

Syllabus for Four-Year Undergraduate Programme in Chemistry



Learning Outcomes based Curriculum
Framework (LOCF) following NEP 2020
with effect from the Academic Session
2023-2024

DEPARTMENT OF CHEMISTRY
VISVA-BHARATI

COURSE STRUCTURE OF FOUR-YEAR UNDERGRADUATE PROGRAMME IN CHEMISTRY

Sem	Major Courses	Minor Courses	Multi Courses	AECC	SEC	CVAC	Research*	Internship	Total Credits	
I	2x4cr=8	MnA 1x4cr=4	1x3cr=3	ENG/MIL1 1x2cr=2	1x3cr=3	TS 1x3cr=3	---		23	B.Sc. Certificate
II	2x4cr=8	MnB 1x4cr=4	1x3cr=3	ENG/MIL2 1x2cr=2	1x3cr=3	ES 1x3cr=3	---		23	
YEAR 1	2x8=16cr	2x4=8cr	2x3=6cr	2x2=4cr	2x3=6cr	2x3=6cr	---	Sum 4cr	46+4	

After successful completion of ONE YEAR Course (Semesters - I & II) securing 46 credits + 4 credits vocational summer internship, students may exit with B.Sc. Certificate in Chemistry or continue further.

III	2x4cr=8	MnA 1x4cr=4	1x3cr=3	MIL/ENG1 1x2cr=2	1x3Cr=3	---	---		20	B.Sc. Diploma
IV	4x4cr=16	MnB 1x4cr=4	---	MIL/ENG2 1x2cr=2	---	---	---		22	
YEAR 2	10x4=40cr	4x4=16cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	---	Sum 4cr	88+4	

After successful completion of TWO-YEAR Course (Semesters - I to IV) securing 88 credits + 4 credits vocational summer internship, students may exit with B.Sc. Diploma in Chemistry or continue further.

V	3x4cr=12	MnA 1x4cr=4	---	---	---	---	---		16	B.Sc. Degree
VI	3x4cr=12	MnB 1x4cr=4	---	---	---	---	---		16	
YEAR 3	16x4=64cr	6x4=24cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	---	Sum 4cr	120+4	

After successful completion of THREE-YEAR COURSE (Semesters - I to VI) securing 120 credits + 4 credits vocational summer internship, students may exit with B.Sc. Degree in Chemistry or continue further.

VII	4x4cr=16	MnA 1x4cr=4	---	---	---	---	---		20	B.Sc. Honours Degree
VIII	4x4cr=16	MnB 1x4cr=4	---	---	---	---	---		20	
YEAR 4	24x4=96cr	8x4=32cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	---	Sum 4cr	160+4	

After successful completion of FOUR-YEAR COURSE (Semesters - I to VIII) securing 160 credits + 4 credits vocational summer internship, students may obtain B.Sc. Honours in Chemistry.

OR

VII	3x4cr=12	MnA 1x4cr=4	---	---	---	---	1x4cr=4*		20	B.Sc. Honours (with Research)
VIII	2x4cr=8	MnB 1x4cr=4	---	---	---	---	2x4cr=8*		20	
YEAR 4	21x4=84cr	8x4=32cr	3x3=9cr	4x2=8cr	3x3=9cr	2x3=6cr	3x4=12cr	Sum 4cr	160+4	

After successful completion of FOUR-YEAR COURSE (Semesters - I to VIII) securing 160 credits + 4 credits vocational summer internship, students may obtain B.Sc. Honours (with Research) in Chemistry.

**Dissertation can be opted by students who attain at least CGPA 75% in 3 years and desire the Research degree. The students pursuing B.Sc. Honours (with Research) have to secure 12 credits (4 credits in Semester VII and 8 credits in Semester VIII). However, students pursuing only B.Sc. Honours have to study additional three Major Courses in Chemistry securing 12 credits (4 credits in*

Semester VII and 8 credits in Semester VIII) in lieu of the Dissertation.

Four-Year Undergraduate Programme in Chemistry

Courses	Duration	Semesters	Credits	Criteria of Admission/Re-entry
Certificate course in Chemistry	1 year	I & II	46 + 4 (Intern)	10+2 pass with Chemistry and Mathematics
Diploma course in Chemistry	2 years	I-IV	88 + 4 (Intern)	Certificate in Chemistry
B.Sc. degree in Chemistry	3 years	I-VI	120 +4 (Intern)	Diploma in Chemistry
B.Sc. (Honours) in Chemistry	4 years	I-VIII	160 + 4 (Intern) (Without dissertation)	3-year B.Sc. degree in Chemistry
B.Sc. (Honours with Research) in Chemistry	4 years	I-VIII	160 + 4 (Intern) With dissertation)	3-year B.Sc. degree in Chemistry with 75% marks or more

Credit Distribution among three Sections of Chemistry

Semester	Inorganic	Organic	Physical	Minor	SEC
I	2 (T) + 2 (Pr)	2 (T)	2 (T)	I: 2 (Pr)	3
II	2 (T)	2 (T) + 2 (Pr)	2 (T)	O: 1(T) P: 1 (T)	3 (I/O/P)
III	2 (T)	2 (T)	2 (T) + 2(Pr)	I: 1 (T)	3 (I/O/P)
IV	4 (T) + 2 (Pr)	4 (T) + 2 (Pr)	4 (T)	O: 2 (Pr) P: 1 (T)	
V	2 (T) + 2 (Pr)	4 (T)	2 (T) + 2 (Pr)	I: 2 (T)	
VI	4(T)	2 (T) + 2 (Pr)	2 (T) + 2 (Pr)	O: 1 (T) P: 1 (T)	
VII	2 (T) + 2 (Pr)	2 (T)+2 (Pr)	4 (T)	I: 1 (T)	
VIII	2 (T)	2 (T)	2 (T) + 2 (Pr)	O: 2 (T) P: 1 (T)	
Total	20 (T) + 8 (Pr)	20 (T) + 8 (Pr)	20 (T) + 8 (Pr)	I: 4 (T) + 2 (Pr) O: 4 (T) + 2 (Pr) P: 4 (T)	

*T = Theory; Pr = Practical, I = Inorganic, O = Organic, P = Physical

FOUR-YEAR UNDERGRADUATE PROGRAMME in CHEMISTRY following NEP 2020

MAJOR COURSES in CHEMISTRY [Discipline-Specific Core Courses]

Course Code	Course Type	Course Title	Credits	Marks	Hours /Week
SEMESTER I					
MJCH01: Gr. A	<i>Inorganic Theory</i>	Atomic Structure, Periodicity of Elements, Chemical Bonding (I+II)	2	50	2
MJCH01: Gr. B	<i>Inorganic Practical</i>	Acid Base Titration, Redox Titration	2	50	4
MJCH02: Gr. A	<i>Organic Theory</i>	Basics of Organic Chemistry and Reaction Mechanism	2	50	2
MJCH02: Gr. B	<i>Physical Theory</i>	Gaseous State, Liquid and Surface Tension	2	50	2
		Total	8 credits	200	
SEMESTER II					
MJCH03: Gr. A	<i>Inorganic Theory</i>	Coordination Chemistry I, Radioactivity, Redox Chemistry	2	50	2
MJCH03: Gr. B	<i>Physical Theory</i>	Thermodynamics I, Conductance	2	50	2
MJCH04: Gr. A	<i>Organic Theory</i>	Chemistry of Aliphatic Non-Nitrogenous, Nitrogenous and Sulphur Compounds; Formation of Alkene and Alkyne	2	50	2
MJCH04: Gr. B	<i>Organic Practical</i>	Qualitative Analysis	2	50	4
		Total	8 credits	200	
ONE-YEAR CERTIFICATE PROGRAMME TOTAL 4 MAJOR COURSES			16 credits	400	
SEMESTER III					
MJCH05: Gr. A	<i>Inorganic Theory</i>	Chemistry of s and p block Elements, Coordination Chemistry II, Acids and Bases, General Principles of Metallurgy	2	50	2
MJCH05: Gr. B	<i>Organic Theory</i>	Chemistry of Halogenated Hydrocarbons, Cycloalkanes and Conformational Analysis, Aromatic Hydrocarbons (Aromatic Electrophilic and Nucleophilic Substitution)	2	50	2
MJCH06: Gr. A	<i>Physical Theory</i>	Thermodynamics II, Chemical Kinetics I	2	50	2
MJCH06: Gr. B	<i>Physical Practical</i>	Surface Tension, Viscosity, Conductometry, Thermochemistry	2	50	4
		Total	8 credits	200	

SEMESTER IV					
MJCH07	<i>Inorganic Theory</i>	Coordination Chemistry III, Bioinorganic Chemistry, Chemistry of Transition Metals, Chemistry of Lanthanides and Actinides Inorganic Polymers, Basics of analytical Chemistry	4	100	4
MJCH08	<i>Organic Theory</i>	Alcohols, Phenols, Ethers and Epoxides; Chemistry of Carbonyl compounds (Aldehydes and Ketones); Carboxylic Acids and their derivatives; Organometallic Compounds of Mg, Li, Cu, B, Si:	4	100	4
MJCH09	<i>Physical Theory</i>	Electrochemistry and solid state, Ionic Equilibria and Colligative Properties, Chemical Kinetics –II and Surface Chemistry	4	100	4
MJCH10: Gr. A	<i>Inorganic Practical</i>	Qualitative Semimicro analysis, Inorganic Preparations	2	50	4
MJCH10: Gr. B	<i>Organic Practical</i>	Identification and Separation, Quantitative Analysis	2	50	4
		Total	16 credits	400	
TWO-YEAR DIPLOMA PROGRAMME TOTAL 10 MAJOR COURSES			40 credits	1000	
SEMESTER V					
MJCH11: Gr. A	<i>Inorganic Theory</i>	Reaction Kinetics and Mechanism of Coordination Compounds, Structure and Properties of Solids	2	50	2
MJCH11: Gr. B	<i>Inorganic Practical</i>	Complexometric Titration, Gravimetric Analysis, Spectrophotometric Estimation	2	50	4
MJCH12	<i>Organic Theory</i>	Dynamic Stereochemistry; Heterocyclic Compounds including Fused Ring system; Pericyclic Reactions; Retrosynthetic Analysis, Functional group Interconversion and Protection-deprotection in Organic Synthesis	4	100	4
MJCH13: Gr. A	<i>Physical Theory</i>	Quantum Mechanics I, Phase Equilibria	2	50	2
MJCH13: Gr. B	<i>Physical Practical</i>	pH-metry, Potentiometry, Phase, Kinetics	2	50	4
		Total	12 credits	300	
SEMESTER VI					
MJCH14	<i>Inorganic Theory</i>	Organometallic Compounds, Inorganic Photochemistry, Nanomaterials, Separation Techniques	4	100	4

MJCH15: Gr. A	Organic Theory	Organic Spectroscopy, Analysis of IR, UV-Vis, NMR and Mass Spectral Data for Elucidating the Structure of Organic Molecules	2	50	2
MJCH15: Gr. B	Organic Practical	Organic Preparation	2	50	4
MJCH16: Gr. A	Physical Theory	Molecular Spectroscopy I, Quantum Mechanics II	2	50	2
MJCH16: Gr. B	Physical Practical	Adsorption, Colourimetry, UV-Vis, Ostwald Dilution	2	50	4
		Total	12 credits	300	
THREE-YEAR DEGREE PROGRAMME TOTAL 16 MAJOR COURSES			64 credits	1600	
SEMESTER VII					
MJCH17: Gr. A	Inorganic Theory	Molecular Magnetism, Physical Characterization of Inorganic Compound by EPR and NMR Spectroscopy, Nuclear Detection Technique	2	50	2
MJCH17: Gr. B	Inorganic Practical	Analysis of some ores and alloys, Chromatographic Techniques, Inorganic Preparations, Colorimetric Estimation	2	50	4
MJCH18: Gr. A	Organic Theory	Chemistry of Proteins, Lipids, Nucleic Acids, Chemistry of Carbohydrates, Polymers	2	50	2
MJCH18: Gr. B	Organic Practical	Separation of components from a mixture of organic compounds	2	50	4
MJCH19	Physical Theory	Molecular Spectroscopy II, Quantum Mechanics III, Group Theory, Statistical Thermodynamics	4	100	2
		Total	12 credits	300	
Additional 4 Credit Course for Students having Marks <75% to Obtain B.Sc(Hons) Degree Without Research					
MJACH 01*	Organic Theory	Static Stereochemistry Dynamic Stereochemistry Reactions Mechanism I Reaction Mechanism II Some Selective Name Reactions	4	100	4
			4 credits	100	
SEMESTER VIII					
MJCH20: Gr. A	Inorganic Theory	Cage, Metal Clusters and Ring Compounds; Thermo-analytical Methods; Electro-analytical Method	2	50	2

MJCH20: Gr. B	<i>Organic Theory</i>	Indian Knowledge System in Natural Products (Alkaloids, Terpenoids) with special reference to Biosynthesis, Advanced reaction mechanism with special reference to newly developed synthetic strategies, Asymmetric synthesis	2	50	2
MJCH21: Gr. A	<i>Physical Theory</i>	Quantum Chemistry, Electronic Spectroscopy and Photochemistry	2	50	2
MJCH21: Gr. B	<i>Physical Practical</i>	Gibbs surface excess, Spectrophotometry, Kinetics with Instruments, CST, CMC	2	50	4
Additional 8 Credit Course for Students having Marks <75% to Obtain B.Sc (Hons) Degree Without Research					
MJACH 02*	<i>Inorganic Theory</i>	Supramolecular Chemistry Advanced Chemistry of the Elements Tutorial	4	100	4
MJACH03*	<i>Physical Theory</i>	Approximate Methods and their Applications Colloids and Polymers Photo-Physical Processes in the Electronically Excited States Electrical and Magnetic Properties of Molecules	4	100	4
			8 credits	200	
FOUR-YEAR HONOURS PROGRAMME					
TOTAL 21 COURSES + 3 COURSES			84 credits	2100	
(Optional in lieu of Dissertation for Honours students)			+	+	
FOUR-YEAR HONOURS with RESEARCH PROGRAMME			12 credits	300	
TOTAL 21 COURSES+ DISSERTATION					

MINOR COURSES in CHEMISTRY [Discipline-Specific Minor Courses]

Course Code	Course Type	Course Title	Credits	Marks	Hours /Week
SEMESTER I					
MNCH01: Gr. A	<i>Organic Theory</i>	Fundamentals of Organic Chemistry, Stereochemistry	2+2	50+50	2
MNCH01: Gr. B	<i>Physical Theory</i>	Gaseous State of Liquids			4
MNCH01: Gr. C	<i>Inorganic Practical</i>	Acid Base Titration, Redox Titration			
SEMESTER II					
MNCH01: Gr. A	<i>Organic Theory</i>	Fundamentals of Organic Chemistry, Stereochemistry	2+2	50+50	2
MNCH01: Gr. B	<i>Physical Theory</i>	Gaseous State of Liquids			4
MNCH01: Gr. C	<i>Inorganic Practical</i>	Acid Base Titration, Redox Titration			
ONE-YEAR CERTIFICATE PROGRAMME			TOTAL 4	100	
TOTAL 1 MINOR COURSE					

SEMESTER III					
MNCH02: Gr. A	<i>Inorganic Theory</i>	Atomic Structure	2+2	50+50	2
MNCH02: Gr. B	<i>Physical Theory</i>	Chemical Energetics, Chemical Kinetics			4
MNCH02: Gr. C	<i>Organic Practical</i>	Qualitative Organic Analysis of Organic Compounds			
SEMESTER IV					
MNCH02: Gr. A	<i>Inorganic Theory</i>	Atomic Structure	2+2	50+50	2
MNCH02: Gr. B	<i>Physical Theory</i>	Chemical Energetics, Chemical Kinetics			4
MNCH02: Gr. C	<i>Organic Practical</i>	Qualitative Organic Analysis of Organic Compounds			
TWO-YEAR DIPLOMA PROGRAMME TOTAL 2 MINOR COURSES			8	200	
SEMESTER V					
MNCH03: Gr. A	<i>Inorganic Chemistry</i>	Chemical Bonding and Molecular Structure, Coordination Chemistry	4	100	4
MNCH03: Gr. B	<i>Organic Chemistry</i>	Aliphatic Hydrocarbons, Aromatic Hydrocarbons			
MNCH03: Gr. C	<i>Physical Chemistry</i>	Chemical Equilibrium, Ionic Equilibria, Phase Equilibria			
			4	100	
SEMESTER VI					
MNCH03: Gr. A	<i>Inorganic Chemistry</i>	Chemical Bonding and Molecular Structure, Coordination Chemistry	4	100	4
MNCH03: Gr. B	<i>Organic Chemistry</i>	Aliphatic Hydrocarbons, Aromatic Hydrocarbons			
MNCH03: Gr. C	<i>Physical Chemistry</i>	Chemical Equilibrium, Ionic Equilibria			
			4	100	
THREE-YEAR DEGREE PROGRAMME TOTAL 3 MINOR COURSES			12	300	
SEMESTER VII					
MNCH04: Gr. A	<i>Inorganic Chemistry</i>	Transition Elements	4	100	4
MNCH04: Gr. B	<i>Organic Chemistry</i>	Alkyl and Aryl Halides; Alcohols, Phenols, and Ethers (Upto 5 carbons); Chemistry of Biomolecules			
MNCH04: Gr. C	<i>Physical Chemistry</i>	Conductance, Electrochemistry, Dilute Solutions and Colligative Properties			
			4	100	
SEMESTER VIII					
MNCH04: Gr. A	<i>Inorganic Chemistry</i>	Transition Elements	4	100	4
MNCH04: Gr. B	<i>Organic Chemistry:</i>	Alkyl and Aryl Halides; Alcohols, Phenols, and Ethers (Upto 5 carbons); Chemistry of Biomolecules			
MNCH04: Gr. C	<i>Physical Chemistry</i>	Conductance, Electrochemistry, Dilute Solutions and Colligative			

		Properties			
			4	100	
FOUR-YEAR HONOURS PROGRAMME TOTAL			4 MINOR COURSES	16	400

SKILL ENHANCEMENT COURSES in CHEMISTRY

Course Code	Course Type	Course title	Credits	Marks	Hours /Week
SEMESTER I					
SEC1		Basic Principles and Laboratory Operations	3	75	
SEMESTER II					
SEC 2A	<i>Inorganic Chemistry-I</i> [Theory + Practical]	Environment and its Segments	3 (1+2)	75 (25+50)	
SEC 2B	<i>Organic Chemistry-I</i> [Theory + Practical]	Green Chemistry	3 (2+1)	75 (50+25)	
SEC 2C	<i>Physical Chemistry-I</i> [Theory]	Thermodynamics	3	75	
SEC 2D	<i>Physical Chemistry-II</i> [Theory]	Bio-Physical Chemistry	3	75	
ONE-YEAR CERTIFICATE PROGRAMME TOTAL			2 COURSES	6 credits	150
SEMESTER III					
SEC 3A	<i>Inorganic Chemistry-II</i> [Theory + Practical]	Inorganic Materials of Industrial Importance	3 (1+2)	75 (25+50)	
SEC 3B	<i>Organic Chemistry- II</i> [Theory + Practical]	Pharmaceutical Chemistry	3 (2+1)	75 (50+25)	
SEC 3C	<i>Physical Chemistry-III</i> [Theory]	Thermodynamics	3	75	
SEC 3D	<i>Physical Chemistry-IV</i> [Theory]	Alternative Energy and Advanced Instrumentations	3	75	
TWO-YEAR DIPLOMA PROGRAMME TOTAL			3 COURSES	9 credits	225

MULTIDISCIPLINARY COURSE in CHEMISTRY

Course Code	Course Type	Course title	Credits	Marks	Hours
SEMESTER I /II/III					
MDCH01	Theory	Chemistry in Everyday Life	3	75	3

CHEMISTRY

MAJOR SYLLABUS

Semester I

MAJOR COURSE [Code: MJCH 01: Gr. A]

Inorganic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Atomic Structure: (8 Lectures)

Bohr's theory of the atomic spectrum of hydrogen, Wave mechanics: de Broglie equation, electrons as a harmonic wave, wave packet, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2 . Quantum numbers and their significance. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Pure and hybrid orbitals, Shapes of s, p, d and f orbitals. Orbital contour diagram. Penetration and Shielding effect, Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number. Atomic term symbols and ground state terms.

Unit 2: Periodicity of Elements: (7 Lectures)

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s and p-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) (h) Lanthanide and Actinide Contractions (i) Relativistic Effects

Unit 3: Chemical Bonding - I: (10 lectures)

(i) *Ionic bond*: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) *Covalent bond*: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N₂, O₂, C₂, B₂, F₂, CO, NO (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths.

Unit 4: Chemical Bonding – II: (5 Lectures)

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

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

Reference Books:

(1) Lee, J.D. Concise Inorganic Chemistry ELBS, 1991. (2) Rodger, G.E. Inorganic and Solid-State Chemistry, Cengage Learning India Edition, 2002. (3) R. L. Dutta & G.S. De, Inorganic Chemistry (Vol. 1), The New Book Stall, 1973. (4) Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press, 2010. (5) R. P. Sarkar, General and Inorganic Chemistry (Vol. 1), New Central Book Agency, ed. 3, 2011 (6) A. K. Das, Fundamental Concepts of Inorganic Chemistry (Vol. 1), CBS Publishers & Distributors, 2010 (7) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (8) Atomic structure and periodicity by Jack Barrett, RSC (9) Principles of inorganic chemistry by Brian William Pfennig, Wiley (10) An Introduction to Atomic and Molecular Physics by Wolfgang Demtröder by Springer (11) Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970

MAJOR COURSE: Inorganic Practical [Code: MJCH 01: Gr. B] (Credits: 02, F.M - 50) (60 Lectures)

(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 $\text{K}_2\text{Cr}_2\text{O}_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

(D) Inorganic preparations-1

(i) Cuprous Chloride, Cu_2Cl_2 (ii) Preparation of Manganese(III) phosphate, $\text{MnPO}_4 \cdot \text{H}_2\text{O}$ (iii) Preparation of Aluminium potassium sulphate $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$ (Potash alum) or Chrome alum.

Reference Books:

(1) Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012. (2) Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009. (3) An Advanced Course in Practical Chemistry by Nad, Mahapatra & Ghosal. Publisher, New Central Book Agency (P) Limited, 2014

MAJOR COURSE [Code: MJCH 02: Gr. A]

Organic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Basics of Organic Chemistry and Reaction Mechanism: (15 Lectures)

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

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples; Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination, and Substitution reactions, ΔH , ΔS , ΔG ; dependence of ΔH on bond energy, etc. of reactants and products, equilibrium-controlled changes, intermolecular vs intramolecular reactions. Hammond Postulate, Kinetic studies, Curtin-Hammett principles, study of intermediates, cross-over experiment, stereochemical proof, isotope labeling-kinetic and non-kinetic, primary and secondary kinetic isotope effect.

Unit 2: Stereochemistry: (15 Lectures)

Concept of constitution, configuration and conformation of Organic molecules, Geometrical isomerism, enantiomerism and diastereomerism, chirality and optical activity, elements of symmetry, asymmetry and dissymmetry, *R/S*, *E/Z*, *D/L*, syn/anti, cis/trans, meso/dl, threo/erythro –nomenclature system, Fischer, Sawhorse, Flying Wedge, Newman formulae, Racemization and resolution, resolution of racemic acids, bases and alcohols; optical purity/enantiomeric excess.

Axial chirality of allenes, biphenyls, conformation of cyclohexane systems, Topicity of ligands and faces (elementary idea); homotopic, enantiotopic and diastereotopic ligands and faces, prochirality, pro-*R*/Pro-*S* and re/si descriptors, Conformational isomerism-eclipsed, staggered gauche and anti; concept of dihedral and torsion angle, energy diagram during variation of torsion angle.

Reference Books:

(1) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988). (2) Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill Education (2000). (3) Graham Solomons, T. W.; Fryhle, C. B. & Snyder, S. A. Organic Chemistry, 12th Ed., John Wiley & Sons (2017). (4) Finar, I. L. Organic Chemistry (Vol. I), 6th Ed., Pearson (2002). (5) Nasipuri, D. Stereochemistry of Organic Compounds (Principles and Applications), 2nd Edition, New age int. (P) Ltd, Publishers, 2005. (6) March, J., Smith, M. B., March's Advanced Organic Chemistry, A John Wiley & Sons, Inc., Publication, 2005. (7) Basic Stereochemistry of organic Molecule by S. Sengupta

MAJOR COURSE [Code: MJCH 02: Gr. B]

Physical Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Gaseous state: (15 Lectures)

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; 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. collision frequency; collision diameter; mean free path. 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, origin of intermolecular interactions (van der Waals interactions), 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, calculation of Boyle temperature, law of corresponding states. Dietrici equation of state; Virial equation of state.

Unit 2: Liquids: (10 Lectures)

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, coefficient of viscosity, and their determination. laminar flow, turbulent flow, Reynolds number, Poiseuille' law, Effect of addition of various solutes on

viscosity. Temperature variation of viscosity of liquids and comparison with that of gases. Diffusion, Fick's law of diffusion, diffusion coefficient.

Unit 3: Surface Tension: (5 Lectures)

Definition, Consideration of different kind of interface, Derivation Laplace equation, Vapor pressure over curved surface, Capillary rise and measurement of surface tension. Work of cohesion and adhesion. Spreading of liquid over other surfaces.

Reference Books:

(1) Physical Chemistry, G. W. Castellan, (2) Physical Chemistry, P. C. Rakshit, (3) A Textbook of Physical Chemistry, Volume- 1, K. L. Kapoor, (4) Atkins' Physical Chemistry, P. Atkins, J. de Paula, J. Keeler. (5) Physical Chemistry (vol-I &II), H. Chatterjee.

Semester II

MAJOR COURSE [Code: MJCH 03: Gr. A]

Inorganic Chemistry Theory

(Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Coordination Chemistry-I: (8 Lectures)

Coordinate bonding: double and complex salts. Werner's theory of coordination complexes. Classification of ligands, Ambidentate ligands, chelates, coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers). Isomerism and chirality: constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedral complexes, Thermodynamics of complex formation: Formation constants, Trends in successive formation constants, the chelate and macrocyclic effects.

Unit 2: Radioactivity: (12 Lectures)

Nuclear stability and nuclear binding energy, nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers. Nuclear reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Separation and uses of isotopes. Radio-chemical method: Principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures. models of disintegration-radiation emission (fluorescence) and electron emission (Auger effect), theory of radioactivity decay-golden rule and selection rule, radioactive equilibrium.

Unit 3: Redox Chemistry: (10 Lectures)

Redox equations. Ion-electron method, standard redox potentials with sign conventions, Nernst equation (without derivation). Influences of complex formation, precipitation and change of pH on Electrode Potential and its application to inorganic reactions. Principles involved in volumetric analysis to be carried out in class. Disproportionation and comproportionation reactions (typical examples), Formal potential, Stability of various oxidation states and e.m.f. diagrams of common elements.

Reference Books:

(1) R. L. Dutta & G.S. De, Inorganic Chemistry (Vol. 1), The New Book Stall, 1973. (2) Purcell, K.F & Kotz, J.C. Inorganic Chemistry W.B. Saunders Co, 1977. (3) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (4) Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999 (5) Comprehensive Coordination Chemistry (6) Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010. (7) Atkin, P. Shriver & Atkins' Inorganic

Chemistry 5th Ed. Oxford University Press (2010). (8) R. P. Sarkar, General and Inorganic Chemistry (Vol. 1), New Central Book Agency, ed. 3, 2011 (9) Asim K. Das Fundamental Concepts of Inorganic Chemistry, Vol-1, CBS Publishers & Distributors (9) H J Arnikar, Essentials of Nuclear Chemistry, New Age Internacional Publishers. (10) Gerhart Friedlander, Joseph W. Kennedy, Edward S. Macias, Julian Malcolm Miller., Nuclear and Radiochemistry, A Wiley – Interscience Publication. (11) Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, Pearson Education Limited.

MAJOR COURSE [Code: MJCH 03: Gr. B]

Physical Chemistry

(Theory, Credits: 2, F.M. 30) (30 Lectures)

Unit 1: Thermodynamics I: (15 Lectures)

Zeroth and First laws of thermodynamics:

Objective of thermodynamics, examples of thermodynamic system (TS), definition of boundary, wall and environment, classification of systems, definition of properties as well as state variable of a TS, thermal equilibrium-zeroth law of thermodynamics and definition of temperature, work, heat, classification of processes, first law of thermodynamics-definition of internal energy and enthalpy, definition of thermodynamics, selective application of the first law to thermochemistry : heat of neutralization, bond enthalpy and bond energy.

Second laws of thermodynamics:

Limitation of the first law and necessity of the second law, adiabatic expansion of an ideal, definition of pressure, Carnot engine with an ideal gas, the second law of thermodynamics, the definition of entropy and the Clausius inequality. definition of Gibbs energy and condition of spontaneity in terms of it. properties of Gibbs energy, definition of volume, Gibbs energy per mole of an ideal gas.

Unit 2: Conductance: (15 Lectures)

Arrhenius theory of electrolytic dissociation, application of Ohm's law to electrolytic solution, conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes, molar conductivity at infinite dilution, Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules, ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods, 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.

Reference Books:

(1) Physical Chemistry, G. W. Castellan, (2) Physical Chemistry, P. C. Rakshit. (3) A Textbook of Physical Chemistry, K. L. Kapoor, Vol. 1, 6 th Edition, McGraw Hill Education, (4) An Introduction to Electrochemistry, Samuel Glasstone, East-West Press Pvt. Ltd.

MAJOR COURSE [Code: MJCH 04: Gr. A]

Organic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Chemistry of Aliphatic Non-nitrogenous, nitrogenous and Sulphur compounds: (20 Lectures)

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Nitrogen and Sulphur containing compounds: Preparation and important reactions of nitro compounds, nitriles and isonitriles, Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Hoffmann's exhaustive methylation, Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Preparation of diazonium salts.

Preparation and reactions of thiols, thioethers and sulphonic acids.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, *e.g.* propene, 1-butene, toluene, ethyl benzene.

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

Unit 2: Formation of alkene and alkyne: (10 Lectures)

Elimination reactions, Mechanism of E1, E2, E1cB reactions. Saytzeff and Hofmann eliminations

Reference Books:

(1) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012). (2) Finar, I. L. Organic Chemistry (Vol. I), 6th Ed., Pearson (2002). (3)

Graham Solomons, T. W.; Fryhle, C. B. & Snyder, S. A. *Organic Chemistry*, 12th Ed., John Wiley & Sons (2017). (4) Norman, R. O. C. & Coxon, J. M. *Principle of Organic Synthesis*, 2nd Ed., Springer (1993). (5) Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi, (1988). (6) Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, 7th Ed., Pearson Education India (2011).

MAJOR COURSE [Code: MJCH 04: Gr. B]
Organic Chemistry
(Practical, Credits: 2, F.M. 50) (60 Lectures)

1. Purification of organic compounds by crystallization using the following solvents:
 - a. Water
 - b. Alcohol
 - c. Alcohol-Water
2. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
3. Qualitative analysis of solid organic compounds in respect of the following: Detection of elements, determination of M.P., detection of functional group and preparation of a derivative (with M.P):
4. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.

Reference Books:

- (1) Mann, F. G. & Saunders, B. C. *Practical Organic Chemistry*, Pearson Education (2009). (2) Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education (2012)

Semester III

MAJOR COURSE [Code: MJCH 05: Gr. A]

Group A

Inorganic Chemistry Theory

(Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Chemistry of *s* and *p* Block Elements: (10 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. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens. Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF₂, XeF₄ and XeF₆; Nature of bonding in noble gas compounds. Molecular shapes of noble gas compounds

Unit 2: Coordination Chemistry-II: (10 Lectures)

Valence bond theory (inner and outer orbital complexes) and its limitations. Electroneutrality principle and back bonding. Crystal field theory, barycentre rule, measurement of 10 Dq (Δ_o) and its significance, Octahedral vs. tetrahedral coordination. Factors affecting the magnitude of 10 Dq (Δ_o , Δ_t): role of coordination geometry, Crystal field splitting of d orbitals in different types of coordination geometry, spectrochemical series of ligands and metals. Uses and limitations of CFT, evidences in favour of CFT: variation of hydration energies, lattice energy, octahedral crystal ionic radii, spinel, OSSE, experimental evidences in favour of metal-ligand overlap.

Unit 3: Acids and Bases: (6 Lectures)

Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, leveling solvents, Lewis's acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB), Application of HSAB principle. Acid-Base equilibria in solution: Hydrolysis of salts, pH calculation. Buffer.

Unit 4: General Principles of Metallurgy: (4 Lectures)

Chief modes of occurrence of metals based on standard electrode potentials. Reduction Potential and Extraction Methods. Role of thermodynamics in metal extraction processes. 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-Langer process, Zone refining.

Reference Books:

(1) Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991. (2) Housecroft, C.E. and Sharpe, A.G. (2012) Inorganic Chemistry. 4th Edition, Pearson, Harlow. (3) Basic Inorganic Chemistry, 3ed by F. Albert Cotton, Geoffrey Wilkinson. (4) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (5) R. P. Sarkar, General and Inorganic Chemistry (Vol. 1), New Central Book Agency, ed. 3, 2011 (6) R. L. Dutta & G.S. De, Inorganic Chemistry (Vol. 1), The New Book Stall, 1973 (7) Comprehensive Coordination Chemistry (8) Asim K. Das Fundamental Concepts of Inorganic Chemistry, Vol. 2, 3A, 3B. CBS Publishers & Distributors (9) Chemistry of the p-block elements by Anil J Elias. (10) Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010). (11) Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997. (12) Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970 (13) Extractive Metallurgy 1 (Basic Thermodynamics and Kinetics) by Alain Vignes, Wiley, (14) The Extraction and Refining of Metals by Colin Bodsworth, CRC Press.

MAJOR COURSE [Code: MJCH 05: Gr. B]

Organic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Chemistry of Halogenated hydrocarbons: (10 Lectures)

Alkyl halides: Methods of preparation, nucleophilic substitution reactions- S_N1 , S_N2 and S_{Ni} mechanisms with stereochemical aspects and effect of solvent *etc.*; nucleophilic substitution vs. elimination.

Unit 2: Cycloalkanes and Conformational Analysis: (10 Lectures)

Nomenclature, types of strain, Bayer strain theory, measurement of strain and classification of ring sizes, consequences of strain in small, normal, medium, and large ring, conformation behaviours of normal rings, substituted cyclohexanes, effect of substitution on ring conformation of cyclohexane, conformation of cyclohexene, the effect of strain on reactivity, ring synthesis-principles controlling ring closure reactions, rules for ring closure (Baldwin's rule), ring expansion and contraction processes, polycyclic system-Bredt's rule, Conformational analysis of n-butane, dihaloethanes, glycols.

Unit 3: Aromatic Hydrocarbons: (10 Lectures)

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

Aryl halides: Preparation, including preparation from diazonium salts and their synthetic applications. nucleophilic aromatic substitution; S_NAr , Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.

Reference Books:

(1) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012). (2) Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill Education (2000). (3) Nasipuri, D. Stereochemistry of Organic Compounds (Principles and Applications), 2nd Edition, New age int. (P) Ltd, Publishers, 2005. (4) Finar, I. L. Organic Chemistry (Vol. I), 6th Ed., Pearson (2002). (5) Graham Solomons, T. W.; Fryhle, C. B. & Snyder, S. A. Organic Chemistry, 12th Ed., John Wiley & Sons (2017). (6) Norman, R. O. C. & Coxon, J. M. Principle of Organic Synthesis, 2nd Ed., Springer (1993). (7) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988).

MAJOR COURSE [Code: MJCH 06: Gr. A]

Physical Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Thermodynamics II: (15 Lectures)

The concept of chemical potential and its significance in chemistry: Gibbs energy as a function of temperature, pressure and composition, definition of chemical potential, chemical potential of a gas in a mixture of ideal gases, definition of activity and activity coefficient, the chemical potential of solute and solvent, examples of states at unit activity, chemical potential and reaction vessel- condition of chemical equilibrium and its special case-phase equilibrium, equilibrium constant for different cases. Third law of thermodynamics and the principle for determination of the absolute entropy.

Unit 2: Chemical Kinetics I: (15 Lectures)

Definition of mole reaction and advancement of chemical reaction, Definition of velocity of chemical reaction in terms of advancement of chemical reaction, Rate law of chemical reaction at constant volume. 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 and concept of pre-equilibrium step (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Introduction of concept of reaction coordinate and potential energy surface for very simple reaction.

Reference Books:

(1) Physical Chemistry, G. W. Castellan, (2) Physical Chemistry, P. C. Rakshit, (3) Atkins' Physical Chemistry, P. Atkins, J. de Paula, J. Keeler. (5) Physical Chemistry (vol-I &II), H. Chatterjee. (6) Chemical Kinetics, K. J. Laidler.

MAJOR COURSE [Code: MJCH 06: Gr. B]

Physical Chemistry Practical

(Credits: 2, F.M. 50) (60 Lectures)

1. Surface tension measurements.

- a. Determine the surface tension by (i) drop number (ii) drop weight method.
- b. Study the variation of surface tension of detergent solutions with concentration.

2. Viscosity measurement using Ostwald's viscometer.

- a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
- b. Study the variation of viscosity of sucrose solution with the concentration of solute.

3. Conductometry

- I. Determination of cell constant
- II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. III. Perform the following conductometric titrations:
 - i. Strong acid vs. strong base
 - ii. Weak acid vs. strong base
 - iii. Mixture of strong acid and weak acid vs. strong base
 - iv. Strong acid vs. weak base

4. Thermochemistry

- i. Determination the Enthalpy of neutralization of a strong acid with a strong base.
- ii. Determination of Enthalpy of dissolution.

Reference Books:

(1) Physical Chemistry Practical, S. K. Maity & N.K.Ghosh (2) A Textbook of Physical Chemistry, Experimental Aspects in Physical Chemistry, Volume-7, K. L. Kapoor

Semester IV

MAJOR COURSE: [Code: MJCH 07]

Inorganic Chemistry Theory

(Credits: 04, F.M. 100) Theory: 60 Lectures

Unit 1: Coordination Chemistry-III (18 Lectures)

Tetragonal distortions from octahedral geometry: Jahn-Teller theorem, Qualitative aspect of Ligand field and MO Theory. nephelauxetic series, structural distortion and lowering of symmetry, electronic, steric and Jahn-Teller effects on energy levels, structural equilibrium. Russel-Saunders (R-S) terms-Inter electronic repulsion parameters (B), splitting of R-S Terms in different Geometries.

Selection rules for electronic spectral transitions; Orgel diagram, different types of d-d bands and their assignment, qualitative Orgel diagrams, Tanabe-Sugano diagram, charge transfer bands, calculation of Dq , B and β parameters.

Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only), spin crossover.

Unit 2: Bioinorganic Chemistry: (15 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, 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. Myoglobin, haemoglobin, hemocyanin, hemerythrin, cytochromes, cytochrome c oxidase, superoxide dismutase, catalase, peroxidase, rubredoxin, ferredoxins; biological fixation of nitrogen, chlorophyll and photosynthesis, Vitamin B₁₂, Important metal complexes in medicine (examples only), antimicrobial activity, antiarthritic gold complexes, anticancer compounds (Pt-complexes and metallocenes), MRI contrast agent, lithium therapy in psychiatric mind disorder

Unit 3: Chemistry of Transition Metals: (12 Lectures)

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stabilization of high and low oxidation states with designed systems. Stability of various oxidation states. Difference between the first, second and third transition series. Chemistry of Sc, Ti, V, Cr, Mn, Fe, Co, Ni and Cu in various oxidation states and magneto-structural correlations in specific cases (excluding their metallurgy).

Chemistry of Lanthanides and Actinides: (5 Lectures) Lanthanoids and Actinoids: Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

Unit 4: Inorganic Polymers: (12 Lectures)

Types of inorganic polymers, comparison with organic polymers, degree of polymerization, classification of polymers, number, weight and viscosity average molecular weights, polydispersity index and molecular weight distribution, some inorganic polymers: synthesis, structural aspects and applications of silicones and siloxanes, borazine, silicates, phosphazenes, polyphosphates and polysulphates.

Unit 5: Basics of Analytical Chemistry: (8 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).

Precision-standard deviation, relative standard deviation; accuracy- absolute error, relative error; types of error in experimental data- systematic (determinants), random (indeterminate) and gross; source of errors and the effects upon the analytical results.

Reference Books:

(1) R. L. Dutta, Inorganic Chemistry, vol. I and II. (2) Inorganic Chemistry, ACS, papers: A. Chakravorty, Cotton, T. J. Collins, R. S. Drago, etc. (3) Comprehensive Coordination Chemistry. (4) Cotton, F.A. & Wilkinson, G, Advanced Inorganic Chemistry Wiley-VCH, 1999. (5) O. Kahn, Molecular Magnetism. (6) R.S. Drago, Physical Methods, 1972, New York. Edn. (7) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (8) R. P. Sarkar, General and Inorganic Chemistry (Vol. 1 and 2), New Central Book Agency, ed. 3, 2011 (9) Asim K. Das Fundamental Concepts of Inorganic Chemistry, Vol. 4 and 5, CBS Publishers & Distributors (10) Housecroft, C.E. and Sharpe, A.G. (2012) Inorganic Chemistry. 4th Edition, Pearson, Harlow. (11) Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010. (12) Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010). (13) Asim K Das, Bioinorganic Chemistry (14) Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994. (15) Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction 6th Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994). (16) Vogel's Textbook of macro and semimicro qualitative inorganic analysis, 5th Edition G. Svehla, Longman, London & New York (17) Semi-Micro qualitative inorganic analysis by G. N. Mukherjee, University of Calcutta (2008).

MAJOR COURSE [Code: MJCH 08]

Organic Chemistry

(Theory, Credits: 4, F.M. 100) (60 Lectures)

Unit 1: Alcohols, Phenols, Ethers and Epoxides: (14 Lectures)

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

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

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

Unit 2: Chemistry of carbonyl Compounds (aldehydes and ketones): (16 Lectures)

Structure, Nomenclature, Physical properties, Reactivity, Keto-enol tautomerism and Synthesis; Nucleophilic addition reactions of aldehydes and ketones [Addition of H_2O , alcohol and thiol (hydration and acetal formation reaction, stability of acetals, use of acetals and thiocetals as protecting group in organic synthesis, Umpolung reaction), HCN , bisulfite, amines [primary and secondary amine (Stork-Enamine synthesis & Mannich reaction)], addition of organometallic reagents. Reduction and Oxidation of carbonyl compounds; Wittig reaction; Substitution reaction of aldehydes and ketones and their analogues at their α -position; Chemistry of enolates; Carbonyl condensations and related reactions [The Aldol and related reactions (crossed, directed, Claisen Schmidt, Claisen reaction, Claisen (ester) condensation (simple and crossed), Intramolecular aldol condensation (Dieckmann reaction), Acyloin condensation, Michael addition, Robinson annulation, Darzens Glycidic Ester condensation, Benzoin condensation, Perkin reaction, Reformatsky reaction, Knoevenagel reaction, Cannizzaro and Tishchenko reaction]

Unit 3: Carboxylic Acids and their Derivatives: (15 Lectures)

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

Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group, Mechanism of acidic and alkaline hydrolysis of esters, Hofmann bromamide degradation and Curtius, Lossen and Schmidt rearrangement.

Unit 4: Organometallic compounds of Mg, Li, Cu, B, Si: (15 Lectures)

Grignard reagent; Organolithiums; Gilman cuprates: preparation and reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; substitution on $-\text{COX}$; directed ortho metalation of arenes using organolithiums, conjugate addition by Gilman

cuprates; Corey-House synthesis; abnormal behavior of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Blaise reaction; concept of umpolung and base-nucleophile dichotomy in case of organometallic reagents.

Reference Books

(1) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012). (2) Dickens, T. K. and Warren, S. "Chemistry of the Carbonyl Group: A Step-by-Step Approach to Understanding Organic Reaction Mechanisms (3) Finar, I. L. Organic Chemistry (Vol. I), 6th Ed., Pearson (2002). (4) Graham Solomons, T. W.; Fryhle, C. B. & Snyder, S. A. Organic Chemistry, 12th Ed., John Wiley & Sons (2017). (5) Norman, R. O. C. & Coxon, J. M. Principle of Organic Synthesis, 2nd Ed., Springer (1993). (6) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988). (7) Advanced Organic Chemistry Part A: Structure and Mechanisms by Francis A. Carey, Richard J. Sundberg (8) Advanced Organic Chemistry Part B: Reaction and Synthesis by Francis A. Carey, Richard J. Sundberg (9) Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, 7th Ed., Pearson Education India (2011).

MAJOR COURSE [Code: MJCH 09]

Physical Chemistry

(Theory, Credits: 4, F.M. 100) (60 Lectures)

Unit 1: Electrochemistry: (20 Lectures)

Electrostatics: Coulomb's law of force, electric field and electric potential, Poisson's equation, work in electrostatics

Electrical circuit: Representation of a relevant circuit with a load and a battery, identification of components of the circuit, equipotential and non-equipotential parts of the circuit, relation between the current density and the force, example of source forces: a battery, a piezoelectric crystal, a thermocouple, light etc. definition of EMF

Electrolytic cells: conversion of electrical energy into the chemical energy, Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry

Galvanic Cells: electrochemical system, thermodynamics of electro chemical systems, understanding and setup of criteria of conversion of chemical energy into electrical energy, Galvanic cells and their thermodynamics, Chemical concentration cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells, electrochemical series and its significance in chemistry, Latimer and Frost diagrams and their importance, factors effecting the EMF of half cells, derivation of Debye-Huckel limiting law and its application to (i) Determination of Standard EMF, (ii) ionic reactions to account salt

effect, Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, efficiency of a cell, the temperature coefficient of the EMF etc. (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb₂O₃ electrodes. Formal potential and its importance. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation)

Commercial cells: Primary and secondary cells, dry cell, acid storage cell, fuel cell, present status of the use of Galvanic cells in technology, limitation of Galvanic cells, searching of catalysis

Unit 2: Solid State Chemistry: (10 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, Scattering of X-rays from a unit cell, Bragg's law, a simple account of rotating crystal method and powder pattern method. Structure factor, missing reflections, Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

Unit 3: Ionic equilibria & Colligative Properties: (15 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, 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, 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. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws 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. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Unit IV: Chemical Kinetics II and Surface Chemistry: (15 Lectures)

Study of fast reaction in solution flow method, relaxation method. Collision theory of reaction rates, absolute rate theory, uni-molecular reaction, Lindemann mechanism. Physical adsorption,

chemisorption, adsorption isotherms. nature of adsorbed state, BET equation with its derivation surface tension and its determination. Gibbs adsorption isotherm, 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.

Reference Books:

(1) Physical Chemistry, Ira N. Levine , (2) Physical Chemistry, G. W. Castellan, (3) Physical Chemistry, P. C. Rakshit, (4) Atkins' Physical Chemistry, P. Atkins, J. de Paula, J. Keeler, (5) A Textbook of Physical Chemistry, Volume- 1, 3 & 5, K. L. Kapoor. (6) Chemical Kinetics, K. J. Laidler.

MAJOR COURSE: [Code: MJCH 10: Gr. A]

Inorganic Chemistry Practical

(Credit: 02, F.M. 50) (60 Lectures)

(A) 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-} , $\text{S}_2\text{O}_3^{2-}$, CH_3COO^- , F^- , Cl^- , Br^- , I^- , NO_3^- , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-} , NH_4^+ , 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 (BaSO_4 , 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^- , NO_3^- and Br^- , NO_3^- and I^- .

Spot tests should be done whenever possible.

(B) Inorganic Preparations-II:

- Tetraamminecopper (II) sulphate, $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- Cis and trans $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2 \cdot (\text{H}_2\text{O})_2]$, Potassium dioxalatodiaquachromate (III)
- Tetraamminecarbonatocobalt (III) ion
- Potassium tris(oxalate)ferrate(III)

(C) Some experiments

- Iodo / Iodimetric Titrations: (a) Estimation of Cu(II) and $\text{K}_2\text{Cr}_2\text{O}_7$ using sodium thiosulphate solution (Iodimetrically). (b) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
- Measurement of 10 Dq by spectrophotometric method
- Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
- Preparation of acetylacetonato complexes of $\text{Cu}^{2+}/\text{Fe}^{3+}$. Find the λ_{max} of the complex.

v. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g. bidentate ligands like acetylacetonate, DMG, glycine) by substitution method.

Reference Books:

1. Vogel's Textbook of macro and semimicro qualitative inorganic analysis, 5th Edition G. Svehla, Longman, London & New York 2. Semi-Micro qualitative inorganic analysis by G. N. Mukherjee, University of Calcutta (2008). 3. Hand Book of Inorganic Analysis by G. N. Mukherjee, U. N. Dhur & Sons Pvt. Ltd. 4. Qualitative analysis by V. N. Alexeyev, Mir Publishers

MAJOR COURSE [Code: MJCH 10: Gr. B]

Organic Chemistry Practical

(Credits: 02, F.M. 50) (60 Lectures)

1. Identification with general reaction and tests of the following compounds

- | | | | |
|-------------------|------------------|------------------|-------------------|
| a) Methyl alcohol | b) Ethyl alcohol | c) Glycerol | d) Acetone |
| e) Formic acid | f) Acetic acid | g) Aniline | h) Nitrobenzene |
| i) Benzyl alcohol | j) Tartaric acid | k) Succinic acid | l) Salicylic acid |
| m) Cane sugar | n) Glucose | m) Resorcinol | |

2. Quantitative estimation of Phenol and aniline

Reference Books:

(1) Mann, F. G. & Saunders, B. C. *Practical Organic Chemistry*, Pearson Education (2009). (2) Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G.; Tatchell, A. R. *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Pearson Education (2012)

Semester V

MAJOR COURSE [Code: MJCH 11: Gr. A]

Inorganic Chemistry Theory

(Credits: 02, F.M. 50) (30 Lectures)

Unit 1: Reaction Kinetics and Mechanism of Coordination Compounds: (16 Lectures)

Introduction to inorganic reaction mechanisms. Thermodynamic and Kinetic stability, Inert and Labile Complexes, Classification of ligand substitution reaction mechanism, associative, dissociative, interchange. Ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes: Acid and Base Hydrolysis, Solvent exchange reaction, Kinetics of octahedral substitution reaction, Substitution reactions in square planar complexes, Trans- effect, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes. Oxidation Reduction Reaction / Redox Reaction, Outer-sphere and inner-sphere electron transfer reaction-characteristics and controlling factors, ligand transfer, role of bridging ligand, chemical mechanism of electron transfer, complementary and non-complimentary redox reactions. racemization in octahedral complexes.

Unit 2: Structure and Properties of Solids: (14 lectures).

Description of Crystal Structures, Close Packed Structures, AB, AB₂ and A₂B₃ types common structures, Factors affecting the properties of Solid, Structure of mixed oxides-spinel, inverse spinel, ilmenite, perovskite, crystal defects-intrinsic and extrinsic, thermodynamics of crystal defects, Schottky and Frenkel defects; color centers, dislocations, Burger vectors and Burger circuits, non-stoichiometric compounds; electronic properties of solids: conductors, semiconductors, insulators, superconductors; ferroelectricity, anti-ferroelectricity, piezoelectricity, pyroelectricity, cooperative magnetism.

Reference Books:

(1) Housecroft, C.E. and Sharpe, A.G. (2012) Inorganic Chemistry. 4th Edition, Pearson, Harlow. (2) Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010. (3) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (4) Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010). (5) Asim K. Das Fundamental Concepts of Inorganic Chemistry, Vol. 3, 4, 5. CBS Publications & Distributors (6) Fundamentals of Crystallography Edited by C. Giacovazzo, International Union of Crystallography, International Union of Crystallography (7) Solid State Chemistry and its Applications 2nd Edition by Anthony R. West, Wiley, 2022. (8) Introduction to solid state physics by Charles Kittel, Chapman & Hall, Ltd.

MAJOR COURSE: [Code: MJCH 11: Gr. B]

Inorganic Chemistry Practical

(Credit: 02, F.M. 50) (60 lectures)

(A) Complexometric Titration:

- (i) Estimation of Zn^{2+} using EBT / Xylenol orange as indicator
- (ii) Estimation of Mg^{2+}
- (iii) Estimation of Ca^{2+}
- (iv) Estimation of Hardness of water: Total, Permanent and Temporary hardness
- (v) To estimate the concentration of Ca in commercially available medicines.
- (vi) To estimate the Mg present in multivitamins.

(B) Gravimetric Analysis:

- i. Estimation of nickel (II) using Dimethylglyoxime (DMG).
- ii. Estimation of copper as $CuSCN$
- iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.
- iv. Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

(C) Spectrophotometric estimation:

- (i) Verify Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7/CoSO_4$ in a solution of unknown concentration
- (ii) Spectrophotometric estimation of Fe^{2+} ions by using 1, 10- phenanthroline
- (iii) Determination of the composition of the Fe^{3+} - salicylic acid complex in solution by Job's method.

Reference Books:

- (1) Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009
- (2) S. Gulati, J. L. Sharma, S. Manocha, Practical Inorganic Chemistry, CBS Publishers distributors, 2017.

MAJOR COURSE [Code: MJCH 12]

Organic Chemistry

(Theory, Credits: 4, F.M. 100) (60 Lectures)

Unit 1: Dynamic Stereochemistry: (16 Lectures)

Conformation, reactivity and mechanism of acyclic and cyclic systems, Asymmetric synthesis and asymmetric induction, Acyclic stereoselection, Addition of nucleophiles to carbonyl compounds: 1,2-asymmetric induction, Cram's open chain, cyclic(chelate) and dipolar model,

Prelogs rule. The aldol reaction. Neighbouring group participation and molecular rearrangements.

Conformation and reactivity of alicyclic compounds, effect of substituent stereochemistry on reactivity of cyclohexane derivatives, steric effect, stereoelectronic effects, reduction of cyclic ketones and reaction of cyclic epoxides, neighboring group effects, effect of conformation on rearrangement and transannular reactions in alicyclic system, lactonization reactions of cyclohexane systems, oxidation of cyclohexanols with chromic acid, steric assistance and steric hindrance. Diastereoselection in cyclic systems: Nucleophilic addition to cyclic ketones, formation of axial and equatorial alcohols.

Unit 2: Heterocyclic Compounds: (16 Lectures)

Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole, Thiophene, Pyridine, Indole, Quinoline, Isoquinoline.

Synthesis of Heterocycles, Typical reactivity of Furan, Pyrrole, Thiophene, Pyridine, Indole, Quinoline, and Isoquinoline. Reactions with electrophilic and nucleophilic reagents, Reactions with oxidized and reducing agents, reactions with bases, Electrocyclic reactions, Photochemical reactions, and reactions of C-metallated pyrroles, furans, thiophenes, and pyridines, Heterocyclic rearrangements. Derivatives of furan: Furfural and furoic acid.

Unit 3: Pericyclic Reactions: (14 Lectures)

Mechanism, stereochemistry, regioselectivity in case of

Electrocyclic reactions: FMO approach involving 4π - and 6π -electrons (thermal and photochemical) and corresponding cycloreversion reactions.

Cycloaddition reactions: FMO approach, Diels-Alder reaction, photochemical [2+2] cycloadditions.

Sigmatropic reactions: FMO approach, sigmatropic shifts and their order; [1,3]- and [1,5]-H shifts and [3,3]-shifts with reference to Claisen and Cope rearrangements.

Unit 4: Retrosynthetic analysis, functional group interconversion and Protection deprotection in organic synthesis: (14 Lectures)

Basic concept on retrosynthesis, disconnection approach towards synthesis of bifunctional molecules (both cyclic and acyclic), concept of synthons, synthetic equivalents, functional group interconversion, Protection and deprotection of common functional groups in synthetic route, activation of synthetic equivalents, Disconnection and synthesis of (1,3),(1,4) and (1,5)-dioxxygenated compounds, Some specific examples indicating the retrosynthetic approach to design a total synthesis.

Reference Books:

(1) Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill Education (2000). (2) Nasipuri, D. Stereochemistry of Organic Compounds (Principles and Applications), 2nd Edition, New age int. (P) Ltd, Publishers, 2005. (3) Heterocyclic Chemistry by John A. Joule, Keith Mills

and G. F. Smith (Indian Edition) (4) Finar, I. L. *Organic Chemistry (Vol. I)*, 6th Ed., Pearson (2002). (5) Finar, I. L. *Organic Chemistry (Vol. II)*, Pearson (2002). (6) Acheson, R. M. *Introduction to the Chemistry of Heterocyclic compounds*, John Welly& Sons (1976). (7) Clayden, J.; Greeves, N. & Warren, S. *Organic Chemistry*, 2nd Ed., Oxford University Press (2012). (8) Warren S. *Organic Synthesis: The disconnection Approach*, Wiley (2008). (9) Ian Fleming-Pericyclic Reactions (Oxford Chemistry Primers, 67)-Oxford University Press, USA (1998) (10) Mandal, Dipak K - Pericyclic chemistry. Orbital mechanisms and stereochemistry (2018, Elsevier) (11) Ian Fleming-Frontier Orbitals and Organic Chemical Reactions-Wiley (1976)

MAJOR COURSE [Code: MJCH 13: Gr. A]

Physical Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Phase Equilibria: (15 Lectures)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems; phase diagrams for multi-component system-two component liquid-liquid system, liquid-vapour, solid-liquid systems, boiling point-composition diagrams, eutectic, congruent and incongruent melting points, distillation, Gibbs-Duhem-Margules equation, its derivation, lever rule, azeotropes, partial miscibility of liquids, CST, miscible pairs salt hydrates, salt-water systems, eutectic formation binary alloys-tin and lead, tin and magnesium, copper and silver. Nernst distribution law: its derivation and applications.

Unit II: Quantum Mechanics I: (15 Lectures)

Failures of Classical Physics, Black Body Radiation, Photo-electric effect, Wave-particle duality, Wave Equation, Postulates of quantum mechanics, quantum mechanical operators, eigenfunction & eigenvalue, linear and Hermitian operator, commutation, probabilistic interpretation, well-behaved function, normalization of the wave function, Heisenberg Uncertainty principle, Ehrenfest theorem, Schrödinger equation and its application to free particle and “particle-in-a-box” (rigorous treatment): quantization of energy levels, zero-point energy, eigenfunctions, nodal properties, extension to two- and three-dimensional boxes, separation of variables, degeneracy, selection rule and application of the present model.

Reference Books:

(1) Physical Chemistry, P. C. Rakshit, (2) Atkins’ Physical Chemistry, P. Atkins, J. de Paula, J. Keeler, (3) A Textbook of Physical Chemistry, Volume- 3, K. L. Kapoor, (4) Quantum Chemistry, Ira N. Levine, Pearson Education India, (5) Quantum Chemistry, R. K. Prasad, New Age International.

MAJOR COURSE [Code: MJCH 13: Gr. B]

Physical Chemistry Practical

(Credits: 2, F.M. 50) (60 Lectures)

1. Potentiometry

Perform the following potentiometric titrations:

- i. Strong acid vs. strong base
- ii. Weak acid vs. strong base
- iii. Dibasic acid vs. strong base
- iv. Potassium dichromate vs. Mohr's salt

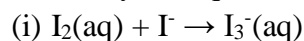
2. Phase equilibrium

I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method: a. simple eutectic and b. congruently melting systems.

III. Distribution of acetic/ benzoic acid between water and cyclohexane.

IV. Study the equilibrium of at least one of the following reactions by the distribution method:



3. pH-metry

a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

b. Preparation of buffer solutions of different pH

i. Sodium acetate-acetic acid

ii. Ammonium chloride-ammonium hydroxide

c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.

d. Determination of dissociation constant of a weak acid.

4. Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction

2. Integrated rate method: a. Acid hydrolysis of methyl acetate with hydrochloric acid. b. Saponification of ethyl acetate.

3. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate.

Reference Books:

(1) Physical Chemistry Practical, S. K. Maity & N.K.Ghosh (2) A Textbook of Physical Chemistry, Experimental Aspects in Physical Chemistry, Volume-7, K. L. Kapoor

Semester VI

MAJOR COURSE [Code: MJCH 14]

INORGANIC CHEMISTRY

(Credits: 04, F.M. 100) (60 Lectures)

Unit 1. Organometallic Compounds: (30 Lectures)

Definition and classification of organometallic compounds. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π -acceptor behaviour of CO, synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. Reaction in organometallic Chemistry: Oxidative addition, reductive elimination and migratory insertion, fluxional organometallic compounds

Catalysis by Organometallic Compounds: Study of the following industrial processes and their mechanism: 1. Alkene hydrogenation (Wilkinson's Catalyst), 2. Hydroformylation (Co salts), 3. Wacker Process, 4. Synthetic gasoline (Fischer Tropsch reaction), 5. Synthesis gas by metal carbonyl complexes

Unit 2: Inorganic Photochemistry: (10 Lectures)

Basics of photochemistry- absorption, excitation, photochemical laws, quantum yield, lifetime of excited states, flash photolysis, stopped flow techniques, energy dissipation by radiative and non-radiative process, absorption spectra, Franck-Condon principles, photochemical stages- primary and secondary process; properties of excited states- structure, dipole moment, acid-base strength, reactivity; photochemical kinetics- calculation of rates of radiative process; bimolecular deactivation - quenching; excited states of metal complexes- comparison with organic compounds, electronically excited states of metal complexes, charge transfer excitation.

Unit 3. Nanomaterials: (10 Lectures)

The scope and challenges of nanomaterials, definition, nano versus bulk, top-down and bottom-up approaches, Stabilization of nanostructures, Synthesis of metallic, semiconducting and oxide nanoparticles, examples of 0D, 1D, 2D and 3D nanostructures, concept of quantum confinement

and its effect on optical properties of metallic and semiconducting nanoparticles, idea of quantum dot, electrical and magnetic properties of nanostructured materials, superparamagnetism, fullerenes and carbon nanotubes, basic characterization tools for nanomaterials, Scherrer's formula, applications of nanomaterials.

Unit-4: Separation Techniques: (10 Lectures)

Principle, distribution ratio and partition coefficient, successive extraction and separation; different methods of extraction systems; Craig extraction and counter current distribution; problems; chromatography: general principle; classification, mathematical relations of capacity, selectivity factor, distribution constant and retention time; chromatogram, evaluation in column chromatography: band broadening and column efficiency; Van Deemeter equation; column resolution, numerical problems, GC, LC, TLC, PC, SEC.

Reference Books:

(1) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (2) Elias, B. D. Gupta, Basic Organometallic Chemistry, Universities Press (ed. 2), 2013. (3) Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988. (4) Shriver, D.D. & P. Atkins, Inorganic Chemistry 4th Ed., Oxford University Press, 1994. (5) Miessler, G. L. & Tarr, D.A. Inorganic Chemistry 4th Ed., Pearson, 2010. (6) Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000. (7) Spessard, G. O. & Miessler, G.L. Organometallic Chemistry. Upper Saddle River, NJ: Printice-Hall, 1996. (8) Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988. (9) Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004. (10) Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016. (11) Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed. (12) Introduction to Nanomaterials and Nanoscience by Asim K Das and Mahua Das, CBS Publications & Distributor (13) Nanostructures & Nanomaterials: Synthesis, Properties and Applications by Guozhong Cao, Imperial College Press. (14). Fundamentals and Applications of Nanomaterials by Zhen Guo & Li Tan, Artech House. (15). Nanoparticles - Nanocomposites Nanomaterials: An Introduction for Beginners by Dieter Vollath, Wiley-VCH (16). Introduction to Nanoscience by S.M. Lindsay, Oxford. (16) Bioinorganic photochemistry by G. Stochel. Wiley

MAJOR COURSE [Code: MJCH 15: Gr. A]

Organic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Organic Spectroscopy: (20 Lectures)

Application of spectroscopy for elucidating the structure of organic molecules:

UV-Vis Spectroscopy:

Fundamental principles, Types of electronic transitions; Interpretation of UV-Vis spectra of organic compounds Chromophores, Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{\max} of α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

IR Spectroscopy: Fundamental principles of molecular vibrations; Interpretation of IR spectra of organic compounds, Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and group frequency regions; application in functional group analysis.

NMR Spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds. Carbon-13 NMR spectroscopy- general considerations; chemical shift values (aliphatic, olefinic, alkyne, heteroaromatic, and carbonyl carbon); coupling constant.

Mass spectrometry: Introduction; ion production – EI, CI, FD, and FAB; factors affecting fragmentation; ion analysis; ion abundance; mass spectral fragmentation of organic compounds; common functional groups; molecular ion peak; metastable peak; McLafferty rearrangement; nitrogen rule; high-resolution mass spectroscopy; examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Unit 2: Analysis of IR, UV-Vis, NMR and Mass spectral data for elucidating the structure of organic molecules. (10 Lectures)

Polynuclear Hydrocarbons:

Bond structure, Aromatic character and positional activity of polynuclear hydrocarbons (Naphthalene, anthracene and phenanthrene); Method of synthesis; Reactions.

Rearrangement Reactions:

Rearrangement reactions: Formation and stability of carbonium ions, carbanion, carbenes, nitrenes, radicals and arynes, rearrangement involving carbocation (Wagner-Meerwein, Pinacol-Pinacolone rearrangement), reaction involving acyl cation, PPA cyclization and Fries rearrangement, rearrangement of carbenes (Wolff & Arndt-Eistert synthesis), rearrangement of nitrenes (Hoffmann, Curtius, Schmidt, Lossen, Beckmann rearrangement); sigmatropic rearrangements.

Reference Books:

(1) Pavia, D. L., Lampman, G. M., and Kriz, G. S., "Introduction to Spectroscopy" (2) Silverstein, R.M., and Webster, F.X., "Spectrometric Identification of Organic Compounds" (3) Kemp, W. "Organic Spectroscopy" (4) Kalsi, P.S., "Spectroscopy of Organic Compounds" (5) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012). (6) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988). (7) Organic Chemistry, Vol-1 &2, I.L. Finar (8) Elementary Organic Spectroscopy by Y. R. Sharma

MAJOR COURSE [Code: MJCH 15: Gr. B]

Organic Chemistry

(Practical, Credits: 2, F.M. 50) (60 Lectures)

- i. 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) by any one method:
 - a. Using conventional method.
 - b. Using green approach
- ii. Benzoylation 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, *p*-cresol) by Schotten-Baumann reaction.
- iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).
- iv. Bromination of any one of the following:
 - a. Acetanilide by conventional methods
 - b. Acetanilide using green approach (Bromate-bromide method)
- v. Nitration of any one of the following:
 - a. Acetanilide/nitrobenzene by conventional method
 - b. Salicylic acid by green approach (using ceric ammonium nitrate).
- vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.
- vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.
- viii. Hydrolysis of amides and esters.
- ix. Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone, benzaldehyde.
- x. *S*-Benzylisothiuronium salt of one each of water soluble and water insoluble acids (benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).
- xi. Aldol condensation using either conventional or green method.
- xii. Benzil-Benzilic acid rearrangement.

Reference Books:

(1) Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson (2009). (2) Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G. & Tatchell, A. R. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson (2012).

MAJOR COURSE [Code: MJCH 16: Gr. A]**Physical Chemistry****(Theory, Credits: 2, F.M. 50) (30 Lectures)****Unit 1: Molecular Spectroscopy I: (15 Lectures)**

Characterization of electromagnetic radiation, regions of spectra, quantization of energy in molecules; representation of spectra, basic elements of spectroscopy, signal-to-noise ratio, intensity and width of spectral transition. Rotational 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, 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. Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Unit 2: Quantum Mechanics II: (15 Lectures)

Quantum mechanical treatment of simple harmonic oscillator: setting up of Schrödinger equation and its solution by operator method and usual technique, discussion of solution and wave functions, vibrational energy of diatomic molecules, uncertainty principle, zero-point energy, selection rule, and application of the model. Orbital angular momentum: operators in polar coordinates, operator algebra for rotational motion, commutation rules, quantization of square of total angular momentum and z-component, determination of eigenvalues and eigenfunctions of L^2 and L_z operators by usual technique and by ladder operator method, space quantization, vector model, central force problem, setting up of Schrödinger equation in polar coordinates.

Reference Books:

(1) Fundamentals of Molecular Spectroscopy, C. N. Banwell, (2) Quantum Chemistry, Ira N. Levine, Pearson Education India, (3) Quantum Chemistry, R. K. Prasad, New Age International. (4) Modern Spectroscopy, J. M. Hollas.

MAJOR COURSE [Code: MJCH 16: Gr. B]

Physical Chemistry Practical

(Credits: 2, F.M. 50) (60 Lectures)

1. Adsorption

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

2. UV/Visible spectroscopy

I. Study the 200-500 nm absorbance spectra of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ (in 0.1 M H_2SO_4) and determine the λ_{max} values. Calculate the energies of the two transitions in different units (J molecule^{-1} , kJ mol^{-1} , cm^{-1} , eV).

II. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of $\text{K}_2\text{Cr}_2\text{O}_7$.

III. Record the 200- 350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

3. Colourimetry

I. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration

II. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture.

III. Study the kinetics of iodination of propanone in acidic medium.

IV. Determine the amount of iron present in a sample using 1,10-phenanthroline.

V. Determine the dissociation constant of an indicator (phenolphthalein).

VI. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.

VII. Analysis of the given vibration-rotation spectrum of $\text{HCl}(\text{g})$

4. To verify **Ostwald dilution** law and determine the K_a of a weak acid by conductometric method.

Reference Books:

(1) Physical Chemistry Practical, S. K. Maity & N.K.Ghosh (2) A Textbook of Physical Chemistry, Experimental Aspects in Physical Chemistry, Volume-7, K. L. Kapoor

Semester VII

MAJOR COURSE [Code: MJCH 17: Gr. A]

INORGANIC CHEMISTRY

(Credits: 02, F.M. 50) (30 Lectures)

Unit 1: Molecular Magnetism: (9 lectures)

Basic concepts of magnetism, magnetization and magnetic susceptibility, types of magnetic behavior (dia-, para-, ferro-, ferri- and antiferro-) and their temperature dependence, Curie and Curie-Weiss laws, temperature independent paramagnetism, Pascal's Constants and its utilities, determination of χ_M in solution, usefulness of μ_s and μ_j equation respectively for transition and inner transition series, van Vleck's equation and its applications, spin-orbit coupling, zero-field splitting, quenching of orbital angular momentum, high-spin/low-spin equilibrium, types of exchange interactions, introduction to magnetic material: A systematic theoretical and experimental approach.

Unit 2: Physical Characterization of Inorganic Compounds by EPR and NMR Spectroscopy: (14 Lectures)

Basic principle of EPR, Standard material for ESR spectroscopy (dpph), detailed understanding of hyperfine coupling constant, significance of g-tensors, application to detect free radicals (H, CH₃, C₆H₅, NH₂, CD₃, PH₄, F₂⁻, [BH₃]⁻, etc.) and various transition metal complexes having one unpaired electron, charge transfer spectra and its application.

Basic principle and spectral display, Application NMR spectroscopy-fundamentals, the contact and pseudo-contact shifts, factors affecting nuclear relaxation, application of H-1, C-13, P-31 and F-19 NMR towards the structural elucidation of metal-organic complexes, an overview of metal nuclides with emphasis on Pt-195 and Sn-119 NMR.).

Unit 3: Nuclear Detection Techniques: (7 lectures)

Mössbauer spectroscopy: Mossbauer effect, nuclear recoil, Doppler effect, instrumentation, chemical shift-examples, quadruple effect, effect of magnetic field, effect of simultaneous electric and magnetic fields, typical spectra of iron and tin compounds, application of Mössbauer spectroscopy-nature of metal-ligand bond, coordination number, structure, oxidation state; NQR.

Reference Books

- (1) O. Kahn, Molecular Magnetism. (2). R.S. Drago, Physical Methods, 1972, New York. Edn.
- (3) N. N. Greenwood - Mossbauer Spectroscopy (1971, Springer)
- (4) P. Gülich, E. Bill, A. X. Trautwein – Mossbauer Spectroscopy and Transition Metal Chemistry_ Fundamentals and Applications,
- (5) A K Das Fundamental Concepts of Inorganic Chemistry Vol 7, CBS Publishers & Distributors
- (6) Organic Spectroscopy by William Kemp
- (7) C N Banwell Fundamentals of Molecular Spectroscopy

MAJOR COURSE: [Code: MJCH 17: Gr. B]

Inorganic Chemistry Practical

(Credit: 02, F.M. 50) (60 lectures)

1. Analysis of some ores and alloys.
2. Separation by chromatographic techniques
3. Determination of composition and formation constant of a few selected systems by pH and spectrophotometric method.
4. Preparation of some complex salts and their characterization.
5. Magnetic susceptibility measurements
6. Colorimetric estimation of some metal ions.
7. Green synthesis of some inorganic compounds

Reference Books

(1) Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012. (2) Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009 (3) Advanced experiments in inorganic chemistry by G. N. Mukherjee

MAJOR COURSE [Code: MJCH 18: Gr. A]

Organic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Chemistry of Proteins, Lipids and Nucleic acids: (15 Lectures)

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

Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis

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

Components of nucleic acids, Nucleosides and nucleotides;

Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine;

Structure of polynucleotides.

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).

Lipids: General ideas of fat, wax, triglycerides; trans-fat, Trans esterification of fats and oils to biodiesel, structure and functions of triacylglycerols, fatty acids, glycerophospholipids, Sphingolipids, Gangliosides, properties of lipid bilayers, Phospholipids, biological membranes, fluid-mosaic models of membrane structure.

Unit 2: Carbohydrates: (10 Lectures)

Occurrence, classification and their biological importance.

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

Disaccharides – Structure elucidation of maltose, lactose and sucrose.

Polyaccharides – Elementary treatment of starch, cellulose and glycogen.

Unit 3: Polymers: (5 Lectures)

Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index.

Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes; 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; Biodegradable and conducting polymers with examples.

Reference Books:

- (1) Morrison, R. T. & Boyd, R. N. Organic Chemistry, 7th Ed., Pearson Education India (2011).
- (2) Finar, I. L. Organic Chemistry (Vol. I), 6th Ed., Pearson (2002).
- (3) Finar, I. L. Organic Chemistry (Vol. II), Pearson (2002).
- (4) Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry, 7th Ed., W. H. Freeman & Co. (2017).
- (5) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012).
- (6) Polymer Chemistry-An introduction: Malcolm P. Stevens
- (7) Principles of Polymerization: G. Odian
- (8) Elements of Polymer Science & Engineering: Alfred Rudin

MAJOR COURSE [Code: MJCH 18: Gr. B]
Organic Chemistry
(Practical, Credits: 2, F.M. 50) (60 Lectures)

Separation of components from a mixture of organic compounds followed by their characterization

a. Chemical Separation

b. Chromatographic Separation

Reference Books:

(1) Mann, F. G. & Saunders, B. C. Practical Organic Chemistry, Pearson (2009). (2) Furniss, B. S.; Hannaford, A. J.; Smith, P. W. G. & Tatchell, A. R. Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Pearson (2012).

MAJOR COURSE [Code: MJCH 19]
Physical Chemistry
(Theory, Credits: 4, F.M. 100) (60 Lectures)

Unit 1: Molecular Spectroscopy II: (15 Lectures)

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Vibrational Raman spectra, Stokes, and anti-Stokes lines; their intensity difference, rule of mutual exclusion. Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, Relaxation time, Interpretation of PMR spectra of organic molecules. Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

Unit 2: Quantum Mechanics III: (15 Lectures)

Particle on a ring and rigid rotator model for diatomic molecule: Schrödinger equation, transformation to spherical polar coordinates, separation of variables, spherical harmonics, solution of Schrödinger equation, discussion of solution, selection rules and application. Treatment of H-like atoms: setting up of Schrodinger equation in spherical polar coordinates,

separation of radial & angular part, quantization of energy (only final energy expression), quantum numbers, n , l and m , nature of wave function up to $n = 3$ (only expression), real wave function, radial distribution function, average and most probable distances of electron from nucleus, concept of orbitals & shapes of s , p , d orbitals.

Unit 3: Statistical Thermodynamics: (15 Lectures)

Importance of statistical thermodynamics, entropy and probability, microstate and microstate, thermodynamic probability, Stirling's approximations, Maxwell-Boltzmann distribution, Gibbs paradox, Sackur-Tetrode equation, concept of partition functions, translational, rotational, vibrational and electronic partition functions, thermodynamic properties in terms of partition functions, equilibrium constant, equipartition principle, Einstein and Debye theory of specific heat capacity of solids.

Unit 4: Group Theory: (15 Lectures)

Introduction to symmetry, symmetry elements and symmetry operations, definition of a group, point symmetry groups, group multiplication tables, theorems of groups, conjugate elements and class, symmetry operators and their matrix representations, function space, reducible and irreducible representations, equivalent representations, characters of representations.

Great orthogonality theorem: statement and interpretation, proof of its corollaries, character table and its construction, number of times an irreducible representation occurs in a reducible one, the reduction of reducible representations, notation of irreducible representations, representations and quantum mechanics, the invariance of Hamiltonian operator under symmetry transformations, direct product representation, molecular vibrations, symmetry species of the vibrational mode, selection rules for infra-red and Raman spectra, crystal field splitting, SALC of atomic orbitals.

Reference Books:

(1) Fundamentals of Molecular Spectroscopy, C. N. Banwell, (2) Quantum Chemistry, Ira N. Levine, Pearson Education India, (3) Quantum Chemistry, R. K. Prasad, New Age International, (4) Physical Chemistry: A Molecular Approach, Donald A. McQuarrie and John D. Simon, Viva Books, (5) Physical Chemistry, P. W. Atkins, J. D. Paula and J. Keeler, Oxford University Press, (6) Chemical Applications of Group Theory by F. A. Cotton. (7) Modern Spectroscopy, J. M. Hollas.

Semester VIII

MAJOR COURSE [Code: MJCH 20: Gr. A]

INORGANIC CHEMISTRY

(Credits: 02, F.M. 50) (30 Lectures)

Unit 1. Cage, Metal Clusters and Ring Compounds: (14 lectures)

Cage compounds- higher boron hydrides- structure and reactivity, equation of balance-styx numbers, Lipscomb topological diagrams, Wades rules, Jemmis' unifying electron counting rule, carboranes, metallocarborane, metalloboranes and heteroboranes, phosphorous cage compounds, metal clusters- cluster classification, skeletal electron counting, bonding in metal clusters, polyhedral skeleton electron pair theory (PSEPT), low nuclearity (M_3 , M_4) and high nuclearity (M_5 - M_{10}) carbonyl clusters: application of isolobal and isoelectronic relationships, capping rules, Zintl ions.

Unit 2: Thermo-analytical Methods: (8 lectures)

Introduction to thermal analysis: thermo-gravimetric analysis (TGA), differential thermo-gravimetric analysis (DTGA), differential thermal analysis (DTA) – principles and methods, presentation of thermal data, differential scanning calorimetry (DSC): a brief outline and a comparative discussion of DSC with DTA, thermal degradation, laws governing nucleation and growth of nuclei, applications of thermal methods of analysis with special reference to solid state reactions, decomposition of inorganic compounds.

Unit 3: Electro-analytical Methods: (8 lectures)

Electrochemical cell, decomposition and discharge potential, current voltage diagram, potentiometry & potentiometric titration, membrane electrodes, ion-selective electrodes, Nikolskii-Eisenman equation, chronoamperometry, Cottrell Equation, Cyclic Voltammetry (CV), excitation and switching potential, Randles-Sevcik equation, applications of CV. Polarography: Basic principles – polarized depolarized electrodes; polarographic wave; diffusion currents, DME, Ilkovič equation and its significance Heyrovsky-Ilkovič equation, DC and AC polarography, stripping voltammetry.

Reference Books

(1). Principles of Instrumental Analysis by Skoog, Holler and Nieman, Harcourt Asia Pvt Ltd
(2). Fundamentals Concepts of Inorganic Chemistry Volume 3B by Asim K. Das, CBS Publications & Distributors
(3). Quantitative Analysis by V. N. Alexeyev, Mir Publishers
(4). Analytical Chemistry 7th Edition by Gary D Christian, Purnendu K. (Sandy) Dasgupta, Kevin A. Schug, WILEY
(5). Analytical Electrochemistry by Joseph Wang, Wiley-VCH
(6) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed.,

Harper Collins 1993, Pearson, 2006. (7) Cotton F., Wilkinson G. Advanced inorganic chemistry (8) Catherine Housecroft, Alan Sharpe - Inorganic Chemistry (2018, Pearson)

MAJOR COURSE [Code: MJCH 20: Gr. B]
Organic Chemistry (Indian Knowledge System)
(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Natural Products (Alkaloids and Terpenoids) with Special Reference to Biosynthesis: (10 Lectures)

Natural products: Foundations of traditional Indian medicine and glimpse of traditionally used Indian medicinal plants, Tulsi, Ashwagandha, and Neem and derived natural products of different classes, like flavonoid, terpenoids, alkaloids etc; Discussion on the biosynthesis: Acetate pathway, biosynthesis of a) secondary metabolites from shikimic acid, flavonoids and related polyphenolics, b) mono, diterpenoids and triterpenoids from mevalonic acid, c) Steroids, d) alkaloids like atropine, quinine.

Unit 2: Advanced reaction mechanism with special reference to newly developed synthetic strategies: (10 Lectures)

Contemporary developments in the field of organic synthesis with special references to the newly developed synthetic strategies, their inherent detailed mechanistic aspects, interrelationship of structure and mechanism, stereochemical aspects, scopes of the reactions, and contexts of the synthetic techniques. Biological relevances of the targeted molecules and structure-activity relationships. Overview of the recent advances in frontier organic reactions. Modifications of the earlier well-known organic reactions (covering all types and categories) as reported in recent times. Metathesis and click chemistry.

Unit 3: Asymmetric Synthesis: (10 Lectures)

Introduction, kinetic and thermodynamic principles to asymmetric synthesis, diastereoselective and enantioselective synthesis; methods of asymmetric synthesis: resolution, use of chiral pool, chiral auxiliaries, use of stoichiometric chiral reagents, asymmetric catalysis.

Asymmetric hydrogenation with special reference to Ru-BINAP catalyst, asymmetric reduction of prochiral ketones with Baker's yeast and CBS catalyst, asymmetric epoxidation with special reference to Sharpless and Jacobsen epoxidation, asymmetric diethyl zinc addition to carbonyl compound, asymmetric aldol reactions, asymmetric Michael reaction; few important industrial applications of asymmetric synthesis.

Book References:

(1) Finar, I. L. Organic Chemistry (Vol. II), Pearson (2002). (2) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012). (3) Paul M. Dewick, Medicinal Natural Products: A Biosynthetic Approach, 3rd Edition.

MAJOR COURSE [Code: MJCH 21: Gr. A]

Physical Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Quantum Chemistry: (15 Lectures)

Solution of Schrödinger equation for H -like atoms. Zeeman Effect: introduction of concept of spin. Need for approximation methods for many-electron systems, statement of variation theorem and application to simple systems (particle- in-a-box, harmonic oscillator and hydrogen atom). Chemical bonding: valence bond and molecular orbital approaches, VBT and MOT for H_2^+ molecular ion, LCAO-MO treatment, bonding and antibonding orbitals.

Unit 2: Electronic Spectroscopy and Photochemistry: (15 Lectures)

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, Stern-Volmer Plot, 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.

Book References:

(1) Quantum Chemistry, Ira N. Levine, Pearson Education India, (2) Quantum Chemistry, R. K. Prasad, New Age International, (3) Fundamentals of Molecular Spectroscopy, C. N. Banwell, (4) Fundamentals of Photochemistry, K.K. Rohatagi-Mukherjee.

MAJOR COURSE [Code: MJCH 21: Gr. B]

Physical Chemistry Practical

(Credits: 2, F.M. 50) (60 Lectures)

1. To determine the rate constant of a reaction in a micellar media by conductometric method.
2. To determine the composition of a mixture of acetic acid, sodium acetate and ammonium acetate by conductometry.
3. To study the formation of charge transfer complex and determination of stoichiometry of the complex conductometrically & spectrophotometrically.
4. To determine the rate constant and salt effect on the rate constant of decomposition of $K_2S_2O_8$ by KI using spectrophotometric method.

5. To determine the dissociation constant of an indicator by spectrophotometry.
6. To study the kinetics of alkaline hydrolysis of crystal violet by spectrophotometry.
7. To determine the pK_a value of a poly-basic acid by pH-metry and preparation of buffer solution of desired pH range.

Book References:

(1) Physical Chemistry Practical, S. K. Maity & N.K.Ghosh (2) A Textbook of Physical Chemistry, Experimental Aspects in Physical Chemistry, Volume-7, K. L. Kapoor

Additional 12-Credit Course

Semester VII

MAJOR COURSE (Additional) [Code: MJACH 01]

Organic Chemistry

(Theory, Credits: 4, F.M. 100) (60 Lectures)

Unit 1: Static Stereochemistry: (10 Lectures)

Molecular symmetry and chirality, Conformation of acyclic and cyclic systems (3 to 5 and 7 to 8 membered ring), conformation of rings with single and multiple double bonds, conformation of 3 to 6 membered heterocycles, stereoelectronic effects in heterocycles, optically active compounds with no asymmetric carbon, Baldwin's rule, stereochemistry of fused ring and bridged ring compounds (with special reference to decalin and phenanthrene systems).

Unit 2: Dynamic Stereochemistry: (10 Lectures)

Conformation and reactivity, Curtin-Hammett principle and Wenstein-Eliel equations, conformation reactivity and mechanism of acyclic and cyclic system (nucleophilic substitution reaction, formation and cleavage of epoxide ring, addition reactions to double bonds, elimination reactions, pyrolytic syn-elimination, oxidation of cyclohexanols, neighbouring group participation reactions), stereoelectronic effects, elementary idea about asymmetric synthesis.

Unit 3: Reactions Mechanism I: (15 Lectures)

Substitution reactions: Aliphatic nucleophilic substitution- S_N1 , S_N2 , mixed S_N1 and S_N2 , SET mechanisms; neighbouring group participation by π - and σ -bonds, anchimeric assistance; S_{Ni} mechanism; nucleophilic substitution at an allylic, aliphatic trigonal and a vinylic carbon; effect of substrate structures on reactivity, nucleophiles, leaving group and reaction medium; phase transfer catalysis, regioselectivity; Aromatic nucleophilic substitution- S_{NAr} , benzyne and $S_{RN}1$ mechanisms; effect of substrate structures on reactivity, leaving group and attacking nucleophile; Aliphatic electrophilic substitution- S_{E1} , S_{E2} , and S_{Ei} mechanisms; electrophilic substitution accompanied by double bond shifts; effects of substrates, leaving group and solvent polarity on the reactivity, Aromatic electrophilic substitution-the arenium ion mechanism; orientation and reactivity; energy profile diagrams; the *ortho/Para* ratio; orientation in other ring systems; *ipso* attack; *Free radical reactions:* types of free radical reactions; free radical substitution mechanism; mechanism at an aromatic substrate; neighbouring group assistance; reactivity for aliphatic and aromatic substrates at a bridgehead; reactivity in the attacking radicals; effects of solvents on reactivity; allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids; auto-oxidation; free radical rearrangements

Elimination reactions: E1, E2 and E1cB mechanisms; product stereochemistry; effects of substrate structures, attacking base, leaving group and the medium on reactivity; mechanism and orientation in pyrolytic elimination

Unit 4: Reaction Mechanism II: (10 Lectures)

Addition reactions: Addition to carbon-carbon multiple bonds-mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals; region- and chemo selectivity; orientation and reactivity; addition to carbon-hetero multiple bonds-mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles; addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds; Mechanism of condensation reactions involving enolates-Aldol, Knoevenagel, Claisen, Perkin and Stobbe reactions.

Metathesis and click chemistry: Definition, classes of reactions, catalysts used, mechanistic aspects and synthetic applications of methathesis reactions and click reactions in organic chemistry with suitable examples.

Unit 5: Some Selective Name Reactions: (15 Lectures)

Shapiro reactions, Mitsunobu reaction, Hofmann-Löffler-Freytag reaction, Barton reaction, ene reaction, Mannich reaction, Stork enamine reaction, Michael addition, Robinson annulations, Barton decarboxylation and deoxygenation, Sharpless asymmetric epoxidation.

Reference Books:

- (1) Eliel, E. L. Stereochemistry of Carbon Compounds, Tata McGraw Hill Education (2000).
- (2) Nasipuri, D. Stereochemistry of Organic Compounds (Principles and Applications), 2nd Edition, New age int. (P) Ltd, Publishers, 2005.
- (3) Norman, R. O. C. & Coxon, J. M. Principle of Organic Synthesis, 2nd Ed., Springer (1993).
- (3) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988).
- (4) Morrison, R. T. & Boyd, R. N. Organic Chemistry, 7th Ed., Pearson Education India (2011).
- (5) Finar, I. L. Organic Chemistry (Vol. II), Pearson (2002).
- (6) Clayden, J.; Greeves, N.; Warren, S. & Wothers, P. Organic Chemistry, 2nd Ed., Oxford University Press (2012).
- (7) Basic Stereochemistry of organic Molecule by S. Sengupta

Semester VIII

MAJOR COURSE (Additional) [Code: MJACH 02]

Inorganic Chemistry

Credits: 4 [3 (Theory) + 1 (Tutorial)] (45 + 15 Lectures) [F.M. 100]

Unit 1: Supramolecular Chemistry: (25 lectures)

Basic aspect of Supramolecular Chemistry, Difference between supramolecular chemistry and molecular chemistry, Progress of supramolecular chemistry, Low molecular weight materials-based supramolecular networks, Basic concept of Self-assembly process, types of Self-assembly process, Uses of Self-assembly, Idea about host-guest chemistry, receptor and receptor-substrate association, Molecular recognition process, ion and chemical recognitions.

Non-covalent interactions in supramolecular systems: cation- π , anion- π , π - π , lone pair- π , hydrophobic and hydrophilic patterns, hydrogen-bondings, van der Waals interactions, Different functional solid, semi-solid, and liquid supramolecular systems, Supramolecular synthon, Supramolecular reactivity and catalysis, Supramolecular electronic, ionic and photonic devices, Systematic synthetic approach towards functional supramolecular architectures.

Unit 2: Advanced Chemistry of the Elements: (20 lectures)

Major applications of the s-block elements, Major landmark discoveries in the chemistry of p-block elements, Bonding and molecular orbitals of polyatomic p-block compounds, Recent developments in boron, carbon, phosphorous and silicon chemistry, Noble gas chemistry, Understanding the reactivity of noble gases and their unusual compounds, Insights into the reaction mechanisms and light-driven processes of transition metal complexes, Fluxional behaviour of p-block and d-block compounds, Applications in luminescence and nuclear technologies of f-block compounds, Artificially synthesized super heavy elements

Unit 3: Tutorial (15 Lectures)

Reference Books:

(1) Jean-Marie Lehn - Supramolecular Chemistry: Concepts and Perspectives; (2) W. Steed Supramolecular Chemistry (3) Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991. (3) Basic Inorganic Chemistry, 3ed by F. Albert Cotton, Geoffrey Wilkinson. (4) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006. (5) R. P. Sarkar, General and Inorganic Chemistry (Vol. 1), New Central Book Agency, ed. 3, 2011 (6) R. L. Dutta & G.S. De, Inorganic Chemistry (Vol. 1), The New Book Stall, 1973 (7) Chemistry of the p-block elements by Anil J Elias. (10) Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997. (11) Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970

MAJOR COURSE (Additional) [Code: MJACH 03]

Physical Chemistry

(Theory, Credits: 4, F.M. 100) (60 Lectures)

Unit 1: Approximate Methods and their Applications: (15 Lectures)

Approximation method for many-electron systems: Perturbation theory and its application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom, and helium atom). Hückel Molecular orbital theory and its applications, Many electrons wave function, Slater determinant.

Unit 2: Colloids & Polymers: (15 Lectures)

Definition of colloids, Classification of colloids, Solids & liquids(sols), Liquids in liquids(emulsions): types of emulsions, Preparation of emulsifier liquids in solids Gels: elastic and non-elastic gels, imbibition, synergesis.

Purification of colloidal solutions—dialysis and ultra-filtration. Kinetic, electrical and optical properties of colloidal systems—Ultra microscope, Coagulation of colloids, Hardy-Schulz rule and gold number, Electrical double layer and zeta potential, Stability of colloids in solution. Surface charge of colloidal particles.

Surfactants-micelles, critical micelle concentration, sedimentation and streaming potential.

Application of colloids-Cottrell precipitator-sewage disposal-formation of deltas.

Monomers, polymers, repeating units, functionality. Nomenclature of polymers. Importance and applications of polymers. Classification of polymers. Ladder and spiral polymers. Cis-trans configuration. DL isomers and tacticity.

Polymerization reaction, Kinetics of free radical and condensation polymer, Graft polymerization, Thermodynamics of polymer solutions, Flory-Huggins model.

Degree of polymerization and molecular weight. Practical significance of molecular weight. Threshold molecular weight. Concept of average molecular mass and molecular mass distribution. Number average, weight average and z average molecular mass and their calculation. Viscosity average molecular mass. Molecular mass distribution curve. Polydispersity and polydispersity index of polymers. Measurement of molecular weight by viscosity method.

Unit 3: Photo-physical processes in the Electronically Excited States: (15 Lectures)

Physical properties of the electronically excited molecules, shapes of absorption and emission band and Franck-Condon principle, mirror image relationship of emission spectra, Jablonski Diagram, types of photophysical pathways, radiation less transition-internal conversion and intersystem crossing, fluorescence emission, triplet states and phosphorescence emission, Characteristics of Fluorescence Emission, The Stokes Shift, Exceptions to the Mirror-Image Rule, Fluorescence Lifetimes and Quantum Yields, Fluorescence Quenching, Timescale of Molecular Processes in Solution, Steady-State and Time-Resolved Fluorescence, Effects of Solvent Polarity on fluorescence spectra, Other Mechanisms for Spectral Shifts, General Solvent

Effects: The Lippert-Mataga Equation Application of the Lippert Equation, Specific Solvent Effects. Temperature Effects, Additional Factors that Affect Emission Spectra, Locally Excited and Internal Charge-Transfer States, Excited-State Intramolecular Proton Transfer (ESIPT), Changes in the Non-Radiative Decay Rates, Changes in the Rate of Radiative Decay. Resonance Energy Transfer, Characteristics of Resonance Energy Transfer, Theory of Energy Transfer for a Donor-Acceptor Pair, Orientation Factor κ^2 , Dependence of the Transfer Rate on Distance (r), the Overlap Integral (J), and τ^2 , Photoinduced Electron Transfer (PET) Mechanism and energetics, Marcus theory of electron transfer, Experimental verification of the Marcus inverted region for Photoinduced Electron transfer..

Unit 4: Electrical & Magnetic Properties of Molecules: (15 Lectures)

Electric Dipole Moment, Molecular Polarization and Polarizability, Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosottii equation, Debye Equation, Experimental method to determine polarizability and dipole moment in Gaseous and Condensed system, Molar Polarization and its dependency with frequency of electric field, Lorentz-Lorenz equation, Molecular Interpretation of Diamagnetism & Paramagnetism, Amgnetic flux density and Magnetic field Intensity, Molar Magnetic Susceptibility and its measurement, molecular interpretation.

Reference Books:

(1) Quantum Chemistry, R. K. Prasad, (2) Principles of Colloid and Surface Chemistry, P C Hiemenz and R Rajagopalan, (3) Elements of Physical Chemistry, Macmillan, (4) Principles of Polymer Chemistry, P. J. Flory, (5) Textbook of Polymer Science, F. W. Billmeyer Jr., (6) Atkin's Physical Chemistry, P. W. Atkins, J. de Paula, (7) Fundamentals of Photochemistry, K.K. Rohatagi-Mukherjee, (8) A Textbook of Physical Chemistry, Volume- 4, K. L. Kapoor. (9) Principles of Fluorescence Spectroscopy, J. R. Lakowicz. (10) Principles of Molecular Photochemistry, N. J. Turro, V. Ramamurthy and J. C. Scaiano.

CHEMISTRY

MINOR SYLLABUS

Semester I/II

MINOR COURSE [Code: MNCH 01: Gr. A]

Organic Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Fundamentals of Organic Chemistry: (7 Lectures)

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Huckel's rule

Unit 2: Stereochemistry: (8 Lectures)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Three and erythro; D and L; cis – trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Book References:

(1) Nasipuri, D. Stereochemistry of Organic Compounds (Principles and Applications), 2nd Edition, New age int. (P) Ltd, Publishers, 2005, (2) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988), (3) Morrison, R. T. & Boyd, R. N. Organic Chemistry, 7th Ed., Pearson Education India (2011), (4) Bahl, A., Bahl, S. S. A Textbook of Organic Chemistry, 22nd Ed., S. Chand Publication, (2016) (5) Basic Stereochemistry of organic Molecule by S. Sengupta

MINOR COURSE [Code: MNCH 01: Gr. B]

Physical Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Gaseous state: (10 Lectures)

The Gas Laws and the equation of states, Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor,

causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants, and their calculation from the van der Waals equation. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation -derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation).

Unit 2: Liquids: (5 Lectures)

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

Book References: (1) Physical Chemistry, P. C. Rakshit. (2) Physical Chemistry, H. Chatterjee

MINOR COURSE [Code: MNCH 01: Gr. C]

Inorganic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Acid-Base Titrations: Principles of acid-base titrations to be discussed.

- (i) Estimation of sodium carbonate using standardized HCl.
- (ii) Estimation of carbonate and hydroxide present together in a mixture.
- (iii) Estimation of carbonate and bicarbonate present together in a mixture.
- (iv) Estimation of free alkali present in different soaps/detergents.

Redox Titrations: Principles of oxidation-reduction titrations (electrode potentials) to be discussed.

- (i) Estimation of oxalic acid by titrating it with KMnO_4 .
- (ii) Estimation of Mohr's salt by titrating it with KMnO_4 .
- (iii) Estimation of oxalic acid and sodium oxalate in a given mixture.
- (iv) Estimation of Fe(II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator (diphenylamine/ N-phenylanthranilic acid)
- (v) Iodometry

Book References: (1) Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012. (2) Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009. (3) An Advanced Course in Practical Chemistry by Nad, Mahapatra & Ghosal. Publisher, New Central Book Agency (P) Limited, 2014

Semester III/IV

MINOR COURSE [Code: MNCH02: Gr. A]

Inorganic Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Atomic Structure: (15 Lectures)

Review of: Bohr's theory and its limitations, Heisenberg uncertainty principle, Dual behaviour of matter and radiation, De-Broglie's relation, Hydrogen atom spectra, need of a new approach to atomic structure. Time independent Schrodinger equation, and meaning of various terms in it. Significance of ψ and ψ^2 , Schrödinger equation for hydrogen atom, radial and angular parts of the hydrogen wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation), radial and angular nodes and their significance, radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s . Shapes of s, p and d atomic orbitals, nodal planes, discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s). Rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and completely filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

Book References:

(1) Fundamentals Concepts of Inorganic Chemistry Volume (1) by Asim K. Das, CBS Publications & Distributors (2) Atomic structure and periodicity by Jack Barrett, RSC (3) Principles of inorganic chemistry by Brian William Pfennig, Wiley (4) An Introduction to Atomic and Molecular Physics by Wolfgang Demtröder by Springer

MINOR COURSE [Code: MNCH02: Gr. B]

Physical Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Chemical Energetics (10 Lectures)

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a

reaction with temperature-Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 2: Chemical Kinetics: (5 Lectures)

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half-life of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Book References: (1) Physical Chemistry, P. C. Rakshit (2) Physical Chemistry, H. Chatterjee

MINOR COURSE [Code: MNCH02: Gr. C]

Organic Chemistry

(Practical, Credits: 2, F.M. 50) (60 Lectures)

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Book References:

An Advanced Course in Practical Chemistry by Nad, Mahapatra & Ghosal. Publisher, New Central Book Agency (P) Limited, 2014

Semester V/VI

MINOR COURSE [Code: MNCH 03: Gr. A]

Inorganic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Chemical Bonding and Molecular Structure: (15 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 (no derivation), Born Haber cycle and its applications, covalent character in ionic compounds, 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) and heteronuclear diatomic molecules such as CO, NO and NO⁺.

Unit 2: Coordination Chemistry (15 Lectures)

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

Crystal Field Theory: Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Ti complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Book References:

- (1) Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press, 2010.
- (2) R. L. Dutta, Inorganic chemistry, vol. I
- (3) A. K. Das, Fundamental Concepts of Inorganic Chemistry (Vol. 1, 4), CBS Publishers & Distributors, 2010
- (4) Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
- (5). Cotton, Wilkinson, Murillo, Bochman, Advance Inorganic, 6th. Edn. 1999.
- (6) Comprehensive Coordination Chemistry.

MINOR COURSE [Code: MNCH 03: Gr. B]

Organic Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Aliphatic Hydrocarbons (10 Lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO_4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymercuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO_4 , ozonolysis and oxidation with hot alk. KMnO_4 .

Unit 2: Aromatic hydrocarbons (5 Lectures)

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Book References:

(1) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988), (2) Morrison, R. T. & Boyd, R. N. Organic Chemistry, 7th Ed., Pearson Education India (2011), (3) Bahl, A., Bahl, S. S. A Textbook of Organic Chemistry, 22nd Ed., S. Chand Publication, (2016).

MINOR COURSE [Code: MNCH 03: Gr. C]

Physical Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Chemical Equilibrium (5 Lectures)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Le Chatelier's principle. Relationships between K_P , K_C , and K_x , for reactions involving ideal gases.

Unit 2: Ionic Equilibria: (5 Lectures)

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

Unit 3: Phase Equilibria: (5 Lectures)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius-Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics points (lead-silver).

Book References: (1) Physical Chemistry, P. C. Rakshit.

Semester VII/VIII

MINOR COURSE [Code: MNCH 04: Gr. A]

Inorganic Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Transition Elements (3d series) (15 Lectures)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanides and actinides: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Book References

(1) R. L. Dutta, Inorganic Chemistry, vol. II. (2) Cotton, Wilkinson, Murillo, Bochman, Advance Inorganic, 6th. Edn. 1999. (3) Inorganic Chemistry, ACS, papers: A. Chakravorty, Cotton, T. J. Collins, R. S. Drago, etc. (4) Comprehensive Coordination Chemistry

MINOR COURSE [Code: MNCH 04: Gr. B]

Organic Chemistry

(Theory, Credits: 2, F.M. 50) (30 Lectures)

Unit 1: Alkyl and Aryl Halides (8 Lectures)

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1 , S_N2 and S_Ni) reactions. Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit 2: Alcohols, Phenols and Ethers (Upto 5 Carbons) (14 Lectures)

Alcohols: Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO_4 , acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten-Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions: Reaction with HCN, ROH, NaHSO_3 , $\text{NH}_2\text{-G}$ derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf-Verley reduction.

Unit 3: Chemistry of Biomolecules (8 Lectures)

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of $-\text{COOH}$ group, acetylation of $-\text{NH}_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme).

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides.

Reference Books

(1) Finar, I. L. Organic Chemistry (Vol. II), Pearson (2002), (2) Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi, (1988), (3) Morrison, R. T. & Boyd, R. N. Organic Chemistry, 7th Ed., Pearson Education India (2011), (4) Bahl, A., Bahl, S. S. A Textbook of Organic Chemistry, 22nd Ed., S. Chand Publication, (2016).

MINOR COURSE [Code: MNCH 04: Gr. C]

Physical Chemistry

(Theory, Credits: 1, F.M. 25) (15 Lectures)

Unit 1: Conductance (5 Lectures)

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Unit 2: Electrochemistry: (5 Lectures)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG , ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Unit 3: Dilute Solutions and Colligative Properties: (5 Lectures)

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws 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.

Book References: (1) Physical Chemistry, P. C. Rakshit (2) Physical Chemistry, H. Chatterjee

CHEMISTRY

SEC SYLLABUS

Semester I

SEC COURSE [Code: SEC 1]

BASIC PRINCIPLES AND LABORATORY OPERATIONS

Credits: 2 (Theory, 30 Lectures) + 1 (Tutorial, 15 Lectures) [F.M. 50 + 25]

Unit 1. Laboratory Proceedings, Data Curation and Analysis: (5 Lectures)

Introduction to chemical laboratory, Learning safety protocols, Introduction to instruments and glassware of laboratory and its careful managements, Hand on training of data curation and analysis, Interpretation and documentation.

Unit 2. Awareness of Chemical Units and Related Terms with Diverse Types of Chemical Process: (15 Lectures)

Mole, Molar mass (calculations in grams and moles), Solutions and their concentrations, Molar, Molal concentration, Analytical molarity, Equilibrium molarity of a particular species, Normality, Percent concentration, Parts per million/billion (ppm/ppb).

Primary and Secondary Standard Solution, Oxidation states and equivalent weight calculation of oxidants, Reductants, Idea of complexing agents.

Laboratory-based idea of Redox reactions, Acid-Base Reactions, Complex formation, Solution, Coagulation, Precipitation, Melting point, Boiling point, Solubility products, Buffer, pH, pKa, solvent polarity, Chemical separation, Crystallization, Masking & Demasking agents.

Unit 3. Types of Analysis: (6 Lectures)

Comparative discussion of Qualitative and Quantitative analyses,

Principles of volumetric analysis, Acid-base titration, Redox titration, Complexometric titration, pH metric titrations, Equivalence point & End point, Role of different Indicators.

Unit 4. Spectroscopic Methods for Chemical Analysis: (4 Lectures)

Preliminary idea of spectrophotometer, and spectrometer, Basic concept of the electromagnetic spectra.

Reference Books:

(1) Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012. (2) Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009. (3) Fundamentals of Molecular Spectroscopy, C. N. Banwell

Semester II

SEC COURSE (INORGANIC CHEMISTRY-I) [Code: SEC 2A]

ENVIRONMENT AND ITS SEGMENTS

Credits: 1 (15 L, Theory) + 2 (60 L, Practical) [F.M. 75 (25 + 50)]

Unit 1: Ecosystems: (2 Lectures)

Biogeochemical cycles of carbon, nitrogen and sulphur.

Unit 2: Air Pollution: (7 Lectures)

Major regions of atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Pollution by SO₂, CO₂, CO, NO_x, H₂S and other foul-smelling gases. Methods of estimation of CO, NO_x, SO_x. Greenhouse effect and Global warming, Ozone depletion, Chlorofluorocarbons, MIC gas pollution. Toxicology of air pollutants

Water Pollution: (6 Lectures)

Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), TDS, Water purification methods.

Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc. Sludge disposal.

Industrial waste management. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

PRACTICAL

1. Determination of dissolved oxygen (DO) in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder
5. Determination of total dissolved solids (TDS) in water
6. Identification of toxic metal ions in environmental sample
7. Estimation of free alkali present in different soaps/detergents
8. Estimation of phosphoric acid in cola drinks

Reference Books:

(1) Environmental Chemistry by Peter O'Neill (2) Anil. K. De, Environmental Chemistry, New Age Publishers Pvt Ltd, 9th Ed. 2018 (3) Environmental Chemistry with Green Chemistry, A. K. Das Books & Allied, Kolkata, (2010) (4) Chemistry of The Environment 2/Ed by Bailey R. A., Elsevier India, 2009

SEC COURSE (ORGANIC CHEMISTRY-I) [Code:]

GREEN CHEMISTRY

Credits: 2 [Theory, 30 L] + 1 [Practical, 30 L] [F.M. 75 (50 + 25)]

Theory and Hand-on Experiments

Introduction: Definitions of Green Chemistry. Brief introduction of twelve principles of Green Chemistry, with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability

The following Real-world Cases in Green Chemistry should be discussed:

- Surfactants for carbon dioxide – Replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments.
- Designing of environmentally safe marine antifoulant.
- Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
- An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.

Practical

- Preparation and characterization of biodiesel from vegetable oil.
- Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.
- Mechano chemical solvent free synthesis of azomethine.
- Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).
- Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

Reference Books:

(1) Anastas, P.T. & Warner, J.K. Green Chemistry- Theory and Practical, Oxford University Press (1998). (2) Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001). (3) Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000). (4) Ryan, M.A. & Tinneland, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002). (5) Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. Green Chemistry Experiments: A monograph I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore. (6) Lancaster, M. Green Chemistry: An introductory text RSC publishing, 2nd Edition. (7) Sidhwani, I.T., Saini, G., Chowdhury, S., Garg, D., Malovika, Garg, N. Wealth from waste: A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated "A Social Awareness Project", Delhi University Journal of Undergraduate Research and Innovation, 1 (1): 2015.

SEC COURSE (PHYSICAL CHEMISTRY-I) [Code: SEC 2C]
THERMODYNAMICS
(Theory, Credits: 3, F.M. 75) (45 Lectures)

Unit 1: Mathematical background for thermodynamics: Part A (14 lecture)

Definition of a function-independent variable-examples from thermodynamics, necessity of derivative of a function and understanding of its definition, derivation of laws of ordinary derivative from the first principle, definition of partial derivative-examples from thermodynamics, law of infinitesimal change of a function interns of change of associated independent variable(s) and its justification, definition and examples of exact and inexact differential, derivation of the cyclic rule and its application in thermodynamics, the basic rule for integration, classification of integration, application of line integration in thermodynamics, physical meaning of an integration constant

Unit 2: Thermodynamics: Part A (18 lectures)

Criteria of a system to be a thermodynamic one from microscopic point of view (kinetic theory), qualitative understanding about the walls based on the microscopic aspect, prescription for preparing of a thermodynamic system(TS), different kinds of classification of properties of a TS, understanding of zeroth law and its consequence based on the kinetic theory, classification of different kind of equilibrium with examples, definition of equilibrium thermodynamics, caloric theory and its break down, detail characterisation of heat and work, difference between reversible and irreversible processes, understanding of the first law of thermodynamics based on the mechanics, justification of the first law of thermodynamics, the Clausius statement on the first law of thermodynamics, principle for testing for extensive and intensive state properties and the relevant microscopic interpretation (if available), characterisation of internal energy, perpetual machine motion of the first kind, number of independent state variable of a pure system at a single phase, changes in internal energy in relation to changes of other state properties, definition of heat capacities and their characterisation, Jule's experiment with a gas and its limitation, experiment by Key and Years, definition of enthalpy and its characterisation

Unit 3: Thermodynamics: Part B (13 lectures)

Change of enthalpy interns of enthalpy of reactants and products, necessity and definition of conventional molar enthalpy and their temperature dependence, formation reaction, principle for determination of conventional molar enthalpy, laws of thermochemistry and their applications, derivation of Kirchoff's equation and its application, idea about order of magnitude of heat of reaction and its sensitivity on the temperature, relation between heat of reactions at constant pressure and volume, respectively, heat of solution, combustion reaction, flame temperature, principle of calorimetric measurement of heat of a reaction

Reference Books: (1) Physical Chemistry, G. W. Castellan (2) Physical Chemistry, P. C. Rakshit (3) Physical Chemistry-Ira N. Levine (4) Atkins' Physical Chemistry- James Keeler, Julio de Paula, and Peter Atkins

**SEC COURSE (PHYSICAL CHEMISTRY-II) [Code: SEC 2D]
BIO-PHYSICAL CHEMISTRY
(Theory, Credits: 3, F.M. 75) (45 Lectures)**

Unit I: Conformation of proteins (15 Lectures)

Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds. Thermodynamics of protein hydration.

Unit 2: Enzymes (10 Lectures)

Introduction - chemical nature and general characterization - nomenclature, IUB system of enzyme classification, specificity, enzyme units, active site, mode of action - Lock and key theory and induced fit theory.

Unit 3: Membrane structure and functions (10 Lectures)

Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps,

Unit 4: Cell Signaling (10 Lectures)

Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways,

Book References:

(1) Charles R. Cantor, Paul R. Schimmel, Biophysical Chemistry (Part I, II, III), 11 th ed, W.H. Freeman and Company, (2) D L Nelson, Cox Lehninger, Lehninger's Principles of Biochemistry ,4th ed , W H Freeman 2004, (3) Jeremy M.Bug, John L.Tymoczko, Lubert Strye, Biochemistry, 5th ed, W.H .Freeman and Company, (4) K.L. Kapoor, A Textbook of Physical Chemistry (Vol-5), Macmillan Publishers (India) Ltd.

Semester III

SEC COURSE (INORGANIC CHEMISTRY-II) [Code: SEC 3A] INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE Credits: 1 (15 L, Theory) + 2 (60 L, Practical) [F.M. 75 (25 + 50)]

Unit 1: Cement, Ceramic and Glass: (5 lectures)

Classification of cement, ingredients and their role, Introduction to lime, gypsum plaster & cement, Manufacture of cement, quick setting cements, Hydration of cement, Classification of ceramics, Manufacture and types of glass

Unit 2: Fertilizers: (5 lectures)

Different types of fertilizers, Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

Unit 3: Batteries and Energy Storage: (5 lectures)

Applications of batteries in daily life, Classification of batteries: Nonrechargeable & Rechargeable, Lead acid batteries, Lithium-ion batteries, Alkaline batteries, Fuel Cell, Manufacturing, Recycling, Environmental impacts

SEC COURSE: PRACTICAL

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. Determination of composition of dolomite (by complexometric titration).
5. Analysis of Cement.
6. Preparation of pigment (zinc oxide).
7. Nitrate and phosphate content in water.
8. Estimation of the amount of calcium in milk powder
9. Estimation of iodine in iodized common salt

Reference Books:

(1) B. K. Sharma, Industrial Chemistry. Goel Publications, 1991. (2) K. H. Buchel, Industrial Inorganic Chemistry, Wiley-VCH, 2000 (3) Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, 2011.

SEC COURSE (ORGANIC CHEMISTRY-II) [Code: SEC 3B]

PHARMACEUTICAL CHEMISTRY

Credits: 2 (Theory, 30 L) + 1 (Practical and 30 L) [F.M. 75 (50 + 25)]

Unit 1: Drugs & Pharmaceuticals: (15 Lectures)

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, Ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Unit 2: Fundamental concepts of physical organic chemistry to understand the molecular functioning, e.g., drug-receptor interaction. (15 Lectures)

SEC COURSE: PRACTICAL

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

Reference Books:

(1) Patrick, G. L. *Introduction to Medicinal Chemistry*, Oxford University Press, UK, 2013. (2) Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, Vallabh Prakashan, Pitampura, New Delhi, 2012. (3) Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

SEC COURSE (Physical Chemistry-III) [Code: SEC 3C]

THERMODYNAMICS

(Theory, Credits: 3, F.M. 75) (45 Lectures)

Unit 1: Mathematical background for thermodynamics: Part B (5 lecture)

Characteristics of an exact differential function and its relevance in thermodynamics, theory of Legendre's dual transformation and its application in thermodynamics, Conditions for optimisation of a function with or without constraint(s), Lagrange's method of undetermined multipliers and its application in thermodynamics.

Unit 2: Thermodynamics: Part C (13 lecture)

Necessity of a heat engine, an impossible heat engine-perpetual machine motion of the second kind, proof of equivalence of the statements of the second law of thermodynamics, the Carnot theorem and its justification, implications of the Carnot engine, refrigerator and heat pump, definition of entropy considering an arbitrary reversible heat engine, relation between entropy and unavailable work and its implication, principle to determine entropy change for phase transition, Trouton's rule and its limitation, THE rule, properties of entropy- volume, temperature and pressure dependence, conditions of thermal and mechanical stability, entropy change due to change of state of an ideal gas, microscopic view of entropy, Boltzmann paradox, the second law - a law of probability

Unit 3: Thermodynamics: Part D (12 lecture)

Condition of equilibrium, breezing between the first and second laws-definition of temperature, conditions of spontaneity under constraints, definition of Helmholtz energy and its characterisation, Gibbs-Helmholtz equations, fugacity and fugacity coefficient, microscopic view of spontaneity-quality of energy, fundamental equations of thermodynamics, Maxwell's relations and their application, J-T experiment and its application, attainment of low temperature - adiabatic demagnetisation and optical trap.

Thermometry, different scale of temperatures and the relations among them, Nernst heat theorem and its consequences, justification of third law of thermodynamics, residual entropy

Unit 4: Thermodynamics: Part E (15 lectures)

Difference between Gibbs energy per mole and chemical potential, thermodynamic functions for mixing of ideal gases and their application to chemical reaction, criteria for spontaneous mixing, fictitious state at unit activity, a general expression for equilibrium constant, correspondence between chemical kinetics and thermodynamics at equilibrium, condition of spontaneous of a chemical reaction, temperature and pressure dependence of the equilibrium constant, Lechatelier principle and its thermodynamic justification for simple cases, disturbance of chemical equilibrium by addition of reactant (s) or product(s) or inert substance, general behaviour of Gibbs energy of a reaction as a function of advancement of a chemical reaction, viewing of a

reaction vessel based on thermodynamics, qualitatively microscopic view of a chemical reaction, partial molar quantities and their additivity rule, calculation of partial molar quantities in a mixture of ideal gases, integrated heat of solution

References: (1) Physical Chemistry, G. W. Castellan (2) Physical Chemistry, P. C. Rakshit (3) Physical Chemistry-Ira N. Levine (4) Atkins' Physical Chemistry- James Keeler, Julio de Paula, and Peter Atkins

**SEC COURSE (Physical Chemistry-IV) [Code: SEC 3D]
ALTERNATIVE ENERGY AND ADVANCED INSTRUMENTATIONS
(Theory, Credits: 3, F.M. 75) (45 Lectures)**

Unit I: Alternative Energy Studies: (15 lecture)

Natural solar energy conversion process (reactions of photosynthesis), photolysis of water, modeling and mimicking of photosynthesis process, photophysical and photochemical process of semiconductor-based materials and dye sensitized photo-galvanic cells in solar energy conversion, theoretical aspects of this conversion process

Unit II: Introduction to advanced experimental Instrumentations: (30 lecture)

Basic principles and applications of Electron Microscopy: Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-ray Photoelectron Spectroscopy (XPS), NMR-Spectrophotometry, Atomic Force Microscopy (AFM), UV-VIS absorption spectrometry, Fluorimetry, FTIR spectrometry, Atomic Absorption Spectrometry, excited state lifetime measurement techniques: TCSPC, Ultrafast-Spectroscopy, Transient Absorption Spectroscopy.

Reference Books:

(1) Scanning Electron Microscopy and X-Ray Microanalysis: A Textbook for Biologists, Materials Scientists and Geologists, J.I. Goldstein, A. D. Romig, D. E. Newbury, C. E. Lyman, P. Echlin, C. Fiori, D. C. Joy, and E. Lifshin

CHEMISTRY

MULTIDISCIPLINARY

SYLLABUS

MULTIDISCIPLINARY COURSE [Code: MDCH 01]
CHEMISTRY IN EVERYDAY LIFE
(Theory, Credits: 3, F.M. 75) (45 Lectures)

Chemistry in Agriculture: (6 Lectures)

Fertilizers: nitrogenous, phosphatic and potassium fertilizers, organic fertilizers, deficiency symptoms of micro and macronutrients.

Pesticides: introduction, types of pesticides, importance of pesticides, natural and artificial pesticides, toxic effects of pesticides.

Environmental Chemistry: (9 Lectures)

Air pollution and its effects, air quality standards, photochemical smog, major primary pollutants produced by human activity: sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide, carbon dioxide. Ozone chemistry, ozone layer and its depletion, global warming and greenhouse effect, greenhouse gases, the Albedo effect, acid rain and its effect, water pollution, major types of water pollution and its causes, biochemical oxygen demand (BOD), chemical oxygen demand (COD).

Chemistry of Food additives and preservatives: (4 Lectures)

Antioxidants and radical scavengers, emulsifiers stabilisers, gums, thickeners and gelling agents as food additives, sweeteners, fragrances, flavouring agents and enhancers, food acids and acidity regulators, food colour and colour retention agents, why preservatives necessary, permissible limit, classes of preservatives, brief overview of some commonly used preservatives, mode of action of chemical preservatives.

Chemistry of cosmetics and personal care products: (3 Lectures)

Definition of cosmetics, history of cosmetics and natural products, broad classification of cosmetics, thickeners, active ingredients, color, preservatives Chemical composition and formulation of skin creams and lotions, shaving cream, sunscreen, lips-stick and lip balms, eye-makeup. Cosmetic formulation, chemistry of hair care, skin care, color cosmetics, and sun protections. Chemistry of perfumes and fragrances, deodorants and antiperspirants. Chemistry of toothpaste, composition of toothpaste.

Chemistry of commonly used Drugs: (2 Lectures)

Drugs and their Classification, Drug-Target Interaction, Therapeutic Action of Different Classes of Drugs such as: Antacids, Antihistamines, Neurologically Active Drugs (Tranquilizer, analgesic), Antimicrobials (Antibiotic, Antiseptic, Disinfectant), Antifertility Drugs.

Polymers and Plastics: (4 Lectures)

Definition, classification, natural rubber and vulcanization, Synthetic rubber, structural features of polymer, molecular weights of polymers, plastic and their characteristics.

Dyes and Pigments: (2 lectures)

Classification, Colour and constitution, Vat Dyes; Chemistry of dyeing, Natural dyes, Edible Dyes with examples.

Weather Prediction: (2 lectures)

Atmospheric Pressure, Temperature, Humidity, Variation of weather with altitude, rainfall, lightning, Precipitation probability, Prediction of weather.

Water purification: (3 lectures)

Common sources of water and its contamination, Pretreatment, pH of water & its adjustment, Coagulation and flocculation, Sedimentation, Sludge storage and removal, Filtration, Ultraviolet disinfection, Reverse Osmosis.

Batteries and Fuels: (5 lectures)

Primary and Secondary batteries, UPS, Performance-capacity-and discharge, Lifetime of battery, Uses of battery in daily life, Fuel: types and its uses, Fossil fuels, Nuclear fuel, Future of alternative fuels.

Cooking, Refrigeration and Cleaning: (5 lectures)

Electrical heater, Heating, boiling, freezing, mixing, smashing, and blending, Emulsification, oxidation of freshly cut vegetables and fruits, Principle of Microwave, Chemical refrigeration, Principle of Refrigerator, Physical process of cleaning, Cleansing action of soap and detergents, Formation of Micelles, Saponification.

Reference Books:

(1) Inorganic Materials of Industrial Importance by S. K. Juneja, A. Kumar. (2) Anil. K. De, Environmental Chemistry, New Age Publishers Pvt Ltd, 9th Ed. 2018 (3) Environmental Chemistry with Green Chemistry, A. K. Das, Books & Allied, Kolkata, (2010) (4) Chopra, H. K., Panesar, P. S. Food Chemistry, Narosa Publishing House, New Delhi (2010) (5) The Chemistry of Cooking and Cleaning by Ellen H Richards.
