbanion
Phosphorous ylides and related reactions like Witting, stabilized and non-stabilzed ylides, phophonate ad phohonium ylides and their applications; Ylides:
Sulfur: Sulfur stabilized anions, sulfonium salts, Sulfonium ylides, sulfur stabilized cations, sulfoxides

Unit II (Advanced organic synthesis-II):

Boron in organic synthesis: Synthetic applications of organobornaes Organoboranes: Preparation of Organobornaes viz hydroboration with BH3-THF, dicylohexyl borane, disiamyl borane, theryl borane, 9-BBN and disopincamphlyel borne, functional group transformations of Organo boranes-Oxidation, protonolysis and rearrangements. Formation, of carbon-carbon-bonds viz organo boranes carbonylation, the cyanoborate process and reaction of alkenyl boranes and trialkenyl borates.

Unit III (Advanced organic NMR spectroscopy):

^{1}H NMR Spectroscopy - Relaxation phenomenon in NMR, broadening of signals, sample handling and solvent for NMR study, chemical shift, internal standards, NMR characteristics of different NMR solvents, factors affecting the chemical shift, spin-spin coupling, multiplicity of splitting and relative intensity of lines, coupling constant, first order and non-first order splitting, vicinal and geminal coupling, long range coupling – two bond coupling (2J) three bond coupling (3J), Nuclear overhauser effect (NOE), Karplus relationship; Designation of spin systems; Chemically induced dynamic nuclear polarization (CIDNP); terminology of 2D NMR

^{13}C NMR spectroscopy- Principle, multiplicity, proton –decoupling, off-resonance decoupling, noise-decoupling, ^{13}C chemical shifts values, DEPT and APT terminology; introduction to two dimensional NMR spectroscopy

Unit IV (Advanced organic mass spectroscopy):

Mass spectroscopy for organic compounds: Introduction – basic theory, instrumentation and sample handling. Methods of generation of mass ions – electron impact (EI), chemical ionization (CI), electron spray ionization (ESI) and fast atom bombardment (FAB) techniques, TOF-MALDI and SELDI; Tandem mass spectroscopy, general mass fragmentation pattern of organic compounds, base peak, molecular ion, relative intensity, mass ions fragmentation, metastable ions, even electron rule, nitrogen rule, HDI, application of mass spectroscopy.

Structure elucidation of organic compounds using IR, NMR and mass spectral data.

Recommended books

1. R O C Norman and J M Coxon, Principles of organic synthesis, 3rd Edition, CRC Press.
2. F. A. Carey and R. J. Sundberg. Advanced Organic Chemistry. 5thEdn. Plenum. Part – I, Part – II.
3. J. March, Organic Chemistry, Structure, Reactions and Mechanisms, 4thedn, John Willey
4. Michael B. Smith & Jerry March, Advanced Organic Chemistry Reactions, Mechanisms, and Structure. (2013) Wiley-Interscience.
5. T. Laue and A. Plagens, Named OrganicReactions,2nd edition (2005), John Wiley & Sons Ltd**.**
6. Reinhard Bruckner Advanced Organic Chemistry, Reaction Mechanisms (2002). Elsevier
7. T. W. Graham Solomons, Craig B. Fryhle, Scott A. Snyder, Organic Chemistry, John Wiley & Sons Inc.
8. W. Carruthers, *Some Modern Methods of Organic Synthesis,* Cambridge University Press
9. H. O. House, Modern Synthetic Reactions, 3rd Edition (1992), Benjamin Publishing Co.
10. High-Resolution NMR Techniques in Organic Chemistry, Third Edition, 2016, by Timothy D.W. Claridge, Oxford, United Kingdom. Published by Elsevier Ltd.
11. Organic Spectroscopy- Principles and Applications, Jag Mohan, Narosa publishing House.
12. Spectroscopic Methods in Organic Chemistry, By D.H. Williams, I. Fleming. Tata McGraw Hill Pub. Co. Ltd.
13. Organic Spectroscopy, 3rd Edn, By William Kemp. Published by Palgrave, NewYork.

Paper Code: ICH 1005E (optional elective, DSE – 11)
Paper Name: Advanced and Industrial Materials
Credit: 4
Full Marks: 100 (70 + 30)

Course Description

- This course focuses on the fundamental aspects of materials science
- The course discusses the basic structure of solids, classification of materials based on the structure and properties.
- This course introduces students to energy storage systems and provides a broad understanding of such systems.
- Units III and IV imparts basic knowledge of chemistry of inorganic and organic materials such as silicates, non-silicates, ceramics, soap, detergents, perfumes and many other industrially important chemicals.

Learning Out come

- To provide the students with basic knowledge of materials science, so that they would be able to understand and distinguish between variety of materials based on their structure and properties
- Students will get to know the different classes of materials used in engineering applications and would be able to choose the right materials for specific applications
- Students will get to know the scientific principles underpinning the operation of energy storage systems.
- Students will be able to work with a team to apply energy storage knowledge to develop and conduct a project.
- Establish an appreciation of the role of inorganic chemistry in the chemical sciences.
- Gain sound knowledge of industrially important organic and inorganic materials

Unit I: Chemistry of Advanced Materials

Introduction to advanced materials- Definition and classes of materials; Molecular design of materials from the molecule to the material; Basic experimental techniques for the characterization of materials: Chemistry of Engineering Plastics: Preparation, properties and applications of ABS, polycarbonates, epoxy resins – polyamides – Nylon and Kevlar; biodegradable plastics.

Chemistry of Carbon nanotubes: Introduction, carbon nanotubes – fabrication, structure, electrical properties – vibrational properties – mechanical properties – applications of carbon nanotubes; Chemistry of Porous materials- Microporous, mesoporous and macroporous materials; Zeolites and other porous materials; Metal-organic frameworks (MOFs).

Functional electro active polymers: Conjugated polymers – synthesis, processing and doping of conjugated polymers: polyacetylene, polyaniline, polythiophene, poly (p-phenylenevinylene) – ionically conducting polymers – applications of conjugated polymers; Semi-conducting, poly ferrocene – photo resist optical fibers and sensors, photo chromic & thermo chromic materials; High energy materials.

UNIT II: Energy Storage Devices:

Solar Cells: Solar energy, Solar devices, Efficiency of Solar energy conversion, Silicon-based solar devices, chalcogenide thin films-based devices, Sensitized solar devices (dye and QDs), Pervoskite solar devices, Mechanism of Solar energy generations, Characterization of solar devices.

Batteries: Li-ion batteries: Principle of operation, Battery components and design, Electrode materials ($LiCoO_2$, $LiNiO_2$, $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$, $LiMn_2O_4$, $LiFePO_4$, graphitic carbon) their synthesis and characterization, Theoretical capacity, Energy density, power density, cycle life, Electrode and battery fabrication, Battery modules and packs, Li-polymer batteries and applications, Electrolytes for Li-ion batteries, All solid state batteries. Future developments and beyond lithium batteries: Li-S battery, Li-Air battery, advanced lead-acid batteries, Sodium battery, Magnesium battery, Aluminum battery, Silicon battery, Battery, Recycling Technologies.

Unit III: Industrial chemicals I

Glass and Ceramics - Physical and chemical properties of glasses, Raw materials, Soda glass, borosilicate glass, Lead Glass manufacturing of special glasses, Colored Glass, glass formers and glass modifiers and applications.; Ceramics and their properties, raw materials, manufacturing of ceramics, Applications of colours to pottery, use of ceramics; Composites and Nonmaterial's; Ceramic structures, mechanical properties, clay products, clay pots, Zeolites.

Fertilizer: General Principles of plant Nutrition:Essential plant nutrients, functions of the essential elements, classification of commercial nitrogenous fertilizers. manufacturing of ammonium sulphate, Urea, Ammonia nitrate; Commercial phosphatic fertilizers. Manufacturing process and properties of phosphatic fertilizers, single super phosphate, triple superphosphate.

manufacturing process and properties of potasium fertilizer, muriate of potassium, potassium sulphate, mixed fertilizer; Nanofertilizers: Nanourea and mixed fertilizers, Nanofertigation - Nanopesticides, Nanoseed Science, organic manures, micronutrients,biopestiside, biofertilizers and agrochemicals. Present status of fertilizer Industries in India.

Special materials for electronic Industry- Preparation of High purity Silicon, Germanium, Gallium Arsenide (GaAs) Indium phosphide(InP) etc. using Zone refining, Crystal growth and their use in electronic industry.

High Tc Materials: Defect perovskites, high Tc superconductivity in cuprates, preparation and normal state properties; anisotropy; temperature dependence of electrical resistance; optical phonon modes, superconducting state; heat capacity; coherence length, elastic constants, position lifetimes, microwave absorption–pairing and multigap structure in high Tc materials, applications of high Tc materials.

Unit – IV: Industrial Chemical II

Food preservatives and additives- Classification, chemical composition and nutritional value of common food stuffs, properties of foods, food preservation and processing, food deterioration, methods of preservation and processing by heat, cold, chill storage, deep freezing, drying, concentration, fermentation, and radiation; Permitted food additives and their role; antioxidants, coluring agents, sweetners and dyes as food additives.

Dairy Chemistry: Milk and milk products, composition and structure of milk, milk proteins,

enzymes, vitamins, minerals, density and viscosity of milk, effect of heat on milk, milk processing, basic milk categories, butter, ghee and clarified butter.

Cosmetics and Perfumes

A general study including preparation and uses of the following: Hair dye, hair spray, Shampoo, Suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Water: Special consideration for cosmetics use. Surfactants: Classification and application in cosmetics – Foaming agents, emulsifiers, and solubilizers.

Soap and Detergents

Soap manufacture: raw materials, characteristics of cold process, semi boiled process and boiled process, additives of soap, detergent action of soap, influence of fatty acid composition of the oil on properties of soap, manufacture of soap for different purposes- laundry soaps, toilet soaps, liquid soaps, transparent soaps, baby soaps, shaving soaps, medicated soaps, textile soaps, naphtha soaps, marine soaps; total fatty mater (TFM) value of soaps, cleansing action and composition of shaving creams.

Shampoos: Ingredients and functions, different kinds of shampoos, Anti-dandruff, antilice, herbal and baby shampoos. Health effects of shampoos.

Synthetic Detergents - Detailed study of the chemistry and applications of anionic, cationic, amphoteric and nonionic detergents used in modern industries and for household purposes. Dish washes, neutral soaps, manufacture and applications; Merits and demerits of syndets over soaps, biodegradability of detergents, green detergents and compact detergents.

Recommended books:

1. Van Vlack, H. Lawrence, Elements of Material Science and Engineering, 6th edition, New York Addison, Wesley, (1989).
2. S. Chawla, A Textbook of Engineering Chemistry, Dhanpat Rai and Co, Delhi, (2001).
3. L. V. Interrante and M. J. Hampden Smith, Chemistry of Advanced Materials, Wiley-VCH, (1988)
4. R. Korthauer, Lithium ion Batteries: Basics and Applications, Springer
5. Yuping Wu, Lithium ion Batteries: Fundamentals and applications, CRC Press, Taylor & Francis
6. K. Ozawa, Lithium ion batteries: Materials, Technology and new applications, Wiley
7. M. Li et al., 30 Years of Lithium-Ion Batteries, Advanced Materials, Vol 30, issue 33, 2018, 1800561.
8. B. K. Sharma, Engineering chemistry, Krishna Prakashan Media.
9. Basudeb Karmakar Functional Glasses and Glass-Ceramics - Processing, Properties and Applications, 2017
10. D. Swern, Bailey's Industrial Oil and Fat Products, Vol. I and II, 4th Edn., John Wiley, 1982.
11. T. H. Applewhite, Bailey's Industrial Oil and Fat Products, Vol. III, 4th Edn., John Wiley, 1985
12. E. S. Pattison, Fatty acids and their Industrial Applications, Marcel Dekker, 1968.
13. A. J. C. Andersen, Refining for Oils and Fats for Edible Purposes, Pergamon Press, 1962.
14. M. Ash, I. Ash, Formulary of Detergents and Other Cleaning Agents, Chemical Publishing, 1999.

Paper Code ICH 1006E (optional Elective, DSE-12)

Paper Name: Chemistry and Society

Credit: 04

Course outcome:

On completion of this course, the students will be able to learn:

- Develop understanding of various branches of science during different eras in different parts of the world
- Analyze the role played by the science in different eras in the evolution of modern day science
- Ethics in science outcomes
- About history and evolution of the major disciplines of science.
- About history of ancient Indian mathematics.
- Comprehend about legacy of ancient Indian scientific discoveries.
- About green chemistry and sustainability, sustainable chemistry technologies and alternate energy sources. Learning Outcome

Learning outcome:

After completion of the course students will be able to

- Acquaint about History and Philosophy of Science as a need of Modern Science.
- Gathered the Knowledge about Construction of materials in the ancient times.
- Acquire key scientific ideas that developed from Aristotle to Newton.
- Acquire ability to recognize the importance of environmental changes and understand various aspects of air, soil and water.
- Earn ability to apply recycling vis-à-vis resource recovery technologies for useful conversion of specific waste type to eco-friendly products.
- Gathered the Knowledge to critically examine development actions with the fundamentals understanding sustainable development.
- Gathered knowledge to demonstrate understanding of the global, regional and local initiatives for energy conservation and sustainable development.
- Ability to apply critical mind in policy and approach aimed at resolving environmental issue, which, often, are with social aspects.
- Earn ability to critically appreciate national and international laws and policies connected with India.

UNIT-I: History and Philosophy of Science-I

Why History of Science? History and evolution of the major disciplines of science, which include the basic sciences, bioscience, natural sciences and medical science, with special emphasis on the Indian perspective; Astronomy in the ancient world - people, theory and instruments; Astronomy across civilizations of the old world, main discoveries, their contribution and instruments during those times. The Dark ages in Europe - the Arabian influence - The Islamic science, translations and original contributions of Arabians, dark ages Europe, logic, literature and scientific method, early universities of Europe; The ethical and moral issues related to social values, along with the controversies that arise in relation to the discourse of science from the philosophical perspectives.

The Copernican revolution and the rise of modern science - The background of Copernican revolution, interaction between civilizations, the rise of modern sciences - when and why?
The key scientific ideas that developed from Aristotle to Newton;
The Greek legacy: Eratosthenes, Pre-Socratic period: the Pythagoreans school; Classic period: Plato and Aristotle; Astronomy and Mathematics in the Hellenistic period: Ptolemy, Eratosthenes, Hipparchus, Euclid, Archimedes.
The scientific revolution at renaissance- Copernicus, Galileo, Kepler, Newton: motion in the solar system; Separation between science and religion; Technology major inventions- printing technics, navigation instrument:
The significant and overwhelming influence of history and scientific philosophy on present day civilization; The journey of development of sciences, the colonial influences on science

UNIT-II: History and Philosophy of Science-II

Introduction, Logic and methodology of Indian sciences; An overview of Indian contributions to sciences; An overview of Indian contributions to technology;
Elements of Indian Astronomy and Mathematics and their influence on Europe: Prehistory: the Vedic period, discoveries in mathematics, astronomy and medicine; Middle age, Late middle age: science technology transfer with Europe.
Astronomy- Development of astronomy in India; Pancanga: Indian calendrical computations; The distinct features of Indian planetary models; Computation of eclipses: Its simplicity, elegance and efficiency; Observational astronomy in India
Mathematics- An overview of the development of mathematics in India; Mathematics contained in Sulbasutras; history of ancient Indian mathematics; Combinatorial aspects of the Chandassastra; Solutions to the first and second order indeterminate equations; Weaving mathematics into beautiful poetry: Bhaskaracarya; The evolution of sine function in India; The discovery of calculus by Kerala astronomers
Ayurveda-History of Ayurveda; Rational foundations of Ayurveda; Textual sources in Ayurveda; Ayurveda and allied disciplines; Approach to health and disease in Ayurveda; Approach to diet and nutrition in Ayurveda; Ayurveda and modern medicine; Ayurveda and Yoga
Technological development in India: Agriculture- Origin and development; Ancient crops; Traditional practices; Water management in ancient time.

UNIT-III: Sustainable Chemical and Environmental Science-I

State of Environment and Unsustainability, concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; Traditional conservation systems in India, Overview of International Treaties and Conventions, Overview of Legal and Regulatory Frameworks. Impacts, causes, effects, control measures, international, legal and regulatory frameworks of: Climate Change, Ozone depletion, Air pollution, Water pollution, Noise pollution, Soil / land degradation / pollution.

UNIT-IV: Sustainable Chemical and Environmental Science-II

Environmental impacts of non-renewable energy consumption; future energy options and challenges. solar cells, JNN solar mission; benefits of hydropower development; nuclear fission reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme. Ethical issues related to resource consumption, Intergenerational ethics, Need for investigation and resolution of the root cause of unsustainability, Traditional value systems of India, Significance of holistic value-based education for true sustainability.

Recommended books:

1. O. S, Owen, D. D, Chiras, and J. P. Reganold, Natural Resource Conservation – Management for Sustainable Future (7th edition). Prentice Hall (1998).
2. J. R. Craig, D. J. Vaughan and B. J. Skinner. Resources of the Earth: Origin, Use, and Environmental Impacts (2nd edition). Prentice Hall, New Jersey (1996).
3. A. M. Freeman, Measures of value and Resources: Resources for the Future, Washington DC. (2001).
4. A. M. Freeman, Millennium Ecosystem Assessment: Conceptual Framework. Island Press. (2003).
5. D. S. Ginley, & D. Cahen, Fundamentals of Materials for Energy and Environmental Sustainability, Cambridge University Press. (2011).
6. G. A. Klee, Conservation of Natural Resources. Prentice Hall Publication, Miller, T. G. 2012. Environmental Science, Wadsworth Publishing Co. (1991).
7. F. Ramade, Ecology of Natural Resources, John Wiley & Sons Ltd., (1984).
8. G. N. Tiwari and M. K. Ghosal, Renewable Energy Resources: Basic Principles and Application. Narosa Publishing House, (2005).
9. Nandan Bhattacharya, The History and Philosophy of Science, An Indian Perspective, Taylor & Francis Books, (2020).
10. A. Reader, The History and Philosophy of Science, Bloomsbury Publishing, (2018).
11. S. J. Reynolds, Philosophy, Science, and History: A Guide and Reader. New York: Routledge publishers, (2014).
12. Edwin Arthur Burtt, The Metaphysical Foundations of Modern Science, Doubleday Anchor Books, (2001).
13. Mansoor Niaz, Chemistry Education and Contributions from History and Philosophy of Science, Springer Link, (2016).