

**DEBRA THANA SAHID KSHUDIRAM
SMRITI MAHAVIDYALAYA
(AUTONOMUS)**

**Gangaram Chak, Chak Shyampur, Debra, West
Bengal**



***SYLLABUS
OF***

**BACHELOR OF SCIENCE WITH
CHEMISTRY(MULTIDISCIPLINARY STUDIES)**

**3 -YEAR UNDERGRADUATE PROGRAMME
(w.e.f. Academic Year 2024-2025)**

Based on

**Curriculum & Credit Framework for Undergraduate
Programmes (CCFUP), 2023 & NEP, 2020**

3 -YEAR UNDERGRADUATE PROGRAMME (w.e.f. Academic Year 2024-2025)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks			
								CA	ESE	TOTAL	
B.Sc. in Life Sc. / Physical Sc. with Chemistry	2 nd	III	SEMESTER-III								
			Major-A2	CHEM/3/MJ-C3	T: Physical Chemistry-I; P: Practical (To be studied by students taken Chemistry as Discipline- A)	4	3-0-1	15	60	75	
			Major-A3	CHEM/3/MJ-C4	T: Organic Chemistry-II; P: Practical (To be studied by students taken Chemistry as Discipline- A)	4	3-0-1	15	60	75	
			SEC	SEC03	To be taken from SEC-03 of Discipline C.	3	0-0-3	10	40	50	
			AEC	AEC03	Communicative English-2 (common for all programmes)	2	2-0-0	10	40	50	
			MDC	MDC03	Multidisciplinary Course-3 (to be chosen from the list)	3	3-0-0	10	40	50	
			Minor-3 (Disc.-C3)	CHEM/3/MI-C3	T: Inorganic Chemistry &Organic Chemistry; P: Practical (To be studied by students taken Chemistry as Discipline- C)	4	3-0-1	15	60	75	
		Semester-III Total					20				375
		IV	SEMESTER-IV								
			Major-B2	CHEM/3/MJ-C3	T: Physical Chemistry-I; P: Practical (Same as MajorA2 for Chemistry taken as Discipline-B)	4	3-0-1	15	60	75	
			Major-B3	CHEM/3/MJ-C4	T: Organic Chemistry-II; P: Practical (Same as Major–A3 for Chemistry taken as Discipline-B)	4	3-0-1	15	60	75	
			Major (Elective) -1	CHEM/3/MJ-E1	Green Chemistry and Quantum Mechanics-II, Photochemistry, Chemistry of s & p Block Elements etc. (To be studied by students taken Chemistry as Discipline- A)	4	3-0-1	15	60	75	
			AEC	AEC04	MIL-2 (common for all programmes)	2	2-0-0	10	40	50	
			Minor -4 (Disc.-C4)	CEMMIN04	T: Physical Chemistry –& Inorganic Chemistry; P: Practical (To be studied by students taken Chemistry as Discipline- C)	4	3-0-1	15	60	75	
			Summer Intern.	IA	Internship / Apprenticeship- activities to be decided by the Colleges following the guidelines to be given later	4	0-0-4	-	-	50	
		Semester-IV Total					22				400
		TOTAL of YEAR-2					42	-	-	-	775

Semester-III(General major)

Theory

PHYSICAL CHEMISTRY-I

Paper Code: CHEM/3/MJ-A2T

- **A. Fitness training for physical chemistry (5 Lectures)**

(I) Units and Dimensions: Physical quantity, Units and unit systems, Symbols, Basic and Derived units, SI units, Dimensions, Principle of homogeneity of dimensions, Atomic Units. (Examples should be taken from various chapters of Physical Chemistry)

(II) Plots of Simple Functions: linear plots; its slopes and intercepts, choice of proper scale, Plots of polynomial, exponential and trigonometric functions and their combinations. Plots of inverse and hyperbolic functions. . (Examples should be taken from various chapters of Physical Chemistry).

- **B. Chemical kinetics: part-1 (12 Lectures)**

(I) Introduction, stoichiometric coefficient, Extent or advancement of reaction, Rate of a reaction in terms of advancement of reaction, Law of mass action, Differential rate law, rate constant and its unit, order and molecularity:

(II) Integrated rate laws for simple reactions involving only one reactant: zero, half, one, two, three and n-th order reactions, Half life time, time of completion, average life time. Integrated rate laws involving more than one reactants: 2nd and third order. Pseudo first order reactions.

(III) Determination of order of a reaction: method of differential rate law, n_t and n_c , method of integrated rate law, method of half-life time, method of isolation.

(IV) Complex reactions: Opposing reactions, Equilibrium Constant; Consecutive reactions, slowest step is the rate determining step. Parallel reactions KCP and TCP

(V) Temperature dependence of rate constant; Arrhenius equation, energy of activation.

(VI) Rate-determining step and steady-state approximation – explanation with suitable examples. Arrhenius Complex and van't Hoff complex.

(VII) Homogeneous catalysis: with reference to acid-base catalysis.

- **C. Thermodynamics: part-1 (first law of thermodynamics & Thermochemistry) (14 Lectures)**

(I) Mathematics for Thermodynamics: Derivatives, Partial derivatives, State functions and Path functions, Exact and Inexact differentials, Cyclic rule, Chain rule, Legendre transformations, Homogeneous functions, Extremization problems.

(II) Introduction, Some basic concepts; System; isolated, closed and open; Thermodynamic system. Surroundings, Universe, Boundaries and its classifications, Properties of a system: Extensive and Intensive; State property and path property, Different types of processes: reversible and irreversible processes, Isothermal and adiabatic processes. Thermodynamic state, Equation of states, Steady state and Equilibrium state. Thermal equilibrium, Zeroth law of Thermodynamics and its applications. Definition of temperature.

(III) Concept of heat and work: Work in various processes (reversible, irreversible, isothermal, adiabatic), indicator diagrams,

(IV) Joule's experiments, Concept of internal energy (U), First law of thermodynamics; its various statements.

(V) Joule-Thomson experiment; concept of enthalpy (H); J-T coefficient, Inversion

temperature, Expressions of J-T coefficient and inversion temperature for VDW gas. Cooling and heating due to JT expansion.

(VI) Heat capacity relations. General relations, relations for ideal and VDW gas.

(VII) Adiabatic Changes of states: relations among various state properties of ideal and VDW gas for adiabatic reversible process, Expressions of work, adiabatic cooling, its difference from the JT cooling.

(VIII) Thermochemistry: Basic laws of thermochemistry, Standard states; Temperature dependence of enthalpy of a reaction: Kirchhoff's equation. Enthalpy of reactions for various processes; enthalpy of formation, enthalpy of combustion, lattice enthalpy and the Born-Haber cycle, enthalpy of neutralizations, bond dissociation enthalpy and the average bond enthalpy, resonance enthalpy, enthalpy of solution and dilution, adiabatic flame temperature.

- **D. Quantum mechanics: part-1 (historical developments and old Quantum theory) (14 Lectures)**

(I) A brief introduction to Quantum Mechanics

(II) Black body radiation: experimental observations, important features, Stefan Boltzmann law, Wien's distribution formula and the Wien's displacement law, Rayleigh-Jeans formula, Planck's hypothesis and the theoretical explanations BB energy distribution.

(III) Particle aspect of light: Photoelectric effect: Experimental observations and Einstein's explanation; Compton effect; Experimental observations and Compton's explanations.

(IV) Wave aspects of particle: de Broglie's wave particle duality

(V) Heisenberg Uncertainty Principle: Position-Momentum Uncertainty principle, Statements and qualitative explanations from the dual nature of light and particle. Various consequences of HUP. Energy-time uncertainty principle.

(VI) Old quantum theory: Bohr, Wilson and Sommerfeld quantization rule and their applications to PIAB, LSHO, RR and H-atom problems.

Reference Books:

7. Chemical Kinetics, K. J. Laidler, Pearson Education India.

8. Quantum Mechanics, J. L. Powel and B. Crasemann, Dover Publications Inc., UK.

9. Quantum Chemistry, I. N. Levine, Pearson Education India.

10. Mathematics for Physical Chemistry, D. A. McQuarrie, Univ Science Books.

11. Heat & Thermodynamics, M. W. Zemansky & R. H. Dittman, The McGraw-Hill Companies Inc., New York.

MJA2P: PHYSICAL CHEMISTRY LAB- I

Paper Code: CHEM/3/MI-A2P

1. Calibration of various apparatus such as burette, pipette, volumetric flask, measuring cylinder etc.

2. Concepts of molecular weight, equivalent weight, various concentration terms, primary and secondary standard solutions and their preparations with proper explanations of types of apparatus to be used to prepare these solutions.

1. Prepare the following solutions

(i) Primary standard oxalic acid solution by accurate weighing

(ii) Primary standard potassium dichromate solutions by accurate weighing

- (iii) Secondary standard sodium hydroxide solutions by approximate weighing
- (iv) Secondary standard sodium thio-sulphate solutions by approximate weighing
- (v) Secondary standard potassium permanganate solution by approximate weighing
- (vi) Secondary standard sulphuric acid, hydrochloric acid and acetic acid solutions of various strength from the supplied concentrated solutions.
- 3. Study of kinetics of acid-catalyzed hydrolysis of an ester
- 4. Study of kinetics of decomposition of H₂O₂
- 5. Determination of specific rotation of cane sugar using polarimeter
- 6. Study the kinetics of inversion of cane sugar using polarimeter.

Reference Books:

- 5. Practical Physical Chemistry – A.M. James, F.F. Prichard
- 6. Findlay's Practical Physical Chemistry – B.P. Levitt
- 7. Experimental Physical Chemistry – Shoemaker and Ga
- 8. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)

MJ-4: ORGANIC CHEMISTRY-I

Paper Code: CHEM/3/MJ-A3T

- **Stereochemistry II (8 Lectures)**

Conformation: conformational nomenclature: eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; P/M descriptors; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, n-butane, 2-methylbutane and 2,3 dimethylbutane; haloalkane, 1,2-dihaloalkanes and 1,2-diols (up to four carbons); 1,2-halohydrin; conformation of conjugated systems (s-cis and s-trans).

- **General Treatment of Reaction Mechanism II (13 Lectures)**

Reaction thermodynamics: free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions.

Concept of organic acids and bases: effect of structure, substituent and solvent on acidity and basicity; proton sponge; gas-phase acidity and basicity; comparison between nucleophilicity and basicity; HSAB principle; application of thermodynamic principles in acid-base equilibria.

Tautomerism: prototropy (keto-enol, nitro-aci-nitro, nitroso-oximino, diazo-amino and enamineimine systems); valence tautomerism and ring-chain tautomerism; composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism; application of thermodynamic principles in tautomeric equilibria.

Reaction kinetics: rate constant and free energy of activation; concept of order and molecularity; free energy profiles for one-step, two-step and three-step reactions; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and secondary kinetic isotopic effect (k_H /k_D); principle of microscopic reversibility; Hammond's postulate.

- **Substitution and Elimination Reactions (12 Lectures)**

Free-radical substitution reaction: halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate. Nucleophilic substitution reactions: substitution at sp³ centre: mechanisms

(with evidence) relative rates and stereochemical features: SN1, SN2, SN2', SN1' (allylic rearrangement) and SNi; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP; role of crown ethers and phase transfer catalysts; [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides].

Elimination reactions: E1, E2, E1cB and Ei (pyrolytic syn eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination; importance of Bredt's rule relating to the formation of C=C.

- **Chemistry of Alkenes and Alkynes (12 Lectures)**

Addition to C=C: mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenations, iodolactonisation, hydrohalogenation, hydration: oxymercuration-demercuration, hydroboration-oxidation, epoxidation, syn and anti-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; electrophilic addition to diene (conjugated dienes and allene); radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; Birch reduction of benzenoid aromatics; interconversion of E- and Z-alkenes; contra- thermodynamic isomerization of internal alkenes.

Addition to C≡C (in comparison to C=C): mechanism, reactivity, regioselectivity (Markownikoff and anti-Markownikoff addition) and stereoselectivity; reactions: hydrogenation, halogenations, hydrohalogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity; interconversion of terminal and non-terminal alkynes.

Reference Books

1. Clayden, J., Greeves, N., Warren, S. *Organic Chemistry, Second edition*, Oxford University Press 2012.
2. Sykes, P. *A guidebook to Mechanism in Organic Chemistry*, Pearson Education, 2003.
3. Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Limited.
4. Carey, F. A. & Guiliano, R. M. *Organic Chemistry, Eighth edition*, McGraw Hill Education, 2012.
5. Loudon, G. M. *Organic Chemistry, Fourth edition*, Oxford University Press, 2008.
6. Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
7. Nasipuri, D. *Stereochemistry of Organic Compounds*, Wiley Eastern Limited.
8. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. *Organic Chemistry (Volume 1)* Pearson Education.
10. Graham Solomons, T.W., Fryhle, C. B. *Organic Chemistry*, John Wiley & Sons, Inc.

MJ4P: ORGANIC CHEMISTRY-I

Paper Code: CHEM/3/MJ-A3P

Experiment: Qualitative Analysis of Single Solid Organic Compounds

- a) Detection of special elements (N, S, Cl, Br) by Lassaigne's test
- b) Solubility and classification (solvents: H₂O, 5% HCl, 5% NaOH and 5% NaHCO₃)
- c) Detection of the following functional groups by systematic chemical tests: aromatic amino (-NH₂), aromatic nitro (-NO₂), amido (-CONH₂, including imide), phenolic -OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O).
- d) Melting point of the given compound

[Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups of unknown (at least six) organic compounds].

Reference Books

1. Vogel, A. I. *Elementary Practical Organic Chemistry, Part 1: Small scale Preparations*, CBS, Publishers and Distributors.
2. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N. University of Calcutta, 2003.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009).
4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry*, 5th Ed. Pearson (2012).
5. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis*, University Press (2000).
6. *Practical Workbook Chemistry (Honours)*, UGBS, Chemistry, University of Calcutta, 2015.

Paper Code: CHEM/3/MJ-SE3

Same as 4yr major

Semester-IV

Paper – B2 and B3 Same as semester III (A2 and A3)

Green Chemistry

- **Introduction to Green Chemistry (3 Lectures)**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

- **Principles of Green Chemistry and Designing a Chemical synthesis (20 Lectures)**

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

- a. Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- b. Prevention/ minimization of hazardous/ toxic products reducing toxicity. Risk = (function) hazard $\times$ exposure; waste or pollution prevention hierarchy.
- c. Green solvents – supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solvent less processes, immobilized solvents and how to compare greenness of solvents.
- d. Energy requirements for reactions – alternative sources of energy: use of microwaves and ultrasonic energy.
- e. Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups.
- f. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- g. Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route to carbaryl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.
- h. Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

- **Green Synthesis/ Reactions and some real world cases: (22 Lectures)**

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)

2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to iodine)
4. Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.
5. Designing of Environmentally safe marine antifoulant.
6. Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.
7. An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
8. Healthier fats and oil by Green Chemistry: Enzymatic interesterification for production of no Trans-Fats and Oils
9. Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

Suggested Readings:

1. Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
5. Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

Practical

Major Elective: Green Chemistry Lab

1. Using renewable resources
 - Preparation of biodiesel from vegetable/ waste cooking oil.
2. Avoiding waste

- Principle of atom economy.
- Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
- Preparation of propene by two methods can be studied

(I) Triethylamine ion + OH⁻ → propene + trimethylpropene + water

(II) 1-propanol H₂SO₄/Δ propane + water

- Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

1. Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

Suggested Readings:

1. Anastas, P.T. & Warner, J.C. *Green Chemistry: Theory and Practice*, Oxford University Press (1998).
2. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
3. Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
4. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore C ISBN 978-93- 81141-55-7 (2013).
5. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).

OR

Major Elective (MJE)-1T:

Quantum Mechanics-II, Photochemistry, Chemistry of s & p Block Elements, Polynuclear Hydrocarbons and Application of Spectroscopy to Simple Organic Molecules.

Major Elective

Course contents:

- **Quantum mechanics-ii:** Postulates of Quantum Mechanics: **(14 Lectures)**

Postulate-1 of Quantum mechanics: Genesis of Schrodinger equation, Time independent Schrodinger equation and its nature, Wave function, Born's probabilistic interpretation of wave function, acceptability criteria of wave function, Normalized wave functions and normalization procedure, Orthogonal and orthonormal set of wave functions, Degeneracy of wave functions, Postulate-2 of Quantum Mechanics: Classical observable, concepts of operators, Linear operators, Systematic approach to construct quantum mechanical operator for a classical observable, Various examples. Postulate-3 of Quantum Mechanics: Eigen value equations, Commutation relations and their physical significance. Important theorems regarding commutations and simultaneous eigen functions. Postulate-4 of Quantum Mechanics: Average values of a classical observable in a quantum state, Representation of quantum mechanics, Hermitian

operator; definition properties and examples, Theorems of Hermitian operators, Postulate-5 of Quantum Mechanics: Time dependent Schrodinger equation, Concept of stationary states, Ehrenfest equation of states.

- **B. Photochemistry: (8 Lectures)**

Basic laws of photochemistry, Quantum yield, Lambert-Beer's law: Lambert-Beer's law and its limitations, Absorbance, transmittance and molar extinction coefficient, calibration curve. Photophysical Processes: Fluorescence, phosphorescence, internal conversion and intersystem crossing, Jablonskii diagram, photostationary state or photochemical equilibrium, photosensitized reaction.

- **C. Chemistry of s and p block elements: (10 Lectures)**

Group trends in electronic configuration, common oxidation states, inert pair effect, diagonal relationship, Oxo/Peroxo acids of P, S and Cl. Study of the following compounds with emphasis on: preparation, structure & bonding, properties and uses: Li_2O , Na_2O_2 and KO_2 , boric acid, borax, sodium perborate, boron nitrides, borazines, borohydrides (diborane), carbides (covalent and ionic type), diamond, graphite, silicones, phosphazenes, sulphur-nitrogen binary compounds, interhalogen compounds, polyhalide ions, pseudohalogens, Chlorofluorocarbons (CFCs). Separation of Noble gases, Clathrates; Structure and properties of XeF_2 , XeF_4 , XeF_6 .

- **D. Polynuclear Hydrocarbons and Application of Spectroscopy to Simple Organic Molecules: (13 Lectures)**

Polynuclear Hydrocarbons: Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene.

Application of Spectroscopy to Simple Organic Molecules:

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions, λ_{max} & ϵ_{max} , chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λ_{max} of conjugated dienes and α,β -unsaturated Compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on $>\text{C}=\text{O}$ stretching absorptions).

Suggested Readings:

1. James E. Huheey, Ellen Keiter & Richard Keiter: *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Publication.
2. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
3. G.L. Miessler & Donald A. Tarr: *Inorganic Chemistry*, Pearson Publication.
4. J.D. Lee: *A New Concise Inorganic Chemistry*, E.L.B.S.
5. F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley & Sons.
6. I.L. Finar: *Organic Chemistry (Vol. I & II)*, E.L.B.S.
7. John R. Dyer: *Applications of Absorption Spectroscopy of Organic Compounds*,
8. Prentice Hall.

Major Elective (MJE)-01P:

Practical

Section A: Inorganic Chemistry

1. Verification of Beers law and determination of molar extinction coefficient and concentration of a color absorbing species ($K_2Cr_2O_7$ and $KMnO_4$ solutions) using a colorimeter or spectrophotometer.
2. Determination of pK_{In} of Bromocresol green indicator and the determination of pH of an unknown buffer spectrophotometrically
3. Study of $K_2S_2O_8$ – KI kinetics and determination of rate constant spectrophotometrically.

Section B: Inorganic Chemistry

1. Estimation of Ni(II) using dimethylglyoxime (DMG)
2. Paper chromatographic separation of (a) Ni(II) and Co(II) (b) Fe(III) and Al(III) (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Suggested Readings:

1. A.I. Vogel: *Qualitative Inorganic Analysis*, Prentice Hall, 7th Edn.
2. A.I. Vogel: *Quantitative Chemical Analysis*, Prentice Hall, 6th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
5. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
6. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).

Semester-III (General minor)

Paper Code: CHEM/3/MI-C3T

Inorganic Chemistry– Chemical Periodicity, Chemical Bonding and Molecular Structure

- **Chemical Periodicity: (8 Lectures)**

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d and f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

- **Chemical Bonding and Molecular Structure. (16 Lectures)**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and

polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding:

VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing): H₂, B₂, C₂, N₂, O₂, F₂. MO diagram of CO and explanation of its ligating behaviour based on MO approach. Comparison of VB and MO approaches.

Organic Chemistry- Aromatic Hydrocarbon, Organometallic Compounds

- **Aromatic Hydrocarbon (12 Lectures)**

Benzene: Preparation: from phenol, by decarboxylation, from acetylene, from Benzene sulphonic acid. Reactions: electrophilic substitution (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination), sulphonation and Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene); side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

- **Organometallic Compounds (9 Lectures)**

Introduction; Grignard reagents: Preparations (from alkyl and aryl halide); concept of umpolung; Reformatsky reaction.

Aryl Halides Preparation: (chloro-, bromo- and iodobenzene): from phenol, Sandmeyer reactions. Reactions(Chlorobenzene): nucleophilic aromatic substitution (replacement by -OH group) and effect of nitro substituent (activated nucleophilic substitution).

Reference Book:

1. Lee, J. D. *Concise Inorganic Chemistry ELBS*, 1991.
2. Cotton, F. A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B. E., McDaniel, D. H. & Alexander, J. J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Huheey, J. E., Keiter, E. A., Keiter, R. L. & Medhi, O. K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India.
3. Sethi, A. *Conceptual Organic Chemistry*; New Age International Publisher.
4. Parmar, V. S. *A Text Book of Organic Chemistry*, S. Chand & Sons.
5. Madan, R. L. *Organic Chemistry*, S. Chand & Sons.
6. Wade, L. G., Singh, M. S., *Organic Chemistry*.
7. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).

MI-3P Practical

Paper Code: CHEM/3/MI-C3P

Inorganic Chemistry Laboratory

1. Estimation of Fe(II).
2. Estimation of Fe(III).
3. Estimation of Cu(II).
4. Estimation of Fe(II) and Fe(III) in a mixture.

Organic Chemistry Lab

Identification of a pure organic compound

Solid compounds: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid.

Liquid Compounds: methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde, chloroform and nitrobenzene.

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Das, S. C., Chakraborty, S. B., *Practical Chemistry*.
3. Mukherjee, K. S. *Text book on Practical Chemistry*, New Oriental Book Agency.
4. Ghosal, Mahapatra & Nad, *An Advanced course in practical Chemistry*, New Central Book Agency.
5. Bhattacharyya, R. C., *A Manual of Practical Chemistry*.
6. Vogel, A. I. *Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis*, CBS Publishers and Distributors.
7. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
8. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman,

Semester-IV (General minor)

Paper Code: CHEM/3/MI-C4T

Physical Chemistry- Principles of Thermodynamics, Chemical and Ionic Equilibrium

• A. Principles of Thermodynamics (16 Lectures)

(I) Introduction and First Law of Thermodynamics: Introduction, Some basic concepts; System; isolated, closed and open; Surroundings, Universe, Boundaries and its classifications, Properties of a system: Extensive and Intensive; State property and path property, Different types of processes: reversible and irreversible processes, Isothermal and adiabatic processes. Steady state and Equilibrium state. Thermal equilibrium, Zeroth law of Thermodynamics and its applications. Concept of heat and work: p-V type work in various processes, indicator diagrams, Joule's experiments, Concept of internal energy (U), First law of thermodynamics; its various statements. Joule-Thomson experiment; concept of enthalpy (H); J-T coefficient, Inversion temperature, Expressions of J-T coefficient and inversion temperature for VDW gas (without derivation). Cooling and heating due to JT expansion.

Heat capacity relations. General relations, relations for ideal gas. Adiabatic changes of states: relations among various state properties of ideal gas for adiabatic reversible process, expressions of work, adiabatic cooling, its difference from the JT cooling.

(II) Thermochemistry: Basic laws of thermochemistry, Standard states; Temperature dependence of enthalpy of a reaction: Kirchhoff's equation. Enthalpy of reactions for various

processes; enthalpy of formation, enthalpy of combustion, lattice enthalpy and the Born-Haber cycle, enthalpy of neutralizations, bond dissociation enthalpy and the average bond enthalpy.

(III) 2nd Law of Thermodynamics and Auxiliary State Functions: Limitations of 1st law of thermodynamics, Spontaneous process and its characteristic features. Need for a Second law. Kelvin-Planck statement, Clausius statement of 2nd law of thermodynamics. Carnot engine: Carnot cycle, Efficiency of Carnot engine taking ideal gas as the working substance, efficiency in terms of P-V diagram. Carnot's theorem; statements only. Concept of entropy (S). Properties of entropy. Clausius inequality; Statement of second law of thermodynamics in terms of entropy and the conditions of spontaneity and equilibrium. Entropy change of systems, surroundings and the universe for various processes and transformations.

Gibbs free energy (G) and Helmholtz free energy (A). Their physical significance.. Thermodynamic criteria for spontaneity and equilibrium in terms of change in G and A. Fundamental equations of thermodynamics, Maxwell's relations; Thermodynamic square, Thermodynamic equations of states,

Temperature dependence of free energy functions: Gibbs- Helmholtz equation.

- **B. Chemical and Ionic Equilibrium (16 Lectures)**

(I) *Chemical Equilibrium*: Concept of Chemical Potential, van't Hoff's reaction isotherm, Different kind of true equilibrium constant K_p and K_c . pseudo equilibrium constant K_x . Interrelations among K_p , K_c and K_x . Temperature dependence of equilibrium constant. van't Hoff's equations (isobar and isochore) Shifting of equilibrium due to change in external parameters e.g. concentration, temperature, pressure and addition of inert gas; Le Chatelier's principle and its applications.

(II) *Ionic Equilibrium*: Concept of mean ionic activity and mean ionic activity coefficient. Ionic strength, Debye-Huckel limiting law. Solubility, activity solubility product, concentration solubility product of sparingly soluble salt. Their interrelations. Effect of addition of inert electrolyte on the solubility and concentration solubility product. Common ion effect and its applications. pH,

calculation of pH in various solutions, ionic product of water, Dissociation constants of weak acids and weak bases, Buffer and buffer capacity, Henderson equation, salt hydrolysis and expressions of pH, acid-base neutralisation reactions, Acid-base neutralization curves, Indicator and its choice for neutralization reactions.

Inorganic Chemistry- Chemistry of s and p block Elements

- **Chemistry of s and p block Elements: (13 Lectures)**

Group trends in electronic configuration, common oxidation states, inert pair effect, diagonal relationship, Oxo/Peroxo acids of P, S and Cl. Study of the following compounds with emphasis on: preparation, structure & bonding, properties and uses: Li_2O , Na_2O_2 and KO_2 , BeH_2 , BeCl_2 , boric acid, borates, borax, sodium perborate, boron nitrides, borazines, borohydrides (diborane), carbides (covalent and ionic type), diamond, graphite, silanes, silicones, phosphazenes, sulphur-nitrogen binary compounds, interhalogen compounds, polyhalide ions, pseudohalogens, Chlorofluorocarbons (CFCs). Noble Gases: Separation of Noble gases, Clathrates; Structure and properties of XeF_2 , XeF_4 , XeF_6 , xenate and perxenate. Use of noble gases.

Reference Books:

1. Barrow, G.M. *Physical Chemistry* Tata McGraw Hill (2007).
2. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
3. McQuirre and Simon, *Physical Chemistry*
4. P.C. Rakshit, *Physical Chemistry*
5. H. Chatterjee, *Physical Chemistry*
6. A Nag, *Physical Chemistry*

Paper Code: CHEM/3/MI-C4P

Identification of three radicals from the given mixtures. Emphasis should be given to the understanding of the chemistry of different reactions:

- Acid Radicals: NH_4^+ , Na^+ , K^+ , Ca^{2+} , Sr^{2+} , Ba^{2+} , $\text{Mn}^{2+}/4^+$, $\text{Fe}^{2+/3+}$, $\text{Co}^{2+/3+}$, Ni^{2+} and Cu^{2+} .
- Basic Radicals: Cl^- , Br^- , I^- , SCN^- , S^{2-} , SO_4^{2-} , NO_3^- , NO_2^- , PO_4^{3-} , BO_3^{3-} and H_3BO_3 .

Reference Books:

1. *University Hand Book of Undergraduate Chemistry Experiments*, edited by Mukherjee, G. N., University of Calcutta, 2003.