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

Credit Distribution Framework for Three / Four-Year Honours / Honours with research Degree Programme with Multiple Entry and Exits Options

NCrF Credit Level	Courses	Duration	Semesters	Credits	Cumulative Total	Criteria /Re-entry
4.5	UG Certificate	1 year	I	20	40	10+2 pass with Chemistry and Mathematics
			II	20		
Exit 1: Award of **UG certificate** in Major with a cumulative 40 credits, with an **additional 4 credits Summer Internship** in core NSQF course, or continue with Major and Minor						
5	UG Diploma	2 years	III	20	80	Certificate in Chemistry
			IV	20		
Exit 2: Award of **UG Diploma in Major** with a cumulative 80 credits, with an **additional 4 credits Summer Internship** in core NSQF course, or continue with Major and Minor						
5.5	UG Degree	3 years	V	20	120	Diploma in Chemistry
			VI	20		
Exit 3: Award of **UG Degree** in Major with a cumulative 120 credits and **Internship (4 credits)** in the same discipline or continue with Major and Minor						
6.0	UG (Honours) Degree	4 years	VII	20	160	(Without dissertation)3-year B.Sc. degree in Chemistry
			VIII	20		
Award of **UG(Honours) Degree** in Major and Minor with a cumulative 160 credits						
6.0	UG (Honours) Degree with Research	4 years	VII		160	(With dissertation) 3-year B.Sc. degree in Chemistry with 75% marks or more
			VIII			
Award of **UG(Honours) Degree with Research** in Major and Minor with a cumulative 160 credits						

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), O: 1(T), P: 1 (T)	3
II	2 (T)	2 (T) + 2 (Pr)	2 (T)		3 (I/O/P)
III	2 (T)	2 (T)	2 (T) + 2(Pr)	I: 1 (T), O: 2 (Pr), P: 1 (T)	3 (I/O/P)
IV	4 (T) + 2 (Pr)	4 (T) + 2 (Pr)	4 (T)		
V	2 (T) + 2 (Pr)	4 (T)	2 (T) + 2 (Pr)	I: 2 (T), O: 1 (T), P: 1 (T)	
VI	4(T)	2 (T) + 2 (Pr)	2 (T) + 2 (Pr)		
VII	2 (T) + 2 (Pr)	2 (T)+2 (Pr)	4 (T)	I: 1 (T), O: 2 (T), P: 1 (T)	
VIII	2 (T)	2 (T)	2 (T) + 2 (Pr)		
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

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 following NEP 2020

MAJOR COURSES in CHEMISTRY [Discipline-Specific Core Courses]

Course Code	Course Type	Course Title	Credits	Marks	Hours /Week
SEMESTER I					
MJCH 01A	***Inorganic Theory***	Atomic Structure, Periodicity of Elements, Chemical Bonding (I+II)	2	50	2
MJCH 01B	***Inorganic Practical***	Acid Base Titration, Redox Titration	2	50	4
MJCH 02A	***Organic Theory***	Basics of Organic Chemistry and Reaction Mechanism	2	50	2
MJCH 02B	***Physical Theory***	Gaseous State, Liquid and Surface Tension	2	50	2
		Total	**8 credits**	**200**	
SEMESTER II					
MJCH 03A	***Inorganic Theory***	Coordination Chemistry I, Radioactivity, Redox Chemistry	2	50	2
MJCH 03B	***Physical Theory***	Thermodynamics I, Conductance	2	50	2
MJCH 04A	***Organic Theory***	Chemistry of Aliphatic Non-Nitrogenous, Nitrogenous and Sulphur Compounds; Formation of Alkene and Alkyne	2	50	2
MJCH 04B	***Organic Practical***	Qualitative Analysis	2	50	4
		Total	**8 credits**	**200**	
ONE-YEAR CERTIFICATE PROGRAMME TOTAL 4 MAJOR COURSES			**16 credits**	**400**	
SEMESTER III					
MJCH 05A	***Inorganic Theory***	Chemistry of s and p block Elements, Coordination Chemistry II, Acids and Bases, General Principals of Metallurgy	2	50	2
MJCH 05B	***Organic Theory***	Chemistry of Halogenated Hydrocarbons, Cycloalkanes and Conformational Analysis, Aromatic Hydrocarbons (Aromatic Electrophilic and Nucleophilic Substitution)	2	50	2
MJCH 06A	***Physical Theory***	Thermodynamics II, Chemical Kinetics I	2	50	2
MJCH 06B	***Physical Practical***	Surface Tension, Viscosity, Conductometry, Thermochemistry	2	50	4
		Total	**8 credits**	**200**	
SEMESTER IV					
MJCH 07	***Inorganic Theory***	Coordination Chemistry III, Bioinorganic Chemistry, Chemistry of Transition Metals, Chemistry of Lanthanides and Actinides Inorganic Polymers, Basics of analytical Chemistry	4	100	4

MJCH 08	***Organic Theory***	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
MJCH 09	***Physical Theory***	Electrochemistry and solid state, Ionic Equilibria and Colligative Properties, Chemical Kinetics –II and Surface Chemistry	4	100	4
MJCH 10A	***Inorganic Practical***	Qualitative Semimicro analysis, Inorganic Preparations	2	50	4
MJCH 10B	***Organic Practical***	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					
MJCH 11A	***Inorganic Theory***	Reaction Kinetics and Mechanism of Coordination Compounds, Structure and Properties of Solids	2	50	2
MJCH 11B	***Inorganic Practical***	Complexometric Titration, Gravimetric Analysis, Spectrophotometric Estimation	2	50	4
MJCH 12	***Organic Theory***	Dynamic Stereochemistry; Heterocyclic Compounds including Fused Ring system; Pericyclic Reactions; Retrosynthetic Analysis, Functional group Interconversion and Protection-deprotection in Organic Synthesis	4	100	4
MJCH 13A	***Physical Theory***	Quantum Mechanics I, Phase Equilibria	2	50	2
MJCH 13B	***Physical Practical***	pH-metry, Potentiometry, Phase, Kinetics	2	50	4
		Total	**12 credits**	**300**	
SEMESTER VI					
MJCH 14	***Inorganic Theory***	Organometallic Compounds, Inorganic Photochemistry, Nanomaterials, Separation Techniques	4	100	4
MJCH 15A	***Organic Theory***	Organic Spectroscopy, Analysis of IR, UV-Vis, NMR and Mass Spectral Data for Elucidating the Structure of Organic Molecules	2	50	2
MJCH 15B	***Organic Practical***	Organic Preparation	2	50	4
MJCH 16A	***Physical Theory***	Molecular Spectroscopy I, Quantum Mechanics II	2	50	2
MJCH 16B	***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					
MJCH 17A	***Inorganic Theory***	Molecular Magnetism, Physical Characterization of Inorganic Compound by EPR and NMR Spectroscopy, Nuclear Detection Technique	2	50	2
MJCH 17B	***Inorganic Practical***	Analysis of some ores and alloys, Chromatographic Techniques, Inorganic Preparations, Colorimetric Estimation	2	50	4
MJCH 18A	***Organic Theory***	Chemistry of Proteins, Lipids, Nucleic Acids, Chemistry of Carbohydrates, Polymers	2	50	2
MJCH 18B	***Organic Practical***	Separation of components from a mixture of organic compounds	2	50	4
MJCH 19	***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					
MJCH 20A	***Inorganic Theory***	Cage, Metal Clusters and Ring Compounds; Thermo-analytical Methods; Electro-analytical Method	2	50	2
MJCH 20B	***Organic Theory***	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
MJCH 21A	***Physical Theory***	Quantum Chemistry, Electronic Spectroscopy and Photochemistry	2	50	2
MJCH 21B	***Physical Practical***	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*	***Inorganic Theory***	Supramolecular Chemistry Advanced Chemistry of the Elements Tutorial	4	100	4
MJACH 03*	***Physical Theory***	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 ADDITIONAL COURSES** **(Optional in lieu of Dissertation for Honours students)** **FOUR-YEAR HONOURS with RESEARCH PROGRAMME: TOTAL 21 COURSES + DISSERTATION**			**84 credits + 12 credits**	**2100 + 300**	

MINOR COURSES in CHEMISTRY [Discipline-Specific Minor Courses]

Course Code	Course Type	Course Title	Credits	Marks	Hours /Week
SEMESTER I					
MNCH 01 (Gr. A)	***Organic Theory***	Fundamentals of Organic Chemistry, Stereochemistry	2 (T) + 2 (P)	50 (T) + 50 (P)	2 (T)
MNCH 01 (Gr. B)	***Physical Theory***	Gaseous State of Liquids			
MNCH 01: Gr. C	***Inorganic Practical***	Acid Base Titration, Redox Titration			4 (P)
SEMESTER II					
MNCH 01 (Gr. A)	***Organic Theory***	Fundamentals of Organic Chemistry, Stereochemistry	2 (T) + 2 (P)	50 (T) + 50 (P)	2 (T)
MNCH 01 (Gr. B)	***Physical Theory***	Gaseous State of Liquids			
MNCH 01: Gr. C	***Inorganic Practical***	Acid Base Titration, Redox Titration			4 (P)
ONE-YEAR CERTIFICATE PROGRAMME		**TOTAL 1 MINOR COURSE**	**4**	**100**	

SEMESTER III					
MNCH 02 (Gr. A)	***Inorganic Theory***	Atomic Structure	2 (T) + 2 (P)	50 (T) + 50 (P)	2 (T)
MNCH 02 (Gr. B)	***Physical Theory***	Chemical Energetics, Chemical Kinetics			
MNCH 02: Gr. C	***Organic Practical***	Qualitative Organic Analysis of Organic Compounds			4 (P)
SEMESTER IV					
MNCH 02 (Gr. A)	***Inorganic Theory***	Atomic Structure	2 (T) + 2 (P)	50 (T) + 50 (P)	2 (T)
MNCH 02 (Gr. B)	***Physical Theory***	Chemical Energetics, Chemical Kinetics			
MNCH 02: Gr. C	***Organic Practical***	Qualitative Organic Analysis of Organic Compounds			4 (P)
TWO-YEAR DIPLOMA PROGRAMME TOTAL 2 MINOR COURSES			**8**	**200**	
SEMESTER V					
MNCH 03 (Gr. A)	***Inorganic Chemistry***	Chemical Bonding and Molecular Structure, Coordination Chemistry	4	100	4
MNCH 03 (Gr. B)	***Organic Chemistry***	Aliphatic Hydrocarbons, Aromatic Hydrocarbons			
MNCH 03 (Gr. C)	***Physical Chemistry***	Chemical Equilibrium, Ionic Equilibria, Phase Equilibria			
			4	100	
SEMESTER VI					
MNCH 03 (Gr. A)	***Inorganic Chemistry***	Chemical Bonding and Molecular Structure, Coordination Chemistry	4	100	4
MNCH 03 (Gr. B)	***Organic Chemistry***	Aliphatic Hydrocarbons, Aromatic Hydrocarbons			
MNCH 03 (Gr. C)	***Physical Chemistry***	Chemical Equilibrium, Ionic Equilibria			
			4	100	
THREE-YEAR DEGREE PROGRAMME TOTAL 3 MINOR COURSES			**12**	**300**	
SEMESTER VII					
MNCH 04 (Gr. A)	***Inorganic Chemistry***	Transition Elements	4	100	4
MNCH 04 (Gr. B)	***Organic Chemistry***	Alkyl and Aryl Halides; Alcohols, Phenols, and Ethers (Upto 5 carbons); Chemistry of Biomolecules			
MNCH 04 (Gr. C)	***Physical Chemistry***	Conductance, Electrochemistry, Dilute Solutions and Colligative Properties			
			4	100	
SEMESTER VIII					
MNCH 04 (Gr. A)	***Inorganic Chemistry***	Transition Elements	4	100	4
MNCH 04 (Gr. B)	***Organic Chemistry***:	Alkyl and Aryl Halides; Alcohols, Phenols, and Ethers (Upto 5 carbons); Chemistry of Biomolecules			
MNCH 04 (Gr. C)	***Physical Chemistry***	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					
SEC CH01AT and SEC CH01AP	***Inorganic Chemistry-I [Theory + Practical]***	Basic Principles and Laboratory Operations	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
SEC CH02BT and SEC CH02BP	***Organic Chemistry-I [Theory + Practical]***	Separation and Isolation Techniques	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
SEMESTER II					
SEC CH02AT and SEC CH02AP	***Inorganic Chemistry-II [Theory + Practical]***	Environment and its Segments	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
SEC CH02BT and SEC CH02BP	***Organic Chemistry-II [Theory + Practical]***	Green Chemistry	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
SEC CH02CT and SEC CH02CP	***Physical Chemistry-I [Theory + Practical]***	Bio-Physical Chemistry	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
ONE-YEAR CERTIFICATE PROGRAMME TOTAL 2 SEC COURSES			**6 credits**	**150**	
SEMESTER III					
SEC CH03AT and SEC CH03AP	***Inorganic Chemistry-III [Theory + Practical]***	Inorganic Materials of Industrial Importance	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
SEC CH03BT and SEC CH03BP	***Organic Chemistry- III [Theory + Practical]***	Pharmaceutical Chemistry	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
SEC CH03CT and SEC CH03CP	***Physical Chemistry-II [Theory + Practical]***	Advanced Instrumentations and BASIC to Python Programming	3 [1(T)+2(P)]	75 [25(T)+50(P)]	
TWO-YEAR DIPLOMA PROGRAMME TOTAL 3 SEC COURSES			**9 credits**	**225**	

MULTIDISCIPLINARY COURSE in CHEMISTRY

Course Code	Course Type	Course title	Credits	Marks	Hours
SEMESTER I /II/III					
MDCH 01	Theory	Chemistry in Everyday Life	3	75	3

CHEMISTRY

MAJOR

SYLLABUS

Semester I

MAJOR COURSE [Code: MJCH 01A]
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 N_2, O_2, C_2, B_2, F_2, 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 Willian 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

Objective of the Course

(1) Knowledge & Understanding: To provide a comprehensive understanding of atomic structure, periodic properties, and chemical bonding.
(2) Application of Knowledge & Skills: Students will apply theoretical principles to interpret atomic and molecular structures, predict chemical behavior using periodic trends and bonding theories, and solve problems involving lattice energy, molecular shapes, hybridization, and electron configurations.
(3) Technical & Professional Skills: Learners will acquire technical skills related to quantum chemistry, molecular modeling, and chemical reasoning. They will also be trained in interpreting chemical behavior using the knowledge of chemical bonding.
(4) Employability and Job Ready Skills: Students will develop a strong theoretical base that supports further studies in research, competitive exams, and various roles in the chemical and materials sectors.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyze atomic and molecular structures using theoretical models such as quantum mechanics, molecular orbital theory, VSEPR. Interpret periodic trends and predict chemical behavior based on atomic and molecular principles.	Critical thinking
2	Develop skills in theoretical interpretation of chemical bonding and periodicity to support further academic research.	Research related skills
3	Engage in group discussions and collaborative learning activities that involve solving chemical problems and explaining atomic/molecular models.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of complex chemical theories and to visualize atomic orbitals, molecular structures, and bonding models.	Digital and technological skills

NSO: 2113.0300 (Chemist, Inorganic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

MAJOR COURSE: Inorganic Practical [Code: MJCH 01B]
(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 $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

(D) Inorganic preparations-1
(i) Cuprous Chloride, Cu_2Cl_2 (ii) Preparation of Manganese(III) phosphate, $MnPO_4{\cdot}H_2O$ (iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (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

Objective of the Course

(1) Knowledge & Understanding: Understand the principles of acid-base and redox titrations and their real-world applications.
(2) Application of Knowledge & Skills: Perform accurate standardization and titrations using $KMnO_4$, $K_2Cr_2O_7$, and various indicators. Apply concepts of stoichiometry in determining unknown concentrations. Identify and quantify components like carbonate, bicarbonate, hydroxide, and Fe(II) in mixtures.
(3) Technical & Professional Skills: Learners will acquire technical skills related to calibrating and handling titration equipment with precision.
(4) Employability and Job Ready Skills: Develop laboratory discipline and documentation practices suitable for industrial, research, and academic labs. Gain foundational skills essential for roles in analytical chemistry, quality control, chemical manufacturing, and education.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluate experimental errors and optimize procedures for accurate and reproducible results.	Critical thinking
2	Design and conduct experiments using classical techniques, forming a base for advanced instrumental analysis. Understand and apply indicator chemistry and reaction stoichiometry in complex titrimetric systems.	Research-related skills
3	Work effectively in pairs or small groups, sharing responsibilities and communicating findings. Follow safety protocols and ensure cooperative use of shared lab resources.	Coordinating/collaborating with others
4	Use digital tools for data recording and analysis where applicable (e.g., spreadsheets, virtual titration simulations).	Digital and technological skills

NCO: 3111.0300 (Laboratory Assistant, Chemical), 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist)

MAJOR COURSE [Code: MJCH 02A]
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; Nucleophlicity 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/enetiomeric 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.

Objective of the Course

(1) Knowledge & Understanding: To provide a comprehensive understanding and connection between the shape and the electronic structure of the molecule

(2) Application of Knowledge & Skills: Students can predict the basic structural effects, like inductive, steric, and resonance effects. They can predict the reactivity of the molecule with other reagents. Students will be able to represent the movement of electrons in bond-breaking and bond-making processes by curly arrows. It will help to classify the reactions as a combination of some fundamental processes like substitution, addition, and elimination steps, and to predict relatively complex mechanisms of some unknown reactions.

From the stereochemistry, students can gain knowledge of the basic 3D structure of a molecule and relate the 3D structure to its optical properties.

(3) Technical & Professional Skills: Learners will acquire technical skills related to basic organic chemistry, prime reactions, stereochemistry, and stereoisomerism. They will also be trained in interpreting the chemical behavior of organic molecules.

(4) Employability and Job-Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the chemical and materials sectors.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	At the end of this course, the students can correlate the electronic structure of a molecule to its specific geometry. He can also predict the reactivity on the basis of its structural properties. He also gained knowledge on how to draw reaction mechanisms and divide a complete reaction into several elementary steps. He also has an idea of the 3D structure and the related properties of a molecule.	Critical thinking
2	Develop skills in the theoretical interpretation of the electronic structure of a molecule to its specific geometry to support further academic research.	Research-related skills
3	Participate in group discussions and collaborative learning activities that involve solving problems and explaining the atomic and molecular structures of organic molecules.	Coordinating/collaborating with others

4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of complex chemical reaction mechanisms and to visualize 3D molecular structures.	Digital and technological skills

NCO: 2113.0300 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

MAJOR COURSE [Code: MJCH 02B]
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.

Objective of the Course

(1) Knowledge & Understanding: To provide a preliminary idea of the behavior of the gases and the change of its property and correlation with volume, temperature and pressure. Study about liquid state and surface tension provides knowledge about the behavior of liquids, including how they minimize their surface area and interact with other substances. Learning the characteristic nature of liquid the concept of fluidity, intermolecular forces between the molecules and incompressibility will be acquired. The phenomena of wetting, formation of emulsion and foams, working principle of detergents and cleaning agents are well understood by learning surface tension.

(2) Application of Knowledge & Skills: Students will apply theoretical principles to interpret how a gaseous system may behave under any circumstances. Then they can solve problems related to properties of gases. This will lead to the application of knowledge in the development of different equipment and machines. Students will also apply it to understand the studying of oil spills, behavior of coatings and paints, movement of fluids in plants, animals.

(3) Technical & Professional Skills: Learners will acquire technical skills and the reasoning related to kinetic theory of ideal gases, the velocity distribution function, calculation of pressure of gas, compressibility factor etc. They will also be trained in interpreting the behavior of real gases, the concept of critical temperature and different equations of states, and the nature of liquid and surface tension which will be applied to environmental, material, biological science.

(4) Employability and Job-Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the materials science environmental, biological science sectors. Job ready skill is acquired for Paint industry, Food industry.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such molecular velocities, kinetic energy, collision frequency, critical constants, degrees of freedom etc. of a gaseous system, and coefficient of viscosity and surface tension of liquid.	Critical thinking
2	Develop skills in theoretical interpretation of different properties of gases, origin of intermolecular forces, development of different equation of states and their interpretation, and theoretical as well as practical interpretation of surface tension and viscosity to proceed further in academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving problems and explaining models relevant to properties of gases, and solving different numerical problems related to viscosity and surface tension.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of complex theories and to visualize microscopic and macroscopic views of a gaseous system, and to deepen understanding of properties of liquid state.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

Semester II

MAJOR COURSE [Code: MJCH 03A]
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.

Objective of the Course

(1) Knowledge & Understanding: To develop a solid foundation in coordination chemistry, radioactivity, and redox processes.
(2) Application of Knowledge & Skills: (i) To apply coordination chemistry concepts to interpret structures, bonding, isomerism, and reactivity of metal complexes. (ii) To analyze and predict outcomes of nuclear reactions and understand their real-world implications in energy production and age dating techniques. (iii) To use redox concepts in practical problem-solving such as calculating cell potentials and understanding reaction spontaneity.

(3) Technical & Professional Skills: (i) To develop skills in IUPAC nomenclature, identification of ligand types, and predicting coordination geometries. (ii) To gain hands-on experience in analyzing and interpreting radioactive decay data and using redox potentials in experimental setups.

(4) Employability and Job Ready Skills: Equipping students with foundational knowledge relevant for careers in chemical research, nuclear energy, radiopharmaceuticals, and environmental monitoring.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will be able to critically evaluate chemical structures, reactions, and theoretical models to solve complex problems in coordination chemistry, radioactivity, and redox systems.	Critical thinking
2	Students will develop the ability to collect, interpret, and apply theoretical and experimental data related to coordination chemistry, radioactive decay, and redox reactions in solving scientific problems.	Research-related skills
3	Students will demonstrate effective teamwork and communication skills through collaborative laboratory experiments and group-based problem-solving activities.	Coordinating/collaborating with others
4	Students will use digital tools and online resources to visualize molecular structures, analyze nuclear data, and solve electrochemical problems, fostering independent learning and adaptability to scientific technologies.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2143.0400 (Waste Management Engineer, Radioactive Material).

MAJOR COURSE [Code: MJCH 03B]
Physical Chemistry
(Theory, Credits: 2, F.M. 50) (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.

Objective of the Course

(1) Knowledge & Understanding: To know zeroth, 1st and 2nd laws of thermodynamics with their relevance in chemistry. To provide a comprehensive concept of how electricity flows through the ionic solutions.
(2) Application of Knowledge & Skills: Students will apply theoretical principles to interpret how an electrolytic solution may behave as an Ohmic resistance. Then they can solve problems related to conducting behavior of electrolytic solutions.
(3) Technical & Professional Skills: Learners will acquire technical skills related to ionic conductance, modeling of distribution of counter ions around a given central ion, and electrochemical reasoning. They will also be trained in interpreting conductance behavior of ionic solutions using the knowledge of charge distribution.
(4) Employability and Job Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the electrochemical and materials sectors.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such as degree of dissociation of weak electrolytes, ionic product of water, solubility and solubility product of sparingly soluble salts, hydrolysis constants of salts, conductometric titrations, etc. Students will learn to calculate heat of reaction, heat of atomization, bond enthalpy, bond energy etc. Students will learn the conditions for spontaneous change and equilibrium state.	Critical thinking
2	Develop skills in theoretical interpretation of ionic distribution in electrolytic solutions, conduction of current through solutions, mobility and transport number of ions in solution to proceed further in academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving electrochemical problems and explaining models relevant to ionic conduction.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of complex electrochemical theories and to visualize charge distributions, ionic transport, and various conduction mechanisms.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

MAJOR COURSE [Code: MJCH 04A]
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).

Objective of the Course

Knowledge & Understanding: To provide students with a comprehensive understanding of the structure, properties, reactivity, and synthetic applications of a wide range of aliphatic organic compounds. These include compounds without nitrogen (like alkanes, alkenes, alcohols, carboxylic acids), compounds containing nitrogen (like amines, amides, nitriles), and sulfur-containing compounds (such as thiols, thioethers, sulfonic acids). The course is also to develop a detailed understanding of the formation, chemical reactivity, and reaction mechanisms of alkenes and alkynes, which are fundamental unsaturated hydrocarbons in organic chemistry.
Application of Knowledge & Skills: (1) To classify and describe various types of aliphatic organic compounds based on the presence of nitrogen and sulfur atoms, along with their physical and chemical properties of alkenes and alkynes. (2) To apply knowledge to synthetic design, enabling the construction of complex organic molecules using alkenes and alkynes as building blocks.
Technical & Professional Skills: **(1)** Mechanistic Understanding to analyse and predict mechanisms for key reactions (e.g., substitution, elimination, nucleophilic addition), including interpreting reaction pathways involving aliphatic nitrogen and sulfur compounds. **(2)** Teamwork and Collaboration: Work effectively in groups during laboratory sessions and discussions. **(3)** Ethical and Environmental Awareness: Recognize the environmental impact and toxicity of nitrogen- and sulfur-containing compounds and adopt green chemistry principles where applicable.
Employability and Job-Ready Skills: **(1)** Hands-on skills in detecting functional groups and determining molecular structure, understanding of reaction conditions, yield optimization, and compound isolation **(2)** Knowledge of compounds used in pharmaceuticals, agrochemicals, polymers, and dyes, which enhances suitability for jobs in chemical, petrochemical, and biotech industries. **(3)** Foundation for working in R&D roles involving small-molecule synthesis, process chemistry, or formulation development.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	At the end of this course, the students can be involved in analyzing and evaluating chemical structures, reactivities, and reaction mechanisms based on the nature of functional groups and their influence on molecular behavior.	Critical thinking
2	Ability to search, analyze, and interpret scientific literature on synthesis, reactivity, and applications of organic compounds; Designing experimental routes for synthesizing target molecules with desired functional groups; Designing environmentally friendly protocols for compound synthesis and purification	Research-related skills

3	Participate in group discussions and collaborative learning activities that involve solving problems and explaining the Chemistry of aliphatic non-nitrogenous, nitrogenous, and sulfur compounds.	Coordinating/collaborating with others
4	Using molecular modelling to predict electronic properties, reactivity, and conformational analysis; Predicting the basicity of amines using electron density calculations; Accurate documentation of experimental procedures, observations, and results; Preparing scientific reports or research papers on synthesized compounds.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

MAJOR COURSE [Code: MJCH 04B]
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)

Objective of the Course

(1) Knowledge & Understanding: Qualitative analysis of functional groups involves identifying characteristic chemical reactions of organic compounds to detect specific functional groups. It helps in confirming the presence of alcohols, phenols, aldehydes, ketones, carboxylic acids, amines, and others through color change, precipitate formation, or the evolution of gas.
(2) Application of Knowledge & Skills: Applying specific chemical tests to identify functional groups in unknown organic compounds during laboratory practice.
(3) Technical & Professional Skills: Performing systematic chemical tests accurately to detect functional groups and interpret the results in organic qualitative analysis.
(4) Employability and Job-Ready Skills: Demonstrating proficiency in laboratory techniques, observation, and analysis for identifying organic functional groups in quality control and research settings.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzing test outcomes logically to differentiate between similar functional groups and draw accurate conclusions in organic qualitative analysis.	Critical thinking
2	Designing and executing experiments to identify functional groups, enabling structure elucidation, and supporting organic compound characterization.	Research-related skills

3	Working effectively in lab teams to perform, verify, and interpret functional group tests in organic qualitative analysis.	Coordinating/collaborating with others
4	Utilizing digital tools for recording observations, analyzing data, and researching reaction mechanisms in functional group analysis.	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

Semester III

MAJOR COURSE [Code: MJCH 05A]
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 XeF_2, XeF_4 and XeF_6; 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.

Objective of the Course

(1) Knowledge & Understanding: (i) To develop a comprehensive understanding of the chemistry of s- and p-block elements, including their trends, structure, bonding, and reactivity. (ii) To understand the principles of coordination chemistry, acid-base theories, and metallurgical processes, along with their theoretical foundations such as valence bond theory, crystal field theory, and thermodynamic concepts.
(2) Application of Knowledge & Skills: (i) To apply concepts such as oxidation states, acid-base behavior, ligand field theory, and metal extraction principles in solving real-life chemical problems. (ii) To relate the structure and bonding of compounds (e.g., borates, interhalogens, noble gas compounds) to their properties and practical uses.
(3) Technical & Professional Skills: (i) To develop proficiency in interpreting molecular structures, reaction mechanisms, and thermodynamic data (e.g., Ellingham diagrams) relevant to both academic and industrial chemistry. (ii) To enhance the ability to analyze coordination compounds, assess acid-base behavior in solutions, and evaluate metal purification techniques using both classical and modern methods.
(4) Employability and Job Ready Skills: (i) To equip students with core chemical knowledge and problem-solving skills applicable in chemical industries, materials science, metallurgy, and laboratory research. (ii) To prepare students for roles that demand competence in analytical reasoning, experimental chemistry, and understanding of industrial chemical processes, such as in pharmaceuticals, metallurgy, and chemical manufacturing sectors.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically evaluate trends in elemental behavior, bonding theories, and metallurgical processes to interpret complex chemical phenomena and predict reactivity and stability.	Critical thinking
2	Students will develop the ability to investigate structural, electronic, and thermodynamic aspects of s-, p-block, and coordination compounds using scientific literature and experimental data.	Research-related skills
3	Students will engage in group discussions and laboratory activities to collaboratively solve chemical problems, interpret observations, and draw logical conclusions.	Coordinating/collaborating with others
4	Students will utilize digital tools and resources to model molecular structures, analyze chemical data, and stay updated with emerging trends in inorganic and industrial chemistry, fostering lifelong learning.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 3117.0300 (Laboratory Assistant, Metallurgical), 8131.8500 (Extraction Attendant, Chemical), 8131.8100 (Acid Worker, Other).

MAJOR COURSE [Code: MJCH 05B]
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).

Objective of the Course

(1) Knowledge & Understanding: To provide students with a comprehensive understanding of the structure, properties, reactivity, and synthetic applications of a wide range of aliphatic organic compounds. These include compounds without nitrogen (like alkanes, alkenes, alcohols, carboxylic acids), compounds containing nitrogen (like amines, amides, nitriles), and sulfur-containing compounds (such as thiols, thioethers, sulfonic acids). The course is also to develop a detailed understanding of the formation, chemical reactivity, and reaction mechanisms of alkenes and alkynes, which are fundamental unsaturated hydrocarbons in organic chemistry.
(2) Application of Knowledge & Skills: (1) Apply principles of halogenation to predict the reactivity and synthetic utility of halogenated hydrocarbons in organic transformations. (2) Solve problems related to physical properties, reactivity, and mechanisms using spectroscopic and theoretical tools.
(3) Technical & Professional Skills: **(1)** Demonstrate proficiency in identifying and analyzing halogenated hydrocarbons and predicting their chemical behavior. Apply knowledge of aromatic substitution to synthesize and modify aromatic compounds for industrial or pharmaceutical use. **(2)** Effectively communicate chemical concepts, mechanisms, and outcomes in both academic and professional settings.
(4) Employability and Job-Ready Skills: (1) Develop problem-solving and analytical skills essential for roles in pharmaceuticals, petrochemicals, and chemical industries, and gain hands-on experience in interpreting molecular structures and reaction mechanisms relevant to quality control and R&D. **(2)** Enhance the ability to work in laboratory environments, using chemical knowledge for synthesis, analysis, and process development.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	At the end of this course, students can evaluate reaction pathways and predict outcomes based on electronic and steric factors in halogenated and aromatic compounds. They can also assess conformational isomerism to determine the most stable structures and their impact on chemical reactivity.	Critical thinking
2	Design and conduct experiments to study reaction mechanisms and conformational behavior of organic compounds. Analyze and interpret spectroscopic and kinetic data to conclude structure–reactivity relationships.	Research-related skills

3	Work effectively in laboratory teams to conduct organic synthesis and analyze results collaboratively. Share insights and data on halogenated, cycloalkane, and aromatic compounds to support group problem-solving and research.	Coordinating/collaborating with others
4	Utilize molecular modeling software to visualize conformations and predict the reactivity of organic compounds. Apply digital tools for spectral analysis and reaction simulation to enhance understanding of complex mechanisms.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

MAJOR COURSE [Code: MJCH 06A]
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.

Objective of the Course

(1) Knowledge & Understanding: Application of 2nd law of thermodynamics in chemistry and introduction to the third law of thermodynamics. To understand the basic concept of chemical reaction its mechanism and speed.
(2) Application of Knowledge & Skills: Students will apply theoretical knowledge and interpretation skills to the conduct various chemical processes in chemical, pharmaceutical and cosmetics industry.
(3) Technical & Professional Skills: Learners will acquire technical skills related to different types of chemical reaction and its different parameters, the theories of rate processes, mechanism of the reactions. They will also be trained in interpreting the kinetics of the chemical reactions using the knowledge of time dependance of reaction pathways.
(4) Employability and Job Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the chemical and pharmaceutical industry where knowledge of chemical kinetics has immense importance.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical parameters of the chemical reaction such as rate, order, molecularity, integrated rate laws, temperature dependence, rate equations for complex reactions etc. Students will understand a chemical reaction in terms of chemical potential. Students will learn to calculate entropy of a pure system based on the third law of thermodynamics.	Critical thinking
2	Develop skills in theoretical interpretation of chemical reaction, rate of advancement, reaction co-ordinate, potential energy, activation energy, etc. to proceed further in academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving problems relevant to chemical reaction and explaining models relevant to mechanism of reaction.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of reaction rate theories related to chemical kinetics.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 3314.9900 (Statistical, Mathematical and Related Associate Professionals, Other)

MAJOR COURSE [Code: MJCH 06B]
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

Objective of the Course

(1) Knowledge & Understanding: Understand core principles and measurement techniques of surface tension, viscosity, conductometry, and thermochemical enthalpy changes in solutions.
(2) Application of Knowledge & Skills: Experimentally determine surface tension, viscosity, conductometric, and calorimetric parameters to analyze solution behavior. Quantitatively interpret data to assess effects of concentration and solute type, validating theoretical models.
(3) Technical & Professional Skills: Skillfully operate lab instruments, prepare and standardize solutions, and control experimental conditions precisely. Ensure accurate data collection, adhere to safety protocols, manage resources effectively, and document all procedures for reproducibility and quality.
(4) Employability and Job-Ready Skills: Gain practical skills in chemical analysis and quality control while enhancing problem-solving and teamwork abilities through collaborative experiments. Demonstrate proficiency in laboratory management, safety, instrumentation, and data analysis vital for research and industry careers.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Critically analyze experimental data to validate physical property models, interpret conductometric and thermochemical results, and identify errors or deviations. Use problem-solving skills to optimize experiments, troubleshoot instruments, and integrate findings with theory for comprehensive understanding.	Critical thinking
2	Plan and execute experiments systematically to measure surface tension, viscosity, conductance, and enthalpy with precise reagent preparation and standardization. Perform quantitative analyses, consult relevant theory and literature, and thoroughly document procedures and results to ensure accuracy and reproducibility.	Research-related skills
3	Collaborate effectively in lab teams by sharing tasks like preparation, instrument setup, and data collection while communicating to resolve issues and ensure accuracy. Work jointly to analyze data, coordinate resource use, and present findings clearly, enhancing group understanding and laboratory efficiency.	Coordinating/collaborating with others
4	Operate and calibrate digital instruments accurately while using software tools for data acquisition, analysis, and visualization of experimental results. Employ computational tools for calculations and maintain organized digital records, leveraging online scientific resources to enhance research and experiment planning.	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

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 B_{12}, 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).

Objective of the Course

(1) Knowledge & Understanding: To provide in-depth understanding of advanced topics in coordination chemistry, bioinorganic systems, transition metal chemistry, lanthanides, actinides, inorganic polymers, and analytical chemistry.
(2) Application of Knowledge & Skills: (i) To enable students to apply theoretical principles to analyze magnetic behavior, spectroscopic transitions, and oxidation state stabilization in coordination and transition metal, lanthanide compounds. (ii) To relate metal functions in biological systems to real-world applications in medicine, environment, and industry.
(3) Technical & Professional Skills: (i) To develop the ability to interpret electronic spectra, calculate ligand field parameters, evaluate bioinorganic functions, and perform qualitative/quantitative analysis using analytical techniques. (ii) To gain technical proficiency in understanding and designing inorganic polymers and interpreting their structural properties.
(4) Employability and Job Ready Skills: To equip students with job-oriented knowledge in chemical research, biochemistry, analytical laboratories, and materials science through exposure to biologically and industrially relevant metal complexes and analytical methods.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically analyze complex electronic structures, spectral behaviors, magnetic properties of transition metal, lanthanides, actinides, and bioinorganic functions of metal ion, inorganic polymer to solve advanced problems in inorganic chemistry.	Critical thinking
2	Students will develop research aptitude by interpreting ligand field parameters, studying metal-ligand interactions in biological systems, and evaluating analytical data for chemical investigations.	Research-related skills
3	Students will enhance teamwork skills through collaborative laboratory work and group discussions to explore spectroscopic analysis, transition metal chemistry, and bioinorganic mechanisms.	Coordinating/collaborating with others
4	Students will use digital tools and scientific databases to visualize molecular structures, analyze spectra, and access up-to-date research for independent and lifelong learning in inorganic chemistry.	Digital and technological skills

NCO: 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2113.0300 (Chemist, Inorganic), 1223.0201 (Research Associate), 2113.0500 (Chemist Analytical), 2131.1300 (Chemist, Biological).

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 a-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 ofdicarboxylic 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 Schimdt 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 -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).

Objective of the Course

(1) Knowledge & Understanding: Understanding the structure, physical and chemical properties, and reactivity of alcohols, phenols, ethers, epoxides, carbonyl compounds, carboxylic acids and their derivatives; Grasping the synthetic applications, mechanisms, and unique reactivities of organometallic compounds of Mg, Li, Cu, B, and Si in organic transformations. Understanding the principles and techniques involved in the identification, separation, and quantitative analysis of chemical substances.

(2) Application of Knowledge & Skills: (1) Effectively apply reaction mechanisms of alcohols, phenols, ethers, and epoxides to design and perform the synthesis of pharmaceuticals and fine chemicals. (2) Integrate these concepts to solve complex synthetic challenges in both laboratory and industrial organic chemistry setups.

(3) Technical & Professional Skills: (1) Demonstrate proficiency in identifying and handling functional groups such as alcohols, phenols, ethers, and epoxides in laboratory settings with the development of professional lab documentation, report preparation, and critical evaluation of reaction outcomes for academic or industrial research. (2) Proficient in using analytical techniques and instruments for the accurate identification, separation, and quantitative analysis of compounds.

(4) Employability and Job-Ready Skills: (1) Ready to contribute to roles in chemical, pharmaceutical, and research industries through hands-on experience and analytical problem-solving abilities. (2) Ability to efficiently perform identification, separation, and quantitative analysis essential for laboratory and industrial applications.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyze and compare reaction mechanisms and pathways to select the most efficient and sustainable synthetic route. Evaluate the reactivity and selectivity of functional groups and organometallic reagents to solve complex organic chemistry problems.	Critical thinking
2	Design and conduct experiments involving synthesis, reactivity studies, and functional group transformations using modern laboratory techniques. Interpret spectral data and literature to develop new methodologies and optimize reactions involving carbonyls, organometallics, and related compounds.	Research-related skills
3	Work effectively in laboratory teams to plan, execute, and troubleshoot multi-step syntheses involving diverse organic functional groups. Collaborate with peers and mentors to analyze results, share insights, and ensure safety and accuracy in experiments with reactive organometallic compounds.	Coordinating/collaborating with others
4	Utilize chemical drawing software (e.g., ChemDraw) and spectral analysis tools (e.g., NMR, IR software) for structure elucidation and reaction planning. Operate digital lab instruments and data logging systems to monitor reactions, analyze yields, and document experimental procedures accurately.	Digital and technological skills

2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2113.0200 (Chemist, Inorganic), 1223.0201 (Research Associate)

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/Sb_2O_3 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.

Objective of the Course

(1) Knowledge & Understanding: To provide a preliminary idea of electrostatics, electrical circuits, and cell construction, along with solid structure and chemical bonding. The understanding also includes reaction kinetics, ionic equilibrium, and colligative properties, which help understand solution behavior and molar mass determination.
(2) Application of Knowledge & Skills: Students will apply electrochemical principles to analyze energy conversion, solve thermodynamics problems, and use EMF measurements for calculating free energy, equilibrium constants, and pH values. They will also interpret reaction kinetics, analyze crystal structures, and understand solution properties like colligative effects, which are important in applications such as polymer weight determination, food preservation, and cryopreservation.
(3) Technical & Professional Skills: Learners will develop skills in electrochemical cell thermodynamics, concentration cells, and solid structure analysis, including reaction rates and crystal data interpretation. They will also apply ionic equilibrium principles in industries like pharmaceuticals, agriculture, and environmental science, focusing on water purification and membrane processes.
(4) Employability and Job Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the field of solid-state chemistry and biological science sectors. Understanding ionic equilibrium and colligative property have wide range of practical applications that impact our daily lives and various industries.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Learn to measure electromotive force and apply the Nernst equation, understand standard electrode potentials, and identify crystal structures. Develop skills in reaction kinetics and calculate physical constants like pH, ebullioscopic and cryoscopic constants, van't Hoff factor, and dissociation constants.	Critical thinking
2	Develop skills to analyze half-cells, crystal structures, reaction kinetics, catalysis mechanisms, ionic equilibrium, and colligative properties both theoretically and practically.	Research-related skills
3	Engage in group discussions and collaborative problem-solving on electrolyte properties, atomic/molecular models, ionic equilibrium, and colligative properties.	Coordinating/ collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of electrochemistry, chemical kinetics and surface chemistry, the ionic equilibrium and colligative properties.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

MAJOR COURSE: [Code: MJCH 10A]
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-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$, 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:
i. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
ii. Cis and trans $K[Cr(C_2O_4)_2.(H_2O)_2]$, Potassium dioxalatodiaquachromate (III)
iii. Tetraamminecarbonatocobalt (III) ion
iv. Potassium tris(oxalate)ferrate(III)

(C) Some experiments
i. Iodo / Iodimetric Titrations: (a) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). (b) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
ii. Measurement of 10 Dq by spectrophotometric method
iii. Controlled synthesis of two copper oxalate hydrate complexes: kinetic vs thermodynamic factors.
iv. Preparation of acetylacetanato complexes of Cu^{2+}/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 acetylacetone, 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

Objective of the Course

(1) Knowledge & Understanding: To develop a thorough understanding of qualitative semimicro analysis, and inorganic complex preparations.
(2) Application of Knowledge & Skills: To enable students to apply theoretical principles in practical settings for the qualitative identification of acid and basic radicals and synthesis of different coordination compounds and their characterizations.
(3) Technical & Professional Skills: To cultivate laboratory skills including precise handling of chemicals, accurate titrations, synthesis of complexes, spectral analysis, and systematic observation through spot tests and controlled experiments.
(4) Employability and Job Ready Skills: To prepare students for professional roles by enhancing their competency in practical inorganic chemical analysis, complex synthesis, and instrumental techniques relevant to industries such as pharmaceuticals, environmental testing, and chemical manufacturing.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will develop the ability to analyze and interpret complex qualitative data and reaction mechanisms to accurately identify ions and synthesize inorganic complexes.	Critical thinking
2	Students will acquire hands-on experience in designing and conducting experiments, troubleshooting procedures, and documenting results for inorganic qualitative and quantitative analyses.	Research-related skills
3	Students will enhance teamwork and communication skills by collaboratively performing laboratory experiments.	Coordinating/collaborating with others
4	Students will utilize digital tools such as spectrophotometers and titration equipment to deepen understanding and refine practical techniques.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic), 8131.8700 (Laboratory Attendant), 3116.0200 (Laboratory Assistant, Food & Beverages/Chemist/Analytical Supervisor/Lab Chemist), 3111.0300 (Laboratory Assistant, Chemical).

MAJOR COURSE [Code: MJCH 10B]
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) Tartartic 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)

Objective of the Course

(1) Knowledge & Understanding: Understanding the principles of identification of organic compounds through their physical and chemical properties. Familiarity with general reactions and confirmatory tests used to identify some commercially available organic compounds.
(2) Application of Knowledge & Skills: Applying the Identification of commercially available organic compounds using general reactions and confirmatory tests.
(3) Technical & Professional Skills: Performing identification of organic compounds through standardized general reactions and diagnostic tests.
(4) Employability and Job-Ready Skills: Ability to accurately identify organic compounds using general reactions and tests relevant to industry and laboratory settings.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzing and interpreting test results to accurately identify organic compounds and troubleshoot anomalies in reactions.	Critical thinking
2	Designing and executing experiments to identify organic compounds using general reactions and analytical tests.	Research-related skills
3	Working effectively in teams to conduct identification tests and share findings on organic compounds.	Coordinating/collaborating with others
4	Utilizing digital tools and laboratory technologies to perform and document identification tests of organic compounds.	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2421.0101 (Analyst – Research)

Semester V

MAJOR COURSE [Code: MJCH 11A]
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-complementary redox reactions, racemization in octahedral complexes.

Unit 2: Structure and Properties of Solids: (**14 lectures**).
Description of Crystal Structures, Close Packed Structures, AB, AB_2 and A_2B_3 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 4$_{th}$ 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.

Objective of the Course

(1) Knowledge & Understanding: To develop a comprehensive understanding of the mechanisms of inorganic reactions including ligand substitution and redox processes, and to analyze the structural and electronic properties of solids and their impact on material behavior.
(2) Application of Knowledge & Skills: (i) Apply mechanistic principles to predict the behavior of metal complexes in substitution and electron transfer reactions. (ii) Use structural knowledge to interpret and predict the physical properties of solid-state materials including conductivity and magnetism.
(3) Technical & Professional Skills: To build proficiency in analyzing mechanisms of coordination compounds, identifying structural types of solids, and evaluating factors affecting stability, conductivity, magnetism, and defects in materials.
(4) Employability and Job Ready Skills: To equip students with the theoretical and analytical foundation essential for careers in research, materials science, chemical manufacturing, and industries related to solid-state technology and coordination chemistry.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Learners will be able to critically analyze and compare different inorganic reaction mechanisms, crystal structures, and defect types to evaluate their impact on chemical behavior and material properties.	Critical thinking
2	Students will develop the ability to interpret experimental and theoretical data on coordination kinetics and solid-state structures, enhancing their capacity to design or assess inorganic systems in research contexts.	Research-related skills
3	Learners will engage in collaborative discussions, fostering teamwork and the ability to jointly solve complex problems in reaction mechanisms and solid-state chemistry.	Coordinating/collaborating with others
4	Students will utilize spectroscopic data, digital models, and simulation tools to study kinetic behaviors and structural properties, enabling self-directed learning in contemporary inorganic chemistry.	Digital and technological skills

NCO: 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2113.0300 (Chemist, Inorganic), 1223.0201 (Research Associate)

MAJOR COURSE: [Code: MJCH 11B]
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 distributers, 2017.

Objective of the Course

(1) Knowledge & Understanding: To develop a solid conceptual understanding of complexometric, gravimetric, and spectrophotometric methods of quantitative analysis, along with the underlying chemistry of metal-ligand interactions and colorimetric detection.
(2) Application of Knowledge & Skills: To apply titrimetric and instrumental techniques to estimate metal ion concentrations in environmental samples, pharmaceuticals, and industrial materials with accuracy and precision.
(3) Technical & Professional Skills: To acquire hands-on experience in standard laboratory practices including solution preparation, titration, gravimetric precipitation, filtration, drying, weighing, and spectrophotometric measurements.

(4) Employability and Job Ready Skills: To enhance analytical proficiency and laboratory competence, preparing students for careers in quality control, pharmaceutical analysis, environmental monitoring, and research laboratories.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will be able to interpret experimental results, identify anomalies, and logically deduce the composition of unknown inorganic samples using titrimetric, gravimetric, and spectrophotometric methods.	Critical thinking
2	Students will gain experience in designing, conducting, and refining chemical experiments, while critically analyzing quantitative data to support conclusions about metal ions and coordination compounds.	Research-related skills
3	Through group-based practical sessions, students will develop teamwork skills by sharing responsibilities, troubleshooting procedures collaboratively, and ensuring accuracy in shared laboratory work.	Coordinating/collaborating with others
4	Students will utilize spectrophotometers and digital tools for data acquisition, analysis, and calibration, thereby learning to adapt to modern instrumental methods in analytical chemistry.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic), 8131.8700 (Laboratory Attendant), 3116.0200 (Laboratory Assistant, Food & Beverages/Chemist/Analytical Supervisor/Lab Chemist), 3111.0300 (Laboratory Assistant, Chemical), 2262.0100 (Chemist, Pharmaceuticals), 8122.6900 (Hardness Tester, Metal).

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)-dioxygenated 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)

Objective of the Course

(1) Knowledge & Understanding: Demonstrates conceptual clarity of dynamic stereochemistry, pericyclic reactions, and the structure and reactivity of heterocyclic and fused ring systems. Applies retrosynthetic analysis, functional group interconversion, and protection–deprotection strategies effectively in organic synthesis.
(2) Application of Knowledge & Skills: (1) Applies dynamic stereochemistry to analyze conformational changes and stereochemical outcomes in organic molecules. (2) Interprets and synthesizes heterocyclic compounds, including fused ring systems, with an understanding of their reactivity and stability. (3) Explains and predicts outcomes of pericyclic reactions using orbital symmetry principles. (4) Designs synthetic routes using retrosynthetic analysis and appropriate disconnections.
(3) Technical & Professional Skills: (1) Skilled in the synthesis and characterization of heterocyclic and fused ring systems with practical laboratory techniques. (2) Effectively employs functional group interconversions and protection-deprotection methods in multi-step organic synthesis.
(4) Employability and Job-Ready Skills: (1) Equipped to apply advanced organic chemistry concepts in research, pharmaceuticals, and chemical industries. (2) Demonstrates problem-solving, critical thinking, and practical synthesis skills essential for professional scientific roles

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzes complex reaction mechanisms and stereochemical outcomes to solve synthetic challenges logically. Evaluates multiple synthetic routes and selects the most efficient strategies using retrosynthetic and mechanistic reasoning.	Critical thinking
2	Capable of designing and optimizing synthetic pathways involving stereochemical control, pericyclic mechanisms, and heterocyclic systems. Proficient in conducting literature reviews, analyzing experimental data, and applying retrosynthetic and functional group strategies in research projects.	Research-related skills

3	Effectively works in team-based research and laboratory settings to plan and execute complex organic syntheses. Collaborates with peers to analyze reaction outcomes, troubleshoot synthetic challenges, and optimize methodologies.	Coordinating/collaborating with others
4	Proficient in using chemical drawing and modeling software (e.g., ChemDraw, Spartan) for stereochemical and mechanistic analysis. Utilizes spectral analysis tools and databases for structure elucidation, reaction prediction, and retrosynthetic planning.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 3213.9900 - (Pharmaceutical Assistants), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

MAJOR COURSE [Code: MJCH 13A]
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.

Objective of the Course

(1) Knowledge & Understanding: Provide a comprehensive understanding of quantum mechanics fundamentals and phase equilibrium principles to predict substance behavior across different phases.
(2) Application of Knowledge & Skills: Students will use theoretical knowledge of quantum mechanical systems to solve problems involving eigenfunctions and energy levels. This understanding is applied in fields like chemical engineering, materials science, and geology for designing processes, predicting material stability, and studying mineral formation.
(3) Technical & Professional Skills: Learners will gain technical skills in quantum mechanics concepts like Black Body radiation, wave-particle duality, and the Schrödinger equation, alongside understanding phase diagrams for applications in chemical processes, geology, drug formulation, and thermodynamic modeling. They will also gain phase equilibrium knowledge which is essential for optimizing industrial systems and interpreting natural mineral formations.
(4) Employability and Job-Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the material science sectors, chemical engineering, metallurgy, geology, pharmaceutical and food industry.

Expected outcome from the Course		

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Strong theoretical foundation about Black Body radiation, Photo-electric effect, Wave-particle duality, Wave equation, Heisenberg Uncertainty principle, operators and their commutation. Calculate several physical quantities such as number of phases, degree of freedom and try to draw different phase diagram of the mixture (solid-solid. solid-liquid etc.)	Critical thinking
2	Develop skills in interpreting quantum mechanics and phase equilibrium theories for advanced academic research and practical applications.	Research-related skills
3	Engage in group discussions and collaborative learning to solve and explain quantum mechanics and phase equilibrium problems.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of quantum mechanical theories and the phase equilibrium.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

MAJOR COURSE [Code: MJCH 13B]
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:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$
(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow [Cu(NH_3)_n]^{2+}$

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 H_2SO_4 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

Objective of the Course

(1) Knowledge & Understanding: Understand the principles of Potentiometric & pH-metric titration, performing chemical kinetics reaction, determination of critical solution temperature and composition of the multi component system.
(2) Application of Knowledge & Skills: Perform accurate standardization and titrations using emf of a cell and pH as indicators. Apply concepts of stoichiometry in determining unknown concentrations. Estimate Order of a reaction and evaluate critical solution temperature.
(3) Technical & Professional Skills: Learners will acquire technical skills related to calibrating and handling titration equipment with precision, pH meter, Potentiometer, construction of a electrochemical cell, etc.
(4) Employability and Job Ready Skills: Develop laboratory discipline and documentation practices suitable for industrial, research, and academic labs. Gain foundational skills essential for roles in analytical chemistry, quality control, chemical manufacturing, and education.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluate experimental errors and optimize procedures for accurate and reproducible results.	Critical thinking
2	Design and conduct experiments using classical techniques, forming a base for advanced instrumental analysis. Understand and apply instruments to find accurate strength of a solution. Estimate order of any unknown reaction.	Research-related skills
3	Work effectively in pairs or small groups, sharing responsibilities and communicating findings. Follow safety protocols and ensure cooperative use of shared lab resources.	Coordinating/collaborating with others
4	Use digital tools for data recording and analysis where applicable (e.g., origin software, Microsoft excel).	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

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 Niusing 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 (Wilkinsons 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 4nd 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

Objective of the Course

(1) Knowledge & Understanding: To provide students with a comprehensive understanding of organometallic chemistry, inorganic photochemistry, nanomaterials, and modern separation techniques. The course aims to develop a deep conceptual foundation in key areas such as metal-ligand bonding, photochemical processes in inorganic systems, structural and electronic properties of nanomaterials, and the theoretical principles underlying chromatographic and extraction methods.

(2) Application of Knowledge & Skills: To enable students to apply theoretical knowledge in solving chemical problems involving organometallic mechanisms, synthesis of nanostructured materials, interpretation of photochemical behaviors of coordination compounds, and the selection and optimization of appropriate separation techniques in analytical and preparative chemistry.

(3) Technical & Professional Skills: To develop technical competencies such as calculating electron counts in metal complexes, analyzing IR data for back bonding, handling photochemical instrumentation, synthesizing and characterizing nanoparticles, and interpreting chromatograms.

(4) Employability and Job Ready Skills: To prepare students for careers in research, pharmaceuticals, materials science, environmental science, and chemical industries by imparting practical skills in catalysis, nanomaterials synthesis, photochemistry, and analytical chemistry. The course emphasizes real-world applications like catalysis in industrial processes, use of organometallics in polymerization, and modern chromatographic methods, making students industry-ready and competitive in the job market.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically analyze the bonding, reactivity, and mechanistic aspects of organometallic compounds and photochemical processes to evaluate their roles in complex chemical transformations and industrial applications.	Critical thinking
2	Students will develop research skills through the study of nanomaterial synthesis, spectroscopic analysis, and separation techniques, enabling them to design experiments, interpret data, and engage in scientific inquiry.	Research-related skills
3	Through group-based discussions, problem-solving exercises, and lab-based applications, students will learn to effectively collaborate and communicate within a team to address advanced inorganic and materials chemistry problems.	Coordinating/collaborating with others
4	Students will acquire the ability to use modern computational, spectroscopic, and chromatographic tools, fostering independent learning and adaptability to emerging technologies in chemical science.	Digital and technological skills

NCO: 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2113.0300 (Chemist, Inorganic), 1223.0201 (Research Associate), 2113.0500 (Chemist Analytical).

MAJOR COURSE [Code: MJCH 15A]
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 &Arndst-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

Objective of the Course

(1) Knowledge & Understanding: Interpretation of IR, UV-Vis, NMR, and Mass spectra to determine organic molecular structures. Understanding the structure, properties, and reactivity of polynuclear hydrocarbons and key rearrangement reactions, along with the methods, mechanisms, and principles involved in the preparation and synthesis of organic compounds.

(2) Application of Knowledge & Skills: (1) Apply IR, UV-Vis, NMR, and Mass spectroscopic techniques to identify functional groups and determine molecular structures. (2) Utilize spectroscopy and rearrangement knowledge in solving structural problems and designing synthetic pathways with molecular features to deduce connectivity and stereochemistry.

(3) Technical & Professional Skills: (1) Capable of integrating spectral interpretation into research, quality control, and synthetic strategy development. (2) Skilled in executing organic synthesis techniques, including reaction setup, monitoring, purification, and characterization of organic compounds.

(4) Employability and Job-Ready Skills: (1) Skilled in using spectroscopic techniques for structural elucidation, essential for roles in pharmaceuticals, research, and quality control. (2) Capable of analyzing complex organic systems, including polynuclear hydrocarbons and rearrangement pathways, for practical problem-solving.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluate and interpret complex spectral data to deduce accurate molecular structures and reaction pathways. Analyze unexpected spectral or structural outcomes in polynuclear systems and rearrangement reactions to propose logical explanations.	Critical thinking
2	Design and conduct experiments involving spectroscopic techniques to investigate organic molecular structures and transformations. Critically analyze spectral data to support hypotheses, elucidate mechanisms in rearrangement reactions, and explore polynuclear hydrocarbons.	Research-related skills
3	Work effectively with interdisciplinary teams to interpret spectroscopic data for complex organic molecules and reactions. Collaborate in research and development projects involving polynuclear hydrocarbons and rearrangement mechanisms to achieve shared goals.	Coordinating/collaborating with others
4	Proficient in using advanced software and digital tools for processing and interpreting IR, UV-Vis, NMR, and Mass spectra. Utilize computational methods and databases to model polynuclear hydrocarbons and predict rearrangement reaction outcomes.	Digital and technological skills

NCO: 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects) 2113.0500 – Chemist, Analytical; 2113.0200 – Chemist, Organic

MAJOR COURSE [Code: MJCH 15B]
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, salicylicacid) by any one method:
a. Using conventional method.
b. Using green approach
ii. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, pcresol) by Schotten-Baumann reaction.
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*-Benzylisothiouronium 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 Textbookof Practical Organic Chemistry, 5th Ed., Pearson (2012).

Objective of the Course

(1) Knowledge & Understanding: Organic compound preparation in the laboratory involves designing and executing chemical reactions to synthesize target molecules with desired purity and yield. It requires understanding reaction mechanisms, conditions, and safety protocols to achieve efficient and reproducible synthesis.
(2) Application of Knowledge & Skills: Applying knowledge and skills in organic compound preparation involves accurately performing synthesis procedures, including reagent handling, reaction monitoring, and product isolation. It also includes troubleshooting reactions and optimizing conditions to improve yield and purity.
(3) Technical & Professional Skills: Expertise in executing organic synthesis techniques and handling laboratory equipment to prepare and purify compounds safely and efficiently.
(4) Employability and Job-Ready Skills: Ability to independently conduct organic syntheses with precision, ensuring quality and safety, essential for roles in chemical research and industry.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzing reaction pathways and troubleshooting experimental challenges to optimize synthesis outcomes and product purity.	Critical thinking
2	Designing and executing synthetic experiments, analyzing results, and applying literature to innovate and improve organic compound preparation methods.	Research-related skills
3	Working effectively with team members to plan, execute, and troubleshoot organic synthesis experiments while ensuring lab safety and data sharing.	Coordinating/collaborating with others
4	Utilizing digital tools for reaction planning, data analysis, and lab documentation, along with operating modern instruments for synthesis and characterization.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic); 2113.0500 (Chemist, Analytical); 2113.0600 (Chemist, Industrial); 3111.0300 (Laboratory Assistant, Chemical).

MAJOR COURSE [Code: MJCH 16A]
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 $\boldsymbol{L^2}$ and $\boldsymbol{L_z}$ 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.

Objective of the Course

(1) Knowledge & Understanding: To understand the fundamentals of spectroscopy, molecular spectra interpretation, and quantum mechanical systems like the harmonic oscillator and orbital angular momentum.
(2) Application of Knowledge & Skills: Students will use spectroscopy to study molecular interactions and visualize molecular structures, while applying quantum mechanics to solve problems involving vibrational energy, zero-point energy, and orbital angular momentum eigenvalues. This integrates theoretical and practical knowledge for understanding molecular properties.
(3) Technical & Professional Skills: Learners will gain technical skills in molecular spectroscopy, including rotational and vibrational spectra, and techniques for acquiring and interpreting these spectra. They will also master solving the Schrödinger equation using operator methods, including ladder operators and rotational motion concepts.
(4) Employability and Job-Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the material science sectors and scientific projects in industry where spectroscopy possesses unquestionable importance.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such as spectral frequency, width, intensity. Find out selection rules for different spectroscopic transitions. Strong theoretical foundation about ladder operator method, space quantization, vector model, central force problem, operator algebra.	Critical thinking
2	Develop skills to interpret molecular spectroscopy, understand microscopic molecular interactions, and solve the Schrödinger equation using operator methods to determine vibrational energies and orbital angular momentum eigenvalues for advanced academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving spectroscopic problems relevant to complex molecules, learning various techniques and instrumentation relevant to spectroscopy, and explaining models relevant to operators in polar coordinates, operator algebra for rotational motion, selection rule.	Coordinating/collaborating with others
4	Utilize scholarly resources and digital tools to enhance understanding of electronic structure, spectral properties, and quantum concepts like harmonic oscillators and orbital angular momentum.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

MAJOR COURSE [Code: MJCH 16B]
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 $K_2Cr_2O_7$ (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 $K_2Cr_2O_7$.

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 $CuSO_4$/$KMnO_4$/$K_2Cr_2O_7$ in a solution of unknown concentration

II. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ 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-phenathroline.

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 HCl(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

Objective of the Course

(1) Knowledge & Understanding: Understand key concepts of adsorption isotherms, UV-Vis spectroscopy, Lambert-Beer's law, reaction kinetics, conductometry, and vibration-rotation spectra in physical chemistry.

(2) Application of Knowledge & Skills: Apply adsorption models and spectroscopic techniques to analyze chemical equilibria, electronic transitions, and reaction kinetics. Use conductometry and spectral analysis to determine dissociation constants, validate dilution laws, and gain molecular-level insights.

(3) Technical & Professional Skills: Operate and calibrate analytical instruments precisely while preparing solutions and maintaining lab protocols. Conduct kinetic experiments with accurate data collection, process results, and document findings systematically.

(4) Employability and Job-Ready Skills: Develop strong analytical, problem-solving, teamwork, and instrumental skills essential for quality control and research in pharmaceutical, chemical, and environmental industries.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Critically analyze adsorption, UV-Vis, and conductometric data to evaluate isotherms, electronic transitions, and acid dissociation, while assessing kinetics and reaction mechanisms. Interpret spectral data and test theoretical laws, linking experimental observations to molecular behavior and energy concepts.	Critical thinking
2	Design and perform systematic experiments with precise solution preparation and reagent standardization to obtain reliable adsorption, spectroscopic, kinetic, and conductometric data. Analyze results quantitatively, reference theoretical models, and document procedures thoroughly to ensure scientific rigor and reproducibility.	Research-related skills
3	Collaborate efficiently in lab teams by sharing tasks, communicating clearly, and troubleshooting experimental issues together. Coordinate instrument use and data sharing to enhance accuracy, interpretation, and optimize workflow.	Coordinating/collaborating with others
4	Accurately operate digital instruments and use software for data acquisition, analysis, and visualization of spectroscopic and kinetic results. Leverage online databases, computational tools, and digital documentation to support research, calculations, and maintain organized lab records.	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

Semester VII

MAJOR COURSE [Code: MJCH 17A]
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, CH_3, C_6H_5, NH_2, CD_3, PH_4, F_2^-, $[BH_3]^-$, 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. Gütlich, 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

Objective of the Course

(1) Knowledge & Understanding: To impart a foundational and advanced understanding of magnetic behavior in molecules, electronic and nuclear spectroscopic techniques (EPR, NMR, Mössbauer), and their theoretical underpinnings for exploring the physical and structural properties of inorganic and organometallic compounds.
(2) Application of Knowledge & Skills: To enable students to interpret magnetic data, analyze EPR/NMR/Mössbauer spectra, and apply theoretical principles (e.g., spin-orbit coupling, hyperfine interactions, chemical shift) for the characterization and elucidation of complex inorganic structures.
(3) Technical & Professional Skills: To develop proficiency in advanced instrumental techniques such as EPR, multinuclear NMR (^1H, ^{13}C, ^{31}P, ^{19}F, ^{119}Sn, ^{195}Pt), and Mössbauer spectroscopy, with the ability to assess electronic environment, coordination geometry, and oxidation state of transition and inner-transition metal complexes.
(4) Employability and Job Ready Skills: To prepare students for careers in chemical research, material science, and spectroscopy-based industries by equipping them with practical analytical competencies, problem-solving abilities, and interpretative skills relevant to modern magnetochemistry and spectroscopic analysis.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically evaluate and interpret magnetic and spectroscopic data to deduce structural and electronic features of inorganic compounds, distinguishing between various magnetic behaviors and spectral patterns.	Critical thinking
2	Students will develop research competency by applying EPR, NMR, and Mössbauer techniques to investigate the bonding, oxidation states, and coordination environments in transition and main group metal complexes.	Research-related skills
3	Students will engage in collaborative problem-solving and peer discussions to analyze spectroscopic data, compare experimental results, and formulate theoretical justifications in team-based learning or laboratory settings.	Coordinating/collaborating with others
4	Students will gain hands-on experience with modern spectroscopic software and analytical tools, fostering self-directed learning and adaptability to evolving technologies in physical inorganic chemistry.	Digital and technological skills

NCO: 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2113.0300 (Chemist, Inorganic), 1223.0201 (Research Associate), 2111.0600 (Physicist, Electricity and Magnetism), 2114.0600 (Mineralogist), 2113.0400 (Chemist, Physical), 2111.0800 (Physicist, Nuclear).

MAJOR COURSE: [Code: MJCH 17B]
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.

Objective of the Course

(1) Knowledge & Understanding: To develop a strong conceptual understanding of analytical and synthetic methods in inorganic chemistry.

(2) Application of Knowledge & Skills: To apply theoretical knowledge in designing and conducting experiments such as pH-metric, spectrophotometric, and colorimetric analyses for the determination of metal ions, formation constants, and compound composition.

(3) Technical & Professional Skills: To train students in essential laboratory skills like chromatographic separation, magnetic susceptibility measurement, preparation and characterization of inorganic complexes, and environmentally sustainable (green) synthesis techniques.

(4) Employability and Job Ready Skills: To equip students with hands-on analytical and synthetic techniques widely used in chemical, environmental, and materials industries, thereby enhancing their readiness for employment in research labs, quality control, or industrial process development.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically analyze experimental data to draw valid conclusions on composition, stability, and behavior of inorganic systems through techniques like colorimetry, pH-metry, and magnetic measurements.	Critical thinking
2	Students will perform and analyze experiments to investigate inorganic systems.	Research-related skills
3	Students will learn to work effectively in teams during chromatographic separations, complex preparation, and green synthesis experiments, enhancing peer-to-peer learning and task coordination.	Coordinating/collaborating with others
4	Students will use instruments and digital tools to carry out modern analytical techniques.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic), 8131.8700 (Laboratory Attendant), 3116.0200 (Laboratory Assistant, Food & Beverages/Chemist/Analytical Supervisor/Lab Chemist), 3111.0300 (Laboratory Assistant, Chemical), 2113.0400 (Chemist, Physical), 2113.0500 (Chemist, Analytical).

MAJOR COURSE [Code: MJCH 18A]
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.

Polysaccharides – 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

Objective of the Course

(1) Knowledge & Understanding: Understanding the structure, function, and chemical properties of proteins, lipids, nucleic acids, carbohydrates, and polymers. Exploring their biological roles, synthesis, and degradation mechanisms in living systems and materials science.
(2) Application of Knowledge & Skills: (1) Designing and synthesizing polymers with tailored properties for industrial and biomedical applications and developing drug delivery systems and biomaterials based on protein and polymer chemistry. (2) Utilizing biochemical knowledge to understand metabolic pathways involving carbohydrates and lipids. Interpreting molecular interactions and reactions to innovate in biotechnology and materials science.
(3) Technical & Professional Skills: (1) Experienced in polymer synthesis, modification, and testing for mechanical and chemical properties. (2) Competent in applying bioinformatics tools to study nucleic acid sequences and protein structures.
(4) Employability and Job-Ready Skills: (1) Prepared to apply biochemical and polymer chemistry knowledge in research, pharmaceuticals, and materials industries. (2) Equipped with practical lab skills and problem-solving abilities essential for roles in biotechnology and chemical manufacturing.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluating molecular interactions and reaction mechanisms to solve complex biochemical and polymer-related problems. Analyzing data critically to optimize synthesis, functionality, and application of biomolecules and polymers.	Critical thinking
2	Designing experiments to investigate the structure, function, and synthesis of biomolecules and polymers. Utilizing advanced analytical techniques and data interpretation to contribute to scientific knowledge and innovation.	Research-related skills
3	Working effectively in multidisciplinary teams to conduct research and solve complex problems in biomolecule and polymer chemistry. Sharing knowledge and integrating expertise to advance projects in biotechnology, pharmaceuticals, and materials science.	Coordinating/collaborating with others
4	Utilizing bioinformatics software and molecular modeling tools to analyze proteins, nucleic acids, and carbohydrates. Applying advanced instrumentation and data acquisition technologies for polymer synthesis and characterization.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 3213.0101 (Pharmacy Assistant), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2131.1300 (Chemist, Biological (Biochemist)), 2145.1400 (Technologist, Plastics)

MAJOR COURSE [Code: MJCH 18B]
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).

Objective of the Course

(1) Knowledge & Understanding: Understanding the principles behind the separation techniques such as distillation, extraction, and chromatography. Ability to apply these methods to isolate individual components from a mixture of organic compounds in the laboratory.
(2) Application of Knowledge & Skills: Effectively utilizes techniques like solvent extraction, chromatography, and distillation for separating organic mixtures. Applies theoretical concepts to design and execute separation procedures in the organic laboratory setting.
(3) Technical & Professional Skills: Proficient in applying separation techniques such as distillation, chromatography, and extraction in organic laboratory practices.
(4) Employability and Job-Ready Skills: Skilled in practical separation methods essential for roles in chemical, pharmaceutical, and research laboratories.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzes mixture properties to select and optimize appropriate separation techniques for efficient component isolation.	Critical thinking
2	Capable of designing and refining separation protocols to investigate complex organic mixtures in experimental research.	Research-related skills
3	Works effectively in team settings to plan, execute, and troubleshoot separation processes in the organic laboratory.	Coordinating/collaborating with others
4	Utilizes digital tools and analytical instruments such as GC, HPLC, and data software for monitoring and analyzing separation processes.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 3213.0101 (Pharmacy Assistant), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2113.0500 (Chemist, Analytical).

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.

Objective of the Course

(1) Knowledge & Understanding: This course covers fundamentals of spectroscopy, quantum mechanical models, molecular symmetry, and the connection between thermodynamics and microscopic molecular dynamics.
(2) Application of Knowledge & Skills: Students will use spectroscopy and quantum mechanics to study molecular interactions, structures, and energies in systems like particles on a ring and rigid rotators, applying these concepts to real atoms and thermodynamic properties. They will also apply group theory to simplify quantum chemistry problems, with knowledge beneficial for CSIR-UGC-NET and GATE exams.
(3) Technical & Professional Skills: Learners will develop skills in molecular spectroscopy, including Raman, NMR, and ESR, and techniques for spectral acquisition and interpretation of chemical processes. They will also master solving the Schrödinger equation, coordinate transformations, orbital concepts, and apply partition functions to model particle distributions and thermodynamic properties.

(4) Employability and Job-Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the scientific projects in industry where spectroscopy possesses unquestionable importance, material science sectors, electrochemical and materials sectors.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Learn to calculate key spectroscopic quantities and selection rules, understand quantum numbers and orbital shapes, and apply statistical mechanics concepts like partition functions and particle statistics. Gain skills to predict IR/Raman activity and simplify quantum chemistry calculations using SALC.	Critical thinking
2	Develop skills to interpret molecular spectroscopy, solve the Schrödinger equation for quantum models, and understand molecular energy distributions, conduction, heat capacity, and phase transitions. Gain expertise in generating symmetry-adapted basis functions for advanced electronic structure research.	Research-related skills
3	Engage in group discussions and collaborative learning to solve complex spectroscopic problems, understand spectroscopy techniques, coordinate transformations, and radial functions, and address thermodynamic statistical models related to molecular energy distribution.	Coordinating/collaborating with others
4	Utilize scholarly resources and digital tools to deepen understanding of molecular electronic structures, spectroscopy, quantum models, and thermodynamic statistical theories.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

Semester VIII

MAJOR COURSE [Code: MJCH 20A]
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, metalloborranes 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: T**hermo-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-Sevčik 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 Pve 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)

Objective of the Course

(1) Knowledge & Understanding: To develop a thorough understanding of cage compounds, metal clusters, and modern thermo- and electro-analytical techniques, along with their theoretical frameworks and classifications.
(2) Application of Knowledge & Skills: To enable students to apply electron counting rules, interpret thermal and electrochemical data, and analyze the stability and reactivity of advanced inorganic compounds.
(3) Technical & Professional Skills: To equip learners with the ability to handle advanced characterization tools such as TGA, DSC, CV, and polarography for the investigation of inorganic materials.
(4) Employability and Job Ready Skills: To build competency in interpreting complex analytical results and handling modern instrumental techniques relevant to research labs, chemical industries, and quality control sectors.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will develop the ability to critically analyze the structure, bonding, and reactivity of complex cage compounds and metal clusters using logical electron-counting rules.	Critical thinking
2	Students will gain foundational expertise in using thermo- and electro-analytical techniques for data interpretation, enabling them to investigate and solve research-level inorganic problems.	Research-related skills
3	Students will learn to effectively collaborate in group during experimental tasks and problem-solving discussions involving metal clusters and advanced analytical methods.	Coordinating/collaborating with others
4	Students will use instruments and digital tools to carry out modern analytical techniques.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic), 2113.0400 (Chemist, Physical), 2113.0500 (Chemist, Analytical), 2310.0600 (University and College Teacher, Science Subjects / Professors / Assistant Professors, Science Subjects)

MAJOR COURSE [Code: MJCH 20B]
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.

Objective of the Course

(1) Knowledge & Understanding: Thorough understanding of natural products like alkaloids and terpenoids, emphasizing their biosynthetic pathways. In-depth knowledge of advanced reaction mechanisms and innovative synthetic strategies, including asymmetric synthesis techniques.
(2) Application of Knowledge & Skills: (1) Apply biosynthetic principles to elucidate the structure and formation pathways of natural products like alkaloids and terpenoids. (2) Design and execute multistep organic syntheses using advanced reaction mechanisms and modern reagents. Utilize asymmetric synthesis to generate enantiomerically pure compounds for pharmaceutical and industrial applications.
(3) Technical & Professional Skills: (1) Skilled in isolating, identifying, and characterizing natural products such as alkaloids and terpenoids. Capable of executing asymmetric synthesis with high stereocontrol and yield optimization. (2) Adept at developing and adapting new synthetic strategies for target-oriented molecule design.
(4) Employability and Job-Ready Skills: (1) Prepared for roles in pharmaceutical, agrochemical, and research industries with expertise in natural product chemistry and modern synthetic techniques. (2) Equipped with practical skills in asymmetric synthesis, reaction mechanism analysis, and biosynthetic pathway interpretation.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Able to critically analyze complex biosynthetic pathways and predict intermediate steps in natural product formation. Evaluates and compares synthetic strategies to identify the most efficient, selective, and sustainable approaches in asymmetric synthesis.	Critical thinking
2	Capable of designing and conducting experimental studies on biosynthetic routes and synthetic transformations of natural products. Skilled in interpreting mechanistic pathways and applying asymmetric synthesis techniques for the development of novel compounds with potential applications.	Research-related skills
3	Effectively collaborates with interdisciplinary teams in research projects involving natural product synthesis and mechanistic studies. Coordinates with peers and mentors to develop and optimize asymmetric synthetic strategies for target molecule construction.	Coordinating/collaborating with others
4	Proficient in using chemical drawing and simulation software (ChemDraw, Gaussian, Spartan) for reaction mechanism modeling and synthesis planning. Experienced in operating analytical instruments (NMR, HPLC, GC-MS) and interpreting spectral data for structure elucidation in natural product research.	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 3213.9900 (Pharmaceutical Assistants, Other) 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects), 2131.1300 (Chemist, Biological (Biochemist), 2113.0621-23 (Lab Chemist – Finished Product Testing, Incoming Raw Material Testing, Compound Testing – Batch Release), 2113.0800 (Chemist, Forensic Science).

MAJOR COURSE [Code: MJCH 21A]
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.

Objective of the Course

(1) Knowledge & Understanding: To understand the need of approximation methods to tackle many-electron systems and quantum mechanical approach to understand chemical bonding and to understand electronic spectroscopy from the fundamental point of view.
(2) Application of Knowledge & Skills: Students will apply theoretical principles to interpret how the approximate energy levels and wave functions of quantum mechanical systems can be obtained by approximation methods. This would, in turn, elucidate the electronic structure of the molecules. Students will learn UV-Visible spectroscopy from basics and will apply it in physical chemistry laboratory
(3) Technical & Professional Skills: Learners will acquire technical skills related to quantum mechanical approximation methods such as linear variation theory, Zeeman Effect, VBT, MOT, LCAO-MO theory, chemical bonding etc. To handle UV-vis spectrophotometer.
(4) Employability and Job-Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the materials science sectors where quantum chemistry possesses unquestionable importance.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such as approximate wave function, approximate energy, Born-Oppenheimer approximation, VBT, MOT, LCAO-MO theory, chemical bonding, electronic structure, Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, etc.	Critical thinking
2	Develop skills in theoretical interpretation of molecular electronic structure, splitting of spectral lines in presence of external magnetic field, nature of chemical bonding, etc. to progress further in academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving quantum mechanical problems and understand photo-physical properties relevant to complex molecules and learning various approximation techniques relevant to molecular electronic structure theory.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of electronic structure of complex molecules, splitting of spectral lines due to the applied magnetic field and knowledge of chemical bonding.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

MAJOR COURSE [Code: MJCH 21B]
Physical Chemistry Practical
(Credits: 2, F.M. 50) (60 Lectures)

- To determine the rate constant of a reaction in a micellar media by conductometric method.
- To determine the composition of a mixture of acetic acid, sodium acetate and ammonium
    - acetate by conductometry.
- To study the formation of charge transfer complex and determination of stoichiometry of the complex conductometrically & spectrophotometrically.
- To determine the rate constant and salt effect on the rate constant of decomposition of $K_2S_2O_8$ by KI using spectrophotometric method.
- To determine the dissociation constant of an indicator by spectrophotometry.
- To study the kinetics of alkaline hydrolysis of crystal violet by spectrophotometry.
- 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

Objective of the Course

(1) Knowledge & Understanding: Understand reaction kinetics, analytical techniques, acid-base equilibria, and how molecular interactions affect physical properties like conductivity, absorbance, and pH.
(2) Application of Knowledge & Skills: Apply conductometric, spectrophotometric, and pH-metric techniques to analyze reaction kinetics, equilibria, and buffer solutions, while interpreting data to calculate key chemical parameters. Integrate theory and experiment to solve complex chemical problems.
(3) Technical & Professional Skills: Demonstrate proficient use and maintenance of analytical instruments, prepare accurate chemical solutions, perform precise measurements, and adhere to lab safety and documentation protocols.
(4) Employability and Job-Ready Skills: Develop analytical and problem-solving skills using modern instruments for industry applications, while gaining expertise in designing and interpreting kinetic and equilibrium studies and enhancing scientific communication.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyze experimental data to identify patterns and factors affecting reaction kinetics and equilibria, including media, salt, and pH effects. Interpret spectroscopic and conductometric results to understand molecular interactions while critically evaluating data accuracy and method limitations.	Critical thinking
2	Design controlled experiments to measure kinetic and equilibrium parameters, systematically collect data using instruments, and perform quantitative analyses. Use initial results to develop hypotheses and refine procedures for further study.	Research-related skills
3	Collaborate effectively in lab teams to share tasks, communicate observations, troubleshoot, and interpret results. Coordinate resources efficiently and engage in group discussions to consolidate findings into clear reports or presentations.	Coordinating/collaborating with others
4	Operate digital instruments accurately and use software for data acquisition, analysis, and visualization. Utilize digital tools for research, documentation, and modeling of chemical equilibria and kinetics to enhance understanding.	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

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 *pi*- and *sigma*-bonds, anchimeric assistance; S_N*i* 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_E^i 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-Loffler-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-pi, anion-pi, pi-pi, lone pair-pi, 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.

Objective of the Course

(1) Knowledge & Understanding: To develop a comprehensive understanding of supramolecular chemistry and advanced element chemistry, including non-covalent interactions, host-guest systems, self-assembly processes, and the behavior of main group and transition elements.
(2) Application of Knowledge & Skills: To enable students to apply concepts of supramolecular design and the reactivity of elemental systems in interpreting molecular behavior, designing functional materials, and solving modern chemical problems.
(3) Technical & Professional Skills: To impart hands-on knowledge in analyzing supramolecular architectures, characterizing element-based compounds, and understanding cutting-edge technologies such as molecular devices and fluxional behavior.
(4) Employability and Job Ready Skills: To equip students with critical analytical abilities and specialized knowledge in supramolecular chemistry and element reactivity, fostering their readiness for careers in research, materials science, catalysis, and high-tech industries.

Expected Outcome from the Course		

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically evaluate molecular interactions and design strategies for constructing functional supramolecular architectures and advanced elemental compounds.	Critical thinking
2	Students will develop the ability to investigate and interpret the behavior, reactivity, and applications of supramolecular systems and unusual compounds of main group and transition elements.	Research-related skills
3	Students will enhance collaborative skills through group-based problem-solving, discussions on recent developments, and analysis of supramolecular and elemental chemistry case studies.	Coordinating/collaborating with others
4	Students will utilize digital resources and modern tools to explore structural design, reaction mechanisms, and electronic functions of complex molecular systems.	Digital and technological skills

2113.0300 (Chemist, Inorganic), 2113.0400 (Chemist, Physical), 2310.0600 (University and College Teacher, Science Subjects / Professors / Assistant Professors, Science Subjects).

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 $\kappa 2$, Dependence of the Transfer Rate on Distance (r), the Overlap Integral (J), and $\tau 2$, 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.

Objective of the Course

(1) Knowledge & Understanding: To understand the basic concept of photo-physics in the excited state. It will give the knowledge about fundamental parameters of Jablonski diagram, Frank-Condon principle, quantum yield excited states processes and their interpretation.
(2) Application of Knowledge & Skills: Students will apply theoretical and instrumental knowledge of photo-physics and photo chemistry to understand the molecular level interactions in a system of molecules and indirectly visualize the molecular structure and the related properties.
(3) Technical & Professional Skills: Learners will acquire technical skills related to photophysical processes, fluorescence, phosphorescence and their applications. Students will learn different processes like FRET, ESPT, PET etc. of molecules and their interpretation toward explaining various chemical and physical processes.
(4) Employability and Job Ready Skills: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the scientific projects in industry where spectroscopy possesses unquestionable importance.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such as spectral frequency, width, intensity. Find out selection rules for different spectroscopic transitions.	Critical thinking
2	Develop skills in interpretation of molecular spectroscopic parameters, understanding of molecular interactions in the microscopic level to progress further in academic research.	Research-related skills

3	Engage in group discussions and collaborative learning activities that involve solving spectroscopic problems relevant to complex molecules and learning various techniques and instrumentation relevant to spectroscopy.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of electronic structure of complex molecules, properties of spectral lines and knowledge of chemical structure.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

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.

Objective of the Course

(1) Knowledge & Understanding: Understanding the basic principles, structure, bonding, and reactivity of organic molecules. Grasping the concepts of isomerism, chirality, and stereochemical representations in organic compounds.
(2) Application of Knowledge & Skills: Apply fundamental concepts to predict the behavior and reactions of organic molecules. Utilize stereochemical principles to determine isomer configurations and assess reaction outcomes.
(3) Technical & Professional Skills: Proficient in drawing and interpreting structural and stereochemical representations of organic compounds. Skilled in analyzing reaction mechanisms and predicting stereochemical outcomes in synthetic processes.
(4) Employability and Job-Ready Skills: Capable of applying organic chemistry and stereochemistry principles in pharmaceutical, chemical, and research industries. Demonstrates problem-solving, analytical thinking, and attention to detail in molecular design and analysis.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzing molecular structures and reaction mechanisms to predict chemical behavior and stereochemical outcomes.	Critical thinking
2	Designing and interpreting experiments to study organic reactions and the stereochemical properties of compounds.	Research-related skills
3	Working effectively in teams to solve complex problems involving organic synthesis and stereochemical analysis.	Coordinating/collaborating with others

4	Utilizing chemical drawing software and molecular modeling tools to visualize and analyze organic structures and stereochemistry.	Digital and technological skills

NCO: 2113.0300 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

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

Objective of the Course

(1) **Knowledge & Understanding**: Understand fundamental gas laws, kinetic theory, critical phenomena, and principles of surface tension and viscosity with their temperature effects.
(2) **Application of Knowledge & Skills**: Apply gas laws and van der Waals equation to determine real gas properties and critical constants, and interpret Maxwell-Boltzmann distributions to study molecular speeds. Knowledge of how experimentally measure surface tension and viscosity using stalagmometer and Ostwald viscometer, and analyze their temperature dependence to understand fluid behavior.
(3) **Technical & Professional Skills**: Develop proficiency in handling and calibrating stalagmometer and Ostwald viscometer for precise fluid property measurements. Analyze molecular velocity distribution data, ensuring lab safety and accurate documentation of experimental procedures and results.
(4) **Employability and Job-Ready Skills**: Apply theoretical and practical knowledge of gases and fluids in industries like chemical engineering and materials science. Demonstrate problem-solving, data analysis, and clear communication skills essential for research, quality control, and collaborative projects.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Critically analyze real gas deviations using compressibility factors and van der Waals equation, while interpreting Maxwell-Boltzmann distributions to understand molecular speeds across temperatures. Evaluate experimental fluid property data to connect theoretical concepts with practical insights on critical phenomena and phase behavior.	Critical thinking

2	Design and perform experiments with stalagmometer and Ostwald viscometer to measure surface tension and viscosity, applying mathematical models for gas behavior and critical constants. Critically evaluate literature and rigorously document results to validate and support research in kinetic theory and fluid properties.	Research-related skills
3	Collaborate effectively in lab teams by sharing responsibilities in setup, measurement, and data collection, while communicating to troubleshoot and refine experiments. Engage in group discussions to analyze results and coordinate equipment use, enhancing understanding and optimizing resources in physical chemistry studies.	Coordinating/collaborating with others
4	Use digital instruments and software for precise measurement, data analysis, and visualization of viscosity, surface tension, and gas properties. Leverage online resources and computational tools to research, model, and simulate kinetic theory, real gas behavior, and fluid dynamics for deeper theoretical insights.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

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 $K_2Cr_2O_7$ 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

Objective of the Course

(1) Knowledge & Understanding: To build a solid foundation in the principles of acid-base and redox titrations, including concepts like electrode potential and titration end points.
(2) Application of Knowledge & Skills: To apply theoretical concepts to quantitatively estimate different analytes such as sodium carbonate, oxalic acid, and Fe(II) ions through standard titration procedures.
(3) Technical & Professional Skills: To develop proficiency in preparing standard solutions, handling titration apparatus, and using indicators and redox agents accurately.
(4) Employability and Job Ready Skills: To equip students with essential laboratory skills required in quality control, chemical analysis, and pharmaceutical or industrial testing laboratories.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will analyze titration results and select appropriate methods and indicators for accurate estimation of different analytes in complex mixtures.	Critical thinking
2	Students will learn to systematically plan and execute titration-based experiments, interpret data, and draw conclusions relevant to chemical analysis.	Research-related skills
3	Students will develop teamwork and communication skills by performing titration experiments collaboratively and discussing experimental outcomes.	Coordinating/collaborating with others
4	Students will enhance their ability to record, calculate, and analyze titration data using digital tools and develop habits for continual improvement in laboratory practices.	Digital and technological skills

NCO: 2113.0500 (Chemist, Analytical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science).

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 Willian Pfennig, Wiley (4) An Introduction to Atomic and Molecular Physics by Wolfgang Demtröder by Springer

Objective of the Course

(1) **Knowledge & Understanding**: To develop a foundational understanding of atomic structure by exploring Bohr's model, quantum mechanical principles, Schrödinger's equation, and atomic orbitals, along with the significance of quantum numbers and electron configurations.
(2) **Application of Knowledge & Skills**: To apply quantum mechanical concepts to explain atomic properties, electronic arrangements, periodic trends, and the stability of orbitals in atoms.
(3) **Technical & Professional Skills**: To enhance analytical and interpretative skills through graphical representation of orbitals, identification of nodal structures, and prediction of atomic behaviour based on quantum numbers and wave functions.
(4) **Employability and Job-Ready Skills**: To prepare students for roles in research, education, and chemical industries by equipping them with critical knowledge in modern atomic theory and the skills necessary to interpret atomic-level phenomena in both theoretical and applied contexts.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Learners will be able to critically evaluate classical and quantum models of atomic structure and justify the need for modern quantum mechanical approaches. .	Critical thinking
2	Students will gain the ability to interpret quantum mechanical equations and atomic orbital behavior, forming a basis for further research in atomic, molecular, and quantum chemistry.	Research-related skills
3	Through group discussions and collaborative problem-solving tasks, students will develop teamwork skills while analyzing and comparing orbital characteristics and electronic configurations.	Coordinating/collaborating with others

4	Learners will utilize digital visualization tools and simulations to better understand orbital shapes, electron distribution, and quantum numbers, fostering self-directed and technology-aided learning.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical); 2111.0800 (Physicist, Atomic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science).

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 stande 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

Objective of the Course

(1) **Knowledge & Understanding**: To provide a comprehensive concept dealing with speed of a chemical reaction and its thermodynamics. To Understand the thermodynamics from basic concept.
(2) **Application of Knowledge & Skills**: Students will apply theoretical principles to interpret how thermodynamics related to chemical reaction. They apply the knowledge of chemical kinetics to solve numerical problems to identify important physical quantity like order and rate constant of a reaction.
(3) **Technical & Professional Skills**: Learners will acquire technical skills related to conducting chemical kinetics and measurement of heat of reaction. They will also be trained in interpreting activation energy, enthalpy of a reaction.
(4) **Employability and Job-Ready Skills**: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the industry and materials sectors.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such as enthalpy, entropy, change in internal energy, order, half-life of a reaction etc..	Critical thinking
2	Develop skills in performing experiments such as heat of neutralization, performing kinetics in academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving numerical problems and explaining models relevant to chemical kinetics and thermodynamics.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of chemical kinetics and thermodynamics.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

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

Objective of the Course

(1) Knowledge & Understanding: Understanding the fundamental principles and techniques used in the qualitative analysis of organic compounds. Recognizing characteristic functional groups through chemical tests and observations to identify unknown organic substances.
(2) Application of Knowledge & Skills: Applying systematic procedures to detect functional groups and classify organic compounds based on their chemical behavior. Interpreting test results and observations to identify unknown organic substances in laboratory settings accurately.
(3) Technical & Professional Skills: Proficiently performing standard qualitative tests for the identification of functional groups in organic compounds. Skillfully handling laboratory equipment and reagents to ensure accurate and safe analysis results.
(4) Employability and Job-Ready Skills: Demonstrating attention to detail and analytical thinking is essential for quality control and research roles. Effectively communicating experimental findings and maintaining laboratory safety and documentation standards.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluating test outcomes to distinguish between similar organic compounds and resolve ambiguous results. Identifying potential sources of error and optimizing analytical methods for reliable qualitative analysis.	Critical thinking
2	Designing and conducting experiments to identify unknown organic compounds using systematic qualitative analysis techniques.	Research-related skills
3	Working effectively with team members to share data, troubleshoot experiments, and ensure accurate qualitative analysis results.	Coordinating/collaborating with others
4	Utilizing digital tools and software for data recording, analysis, and presentation of qualitative organic analysis results.	Digital and technological skills

NCO: 2113.0300 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

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.

Objective of the Course

(1) **Knowledge & Understanding**: To impart a comprehensive understanding of chemical bonding models including ionic, covalent, and coordination bonding, along with advanced concepts such as molecular orbital theory, VSEPR theory, hybridization, and crystal field theory.
(2) **Application of Knowledge & Skills**: To enable students to analyze bonding patterns, predict molecular geometry, assess compound stability, and evaluate stereoisomerism in coordination compounds using theoretical frameworks like Born-Haber cycle, VBT, and CFT.
(3) **Technical & Professional Skills**: To build proficiency in interpreting molecular structure and bonding using theoretical models, drawing isomeric structures, and applying IUPAC nomenclature to coordination compounds.
(4) **Employability and Job-Ready Skills**: To prepare students for careers in chemical industries, research labs, and higher education by developing problem-solving abilities in molecular structure prediction, ligand field analysis, and bonding interactions relevant to material and medicinal chemistry.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will evaluate and compare different bonding theories (VBT, CFT, MO theory) to explain the geometry, stability, and properties of chemical compounds and coordination complexes.	Critical thinking
2	Learners will develop the ability to apply theoretical bonding models and spectrochemical concepts to predict properties of novel compounds, laying a foundation for research in inorganic and materials chemistry.	Research-related skills
3	Through collaborative assignments and group discussions, students will enhance teamwork skills while interpreting molecular structures and isomerism in coordination complexes.	Coordinating/collaborating with others
4	Students will utilize molecular modeling software and digital visualization tools to better understand hybridization, orbital interactions, and complex geometries, promoting self-directed and technologically enhanced learning.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic); 2113.0400 (Chemist, Physical); 2330.0200 (Senior Secondary and Secondary School Teacher, Science).

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, oxymecuration-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).

Objective of the Course

(1) Knowledge & Understanding: Understanding the structure, classification (alkanes, alkenes, alkynes), and chemical properties of open-chain hydrocarbons and comprehending their reactions, such as combustion, substitution, and addition reactions. Grasping the concept of aromaticity, the structure of benzene and its derivatives, and resonance stabilization. Studying electrophilic substitution reactions and properties unique to aromatic compounds.

(2) Application of Knowledge & Skills: Applying reaction mechanisms and analytical techniques to synthesize and identify aliphatic compounds. Using electrophilic substitution and characterization methods to synthesize and analyze aromatic compounds.
(3) Technical & Professional Skills: Proficient in conducting synthesis, purification, and analysis of aliphatic hydrocarbons using lab techniques. Skilled in performing aromatic substitution reactions and characterizing aromatic compounds with standard analytical tools.
(4) Employability and Job-Ready Skills: Ability to apply practical knowledge of aliphatic hydrocarbon reactions and analysis in industrial and research settings. Competence in handling aromatic compounds for synthesis, quality control, and product development in chemical industries.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Analyzing reaction pathways and predicting outcomes for aliphatic hydrocarbon transformations. Evaluating aromatic stability and mechanism feasibility in substitution reactions.	Critical thinking
2	Designing and conducting experiments to explore reactivity patterns and the synthesis of aliphatic compounds. Investigating aromatic compound behavior and reaction mechanisms to develop novel aromatic derivatives.	Research-related skills
3	Working collaboratively in laboratory settings to synthesize and analyze aliphatic hydrocarbons safely and efficiently. Cooperating with team members to plan and execute experiments involving aromatic compounds and interpret results.	Coordinating/collaborating with others
4	Utilizing digital tools and instrumentation for modeling, analyzing, and characterizing aliphatic hydrocarbons. Applying spectroscopy software and chemical databases to study structures and reactions of aromatic compounds.	Digital and technological skills

NCO: 2113.0300 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

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.

Objective of the Course

(1) **Knowledge & Understanding**: To understand thermodynamic and equilibrium concepts—including Gibbs free energy, Le Chatelier's principle, ionization, pH, solubility, and phase behavior—to predict chemical reactivity and system behavior under varying conditions.
(2) **Application of Knowledge & Skills**: Apply thermodynamic principles to calculate free energy changes, equilibrium constants, ionization parameters, and solubility products, enabling prediction of reaction and phase behavior. Use tools like Le Chatelier's principle, Gibbs Phase Rule, and Clausius-Clapeyron equation to analyze chemical equilibria and construct phase diagrams for single and binary systems.
(3) **Technical & Professional Skills**: Demonstrate accuracy in calculating thermodynamic and equilibrium parameters while interpreting phase diagrams and experimental data. Apply logical reasoning to explain chemical behavior and effectively communicate complex concepts in both written and oral formats.
(4) **Employability and Job-Ready Skills**: Develop and apply analytical and problem-solving skills in thermodynamics and equilibria to optimize chemical processes and collaborate effectively in research and industrial settings.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Critically analyze how free energy, equilibrium constants, and system variables influence chemical reactivity, ionization, solubility, and phase behavior. Evaluate theoretical assumptions and interpret complex phase diagrams to predict equilibrium shifts and design-controlled reaction conditions.	Critical thinking
2	Design experiments and use quantitative methods to analyze chemical equilibria, solubility, and thermodynamic parameters. Validate theoretical models through experimental data and critically review scientific literature to guide research and methodology.	Research-related skills
3	Collaborate effectively in multidisciplinary teams to conduct experiments, analyze data, and present findings on chemical equilibria and phase behavior. Communicate and troubleshoot complex thermodynamic concepts while sharing responsibilities in research and reporting.	Coordinating/collaborating with others
4	Use digital tools and software to acquire, analyze, and visualize data related to chemical equilibria, thermodynamic properties, and phase behavior. Access scientific databases and apply computational models to simulate and interpret molecular interactions and equilibrium processes.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical); 2111.0800 (Physicist, Atomic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science).

<u>**Semester VII/VIII**</u>

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

Objective of the Course

(1) **Knowledge & Understanding**: To provide students with a deep understanding of the periodic trends and characteristic properties of transition and f-block elements, including their electronic configurations, oxidation states, magnetic behavior, colour, and complexation tendencies.
(2) **Application of Knowledge & Skills**: To enable learners to analyze and predict the chemical behavior and stability of various oxidation states using tools like Latimer diagrams and to explain properties such as catalytic activity and variable valency.
(3) **Technical & Professional Skills**: To equip students with the ability to interpret and compare magnetic and spectroscopic properties of transition metals and lanthanides, and understand the principles behind their separation using ion exchange techniques.
(4) **Employability and Job-Ready Skills**: To prepare students for careers in research, metallurgy, analytical labs, and chemical industries by building competencies in transition metal chemistry and rare earth separation techniques relevant to material science and catalysis.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically evaluate trends in oxidation states, magnetic and catalytic properties, and complex formation abilities to explain the unique chemical behavior of transition and f-block elements.	Critical thinking
2	Learners will apply Latimer diagrams and electronic configuration concepts to investigate the redox chemistry and stability of different oxidation states, supporting further exploration in inorganic chemistry and materials science.	Research-related skills
3	Students will enhance their teamwork abilities through group tasks involving the analysis and comparison of transition metal and lanthanide properties, and discussion of their industrial and environmental relevance.	Coordinating/collaborating with others
4	Learners will use digital periodic tables, online modeling tools, and databases to visualize electron configurations, magnetic behavior, and lanthanide separations, fostering independent and technology-assisted learning.	Digital and technological skills

NCO: 2113.0300 (Chemist, Inorganic); 2113.0400 (Chemist, Physical); 2330.0200 (Senior Secondary and Secondary School Teacher, Science).

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): (Formaldehye, acetaldehyde, acetone and benzaldehyde)
Preparation: from acid chlorides and from nitriles.
Reactions: Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff-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 -COOH group, acetylation of $-NH_2$ 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).

Objective of the Course

(1) Knowledge & Understanding: Understanding the structure, nomenclature, methods of preparation, physical and chemical properties of these organic compounds. Comprehending their reactivity patterns, mechanisms of substitution and elimination reactions, and their practical applications.
(2) Application of Knowledge & Skills: Applying knowledge of functional groups to predict products, mechanisms, and reactivity trends in organic reactions. Applying structural and functional understanding of biomolecules to explain biological processes and metabolic pathways.
(3) Technical & Professional Skills: Ability to analyze and perform organic reactions involving substitution, elimination, and functional group interconversion. Skill in identifying, classifying, and interpreting the structure–function relationships of key biomolecules.
(4) Employability and Job-Ready Skills: Competence in handling organic compounds and interpreting reaction outcomes relevant to pharmaceuticals and chemical industries. Readiness to apply biochemical knowledge in healthcare, food science, and biotechnology sectors.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluating reaction pathways and predicting mechanisms based on structural and electronic factors. Analyzing molecular structures to understand their biological roles and interactions in complex systems.	Critical thinking
2	Designing and investigating synthetic routes and reaction conditions for targeted organic molecules. Exploring structure-function relationships and biochemical pathways through experimental and analytical techniques.	Research-related skills
3	Working effectively in teams to conduct organic synthesis and analyze reaction outcomes collaboratively. Collaborating in interdisciplinary teams to study biomolecular functions and apply findings in real-world contexts.	Coordinating/collaborating with others
4	Using software tools for molecular modeling, reaction simulation, and data analysis in organic chemistry. Employing bioinformatics and analytical technologies to study and visualize biomolecular structures and interactions.	Digital and technological skills

NCO: 2113.0300 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

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. Nemst equation and its importance. Types of electrodes. Standard electrode potential. Thermodynamics of a reversible cell, calculation of thermodynamic properties: AG, AH and AS 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.

Reference Books: (1) Physical Chemistry, P. C. Rakshit (2) Physical Chemistry, H. Chatterjee

Objective of the Course

(1) **Knowledge & Understanding**: To provide a comprehensive concept of how electricity flows through the ionic solutions and the associated chemical reactions involved. To understand the basic concept of colligative properties of solutions.
(2) **Application of Knowledge & Skills**: Students will apply theoretical principles to interpret how an electrolytic solution may behave as an Ohmic resistance. They apply the knowledge of EMF for the designing of new electrochemical cells Then they can solve problems related to the presence of ions in solutions.
(3) **Technical & Professional Skills**: Learners will acquire technical skills related to ionic conductance, modeling of distribution of counter ions around a given central ion, and electrochemical reasoning. They will also be trained in interpreting conductance behavior of ionic solutions and interesting properties of dilute solutions.
(4) **Employability and Job-Ready Skills**: Students will develop a strong theoretical foundation that supports further studies in research, competitive exams, and various roles in the electrochemical and materials sectors.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Calculate several physical quantities such as degree of dissociation of weak electrolytes, ionic product of water, hydrolysis constants of salts, conductometric titrations, EMF, potentiometric titration etc.	Critical thinking
2	Develop skills in theoretical interpretation of ionic distribution in electrolytic solutions, conduction of current through solutions, mobility and transport number of ions in solution to proceed further in academic research.	Research-related skills
3	Engage in group discussions and collaborative learning activities that involve solving electrochemical problems and explaining models relevant to ionic conduction.	Coordinating/collaborating with others
4	Access and interpret scholarly resources, digital databases, and online learning tools to deepen understanding of complex electrochemical theories and to visualize charge distributions, ionic transport, and various conduction mechanisms.	Digital and technological skills

NCO: 2113.0400 (Chemist, Physical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects

CHEMISTRY

SEC

SYLLABUS

Semester I

SEC COURSE: Inorganic Chemistry-I [Code: SEC CH01AT and SEC CH01AP]
BASIC PRINCIPLES AND LABORATORY OPERATIONS
Credits: 1 (Theory, 15 Lectures) + 2 (Practical, 30 Lectures) [F.M. 25 + 50]

Unit 1. Laboratory Proceedings, Data Curation and Analysis: (**2 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: (**6 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: (**2 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: (**5 Lectures**)
Preliminary idea of spectrophotometer, and spectrometer, Basic concept of the electromagnetic spectra.

PRACTICAL

- Familiarization with Laboratory Glassware and Safety Devices (Identification and handling of beakers, pipettes, burettes, conical flasks, etc, Demonstration of proper use of gloves, goggles, lab coats, fume hood, fire extinguisher, eye wash station, Understanding chemical hazard symbols)
- Basic Laboratory Techniques (Proper techniques for measuring liquids e.g, pipetting, buretting, volumetric flask, measuring cylinder etc.)
- Data Entry and Documentation Practice (Recording weights, temperatures, titration readings in lab notebook, Calibration of volumetric glassware, Format of result calculation and error estimation, % yield calculation, accuracy and precision in repeated experiments)
- Understating and preparation of different solutions with varied concentrations (Preparation of standard solutions, Normality and Molarity Calculation, Dilution of concentrated solution, Oxidation State and Equivalent Weight)
- Determining pH (acid/base identification), conductance of solution and Buffer Preparation
- Fundamental idea about qualitative and quantitative analyses, Knowledge of Equivalence Point
- Basic theme of UV-VIS and NMR spectral studies.
- Metal complex formation study.
- Identification of Precipitation and Coagulation
- Identification of amorphous and crystalline materials.

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

Objective of the Course

(1) **Knowledge & Understanding**: To provide foundational knowledge of chemical laboratory practices, chemical units, types of chemical reactions, and the principles behind qualitative, quantitative, and spectroscopic methods of analysis.
(2) **Application of Knowledge & Skills**: To enable students to apply chemical concepts such as concentration, molarity, redox reactions, titration principles, and spectroscopic techniques in solving real-world laboratory problems and analyzing chemical data.
(3) **Technical & Professional Skills**: To develop hands-on proficiency in handling laboratory instruments and glassware, preparing standard solutions, conducting titrations, interpreting results, and maintaining accurate laboratory records.
(4) **Employability and Job-Ready Skills**: To equip students with essential practical competencies in chemical analysis, safety compliance, data interpretation, and documentation, fostering readiness for roles in chemical industries, quality control labs, and research institutions.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will analyze and interpret experimental data from various chemical processes and titrations to draw accurate conclusions and troubleshoot procedural errors.	Critical thinking
2	Learners will develop foundational skills in data curation, documentation, and the use of standard analytical methods, preparing them for research-based tasks in chemical sciences.	Research-related skills
3	Through laboratory teamwork, students will practice collaborative experimentation, sharing responsibilities in data collection, solution preparation, and reporting results effectively.	Coordinating/collaborating with others
4	Students will gain exposure to digital tools such as spectrophotometers and data analysis software, enhancing their ability to adapt to evolving laboratory technologies and engage in continuous, independent learning.	Digital and technological skills

NCO: 2113.0100 (Chemist, General), 3116.0300 (Laboratory Assistant), 2113.0622-2113.0624 (Lab Chemist – Compound/Batch/Cured Testing), 2113.0500 (Chemist, Analytical), 3133.0100 (Process Man, Chemical), 2113.0601 (Quality Control Chemist), 2113.0800 (Chemist, Forensic Science).

SEC COURSE (ORGANIC CHEMISTRY-I) [Code: SEC CH01BT and SEC CH01BP]
SEPARATION AND ISOLATION TECHNIQUES
Credits: 1 (Theory, 15 L) + 2 (Practical and 60 L) [F.M. 75 (25 + 50)]

Solvent based Techniques: (5 L)

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

Chromatographic Techniques: (5 L)

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

Stereoisomeric separation and analysis: (3 L)

Measurement of optical rotation, calculation of Enantiomeric excess (ee) and determination of enantiomeric composition, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Ion exchange Chromatography: (2 L)
Introduction, classification, ion exchange resins, properties, mechanism of ion exchange process, factors affecting ion exchange, methodology and applications

Reference Books: (1) Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009. (2) Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed. (3) Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elle.

PRACTICAL

(I) Chromatographic separation of mixture of organic compounds:
Separation of a mixture of two/ three amino acids by paper chromatography
Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)
Column chromatographic separation of leaf pigments from spinach leaves
Column chromatographic separation of mixture of dyes

(II) Isolation of some natural products
Isolation of caffeine from tea.
Isolation of cinnamaldehyde from cinnamon.
Isolation of curcumin from turmeric.
And other similar isolations.

(III) Concept of melting point and mixed melting point

(IV) Concept of recrystallisation using alcohol/water/alcohol-water systems

Reference Books: Arthur, I. V. Quantitative Organic Analysis, Pearson (2) University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta (3) Nad, Mahapatra, Ghosal-Practical Chemistry.

Objective of the Course

(1) Knowledge & Understanding: To provide a comprehensive understanding on chromatographic separation and isolation techniques.
(2) Application of Knowledge & Skills: Students can learn the basic separation techniques, like chromatography and thin layer chromatography.
(3) Technical & Professional Skills: Learners will acquire technical skills related to organic compound separation using chromatographic techniques such as column chromatography, thin layer chromatography (TLC) and Paper chromatography etc.
(4) Employability and Job-Ready Skills: Students will develop a strong foundation and hands on experience in purifying organic compounds that supports employability and techniques required for pursuing research, and finding jobs in chemical and pharmaceutical company.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Develop skills in the basic separation techniques, like chromatography and thin layer chromatography.	Research-related skills
2	Hands on experience in purifying organic compounds	Technological skills

NCO: 2113.0200 (Chemist, Organic), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects)

Semester II

SEC COURSE (INORGANIC CHEMISTRY-I) [SEC CH02AT and SEC CH02AP]
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 SO_2, CO_2, CO, NO_X, H_2S 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

- Determination of dissolved oxygen (DO) in water.
- Determination of Chemical Oxygen Demand (COD)
- Determination of Biological Oxygen Demand (BOD)
- Percentage of available chlorine in bleaching powder
- Determination of total dissolved solids (TDS) in water
- Identification of toxic metal ions in environmental sample
- Estimation of free alkali present in different soaps/detergents
- 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

Objective of the Course

(1) **Knowledge & Understanding:** To provide students with a comprehensive understanding of ecosystems and environmental pollutants, their sources, impacts, and analytical methods for assessment and control.
(2) **Application of Knowledge & Skills:** To enable learners to apply scientific principles in identifying, estimating, and interpreting environmental parameters such as COD, BOD, DO, TDS, and toxic gases, and relate them to real-world pollution problems.
(3) **Technical & Professional Skills:** To develop technical competencies in using laboratory techniques for environmental monitoring, handling pollution-related data, and performing accurate analysis of industrial and natural water samples.
(4) **Employability and Job Ready Skills**: To equip students with practical skills in environmental testing, pollution analysis, and waste management, enhancing their readiness for roles in environmental consultancy, pollution control boards, and industrial safety and compliance sectors.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically evaluate the sources, chemical nature, and impact of various environmental pollutants and propose scientifically sound solutions for pollution control and mitigation.	Critical thinking
2	Students will gain hands-on experience in standard environmental analysis techniques, enabling them to collect, interpret, and analyze pollution data for research and environmental impact studies.	Research-related skills
3	Through laboratory experiments and group-based pollution monitoring tasks, students will develop effective communication and teamwork skills essential for collaborative environmental assessments.	Coordinating/collaborating with others
4	Students will learn to operate modern environmental instrumentation (e.g., for COD, BOD, TDS analysis), interpret digital data outputs, and adapt to evolving technologies and protocols in environmental monitoring and sustainability practices.	Digital and technological skills

NCO: 2133.0100 (Ecologist), 2133.0200 (Environmental Scientist), 2143.0500 (Pollution Control Engineer), 3257.0400 (Environmental Compliance Inspector), 3257.0500 (Environmental Engineering Technician), 3132.0400 (Wastewater Treatment Plant Operator), 3111.0300 (Laboratory Assistant, Chemical).

SEC COURSE (ORGANIC CHEMISTRY-II) [SEC CH02BT and SEC CH02BP]
GREEN CHEMISTRY
Credits: 1 [Theory, 15 L] + 2 [Practical, 60 L] [F.M. 75 (25 + 50)]

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 will be discussed:

- Surfactants for carbon dioxide – Replacing smog producing and ozone depleting solvents with CO_2 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.
- Common Organic name reactions using green concept.

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.
- Acetylation of primary amine using acetic acid and zinc dust.
- Bromination of stilbene using HBr and hydrogen peroxide.

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. &Tinnesand, 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.

Objective of the Course

Knowledge & Understanding: To provide a comprehensive understanding on green chemistry and design the new chemical products and processes that minimize adverse impacts on human and environmental issues.
Application of Knowledge & Skills: To learn the principle to design the processes that minimize adverse impacts on human and environmental issues in organic synthesis.
Technical & Professional Skills: Hands on experience in organic synthesis and performing organic reactions
Employability and Job-Ready Skills: Students will develop hands on experience in synthesizing organic compounds using green methods that supports employability and techniques required for pursuing research, and finding jobs in chemical and pharmaceutical company.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Learn how to perform organic reactions in a sustainable and greener method.	Critical thinking
2	Develops knowledge in green chemistry and skill set for designing safer processes, chemicals and products through understanding of inherently safer design (ISD).	Research-related skills
3	Hands on experience in synthesizing organic compounds	Digital and technological skills

NCO: 2113.0200 (Chemist, Organic), 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

SEC COURSE (PHYSICAL CHEMISTRY-I) [Code: SEC CH02CT and SEC CH02CP]
BIO-PHYSICAL CHEMISTRY
Credits: 1 [Theory, 15 L] + 2 [Practical, 60 L] [F.M. 75 (25 + 50)]

Unit I: Conformation of proteins (5 Lectures)
Ramachandran plot, secondary, tertiary and quaternary structure;

Unit 2: Enzymes (5 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 (5 Lectures)
Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, ion pumps

PRACTICAL

- Buffer Solution Preparation and pH measurement.
- Qualitative analysis of carbohydrates (Glucose, Fructose, Lactose, Maltose, Sucrose and starch).
- Amino acids and protein qualitative tests.
- Lipids Qualitative tests.
- To determine pKa values of the ionizable groups of the amino acid and its isoelectric point.
- Estimation of protein by lowrey's method.

Reference Book: (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.

Objective of the Course

(1) Knowledge & Understanding: Understand protein structures and hydration thermodynamics, enzyme classification and mechanisms, membrane composition and transport processes, and hormone-receptor signaling pathways including G-protein coupled receptors.
(2) Application of Knowledge & Skills: Utilize Ramachandran plots and enzyme kinetics to assess protein structures and predict catalytic activity. Model membrane transport and analyze signaling pathways to understand cellular responses to hormones and stimuli.
(3) Technical & Professional Skills: Analyze protein conformation data and enzyme kinetics alongside biochemical assays of enzyme activity and membrane transport. Use models to depict membrane and signaling structures while critically evaluating related scientific literature.
(4) Employability and Job Ready Skills: Gain expertise in biochemical and biophysical techniques vital for pharmaceuticals and biomedical research, while effectively communicating complex concepts within interdisciplinary teams. Demonstrate strong problem-solving abilities in experimental design and uphold professional standards in lab safety and documentation.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Critically evaluate enzyme action models, receptor signaling, and thermodynamic data on protein hydration to understand molecular stability. Analyze membrane transport mechanisms and signaling pathway regulation, assessing their roles in physiological and pathological contexts.	Critical thinking
2	Review scientific literature on protein structure, enzyme mechanisms, and membrane biology to inform experimental design. Collect and analyze data on enzyme kinetics and signaling, utilizing biochemical databases and software for research support and interpretation.	Research-related skills
3	Collaborate effectively in multidisciplinary teams by communicating protein, enzyme, and signaling pathway findings clearly. Coordinate and integrate structural, kinetic, and cellular data in joint experimental projects.	Coordinating/collaborating with others

4	Use molecular visualization software and bioinformatics databases to analyze protein structures, enzyme kinetics, and transport processes. Employ digital tools for pathway mapping and simulation of signaling networks.	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

Semester III

SEC COURSE (INORGANIC CHEMISTRY-III) [Code: SEC CH03AT and SEC CH03AP]
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

PRACTICAL

- Determination of free acidity in ammonium sulphate fertilizer.
- Estimation of Calcium in Calcium ammonium nitrate fertilizer.
- Estimation of phosphoric acid in superphosphate fertilizer.
- Determination of composition of dolomite (by complexometric titration).
- Analysis of Cement.
- Preparation of pigment (zinc oxide).
- Nitrate and phosphate content in water and qualitative test for detection of nitrate and phosphate.
- Estimation of the amount of calcium in milk powder.
- 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.

Objective of the Course

(1) Knowledge & Understanding: To impart foundational knowledge of key inorganic industrial materials (cement, ceramics, glass, fertilizers) and energy storage systems (batteries, fuel cells).
(2) Application of Knowledge & Skills: To apply chemical principles in the analysis and quality control of industrial materials like cement and fertilizers. To develop skills in estimating key components in fertilizers, cement, and other inorganic materials through analytical techniques.
(3) Technical & Professional Skills: To understand manufacturing processes, recycling methods, and environmental considerations related to industrial inorganic materials.
(4) Employability and Job Ready Skills: To prepare students for careers in industries such as construction, ceramics, glass manufacturing, fertilizer production, and energy storage. To enhance problem-solving and analytical skills required for quality control, research, and development in chemical industries.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will analyze the composition and manufacturing processes of industrial materials (cement, ceramics, fertilizers) to evaluate their efficiency, environmental impact, and potential improvements.	Critical thinking
2	Students will conduct chemical analyses (titration, compositional testing) and interpret experimental data to assess material quality and compliance with industrial standards.	Research-related skills
3	Students will work effectively in teams during laboratory experiments and case studies to solve problems related to material synthesis, testing, and industrial applications.	Coordinating/collaborating with others
4	Utilize modern analytical tools and digital resources to access, process, and present scientific data on inorganic materials and energy storage systems.	Digital and technological skills

NCO: 2113.0600 (Chemist, Industrial), 3116.0100 (Laboratory Assistant, Glass and Ceramics), 2113.9900 (Chemists, Other), 2113.0601 (Quality Control Chemist), 2113.0500 (Chemist, Analytical), 2113.0300 (Chemist, Inorganic).

SEC COURSE (ORGANIC CHEMISTRY-III) [Code: SEC CH03BT and SEC CH03BP] PHARMACEUTICAL CHEMISTRY
Credits: 1 (Theory, 15 L) + 2 (Practical and 60 L) [F.M. 75 (25 + 50)]

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, lbuprofen); 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).

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.

PRACTICAL

- Preparation of Aspirin and its analysis.
- Preparation of magnesium bisilicate (Antacid)and its analysis.
- Preparation of paracetamol and its analysis.
- Preparation of sulphacetamide of sulphonamide and its analysis.
- Determination of ascorbic acid in vitamin C tablets by iodometric titrations.

Reference Books: 1. Lectures on Pharmaceutical Chemistry and Pesticide Chemistry, Chandan Saha, Biswanath Chakraborty, Suchandra Chakraborty, Kaushik Basu; Techno World.
2. Marsh, D.G.; Jacobs, D.L.; Veening, H. Analysis of commercial vitamin C tablets by iodometric and coulometric titrimetry. J. Chem. Educ., 1973, 50 (9), p 626.

Objective of the Course

Knowledge & Understanding: To provide a basic understanding of drugs discovery, design, development and their side effects.

Application of Knowledge & Skills:
Cover synthesis of major drug classes including-analgesics, antipyretics, anti- inflammatory agents, antibacterial and antifungal agents.
Technical & Professional Skills:
Hands on experience in organic synthesis and performing organic reactions
Employability and Job-Ready Skills:
Students will develop hands on experience in pharmaceutical chemistry that supports employability and techniques required for pursuing research, and finding jobs in chemical and pharmaceutical company.

Expected outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Gain insight into retro-synthesis approach in relation to drug design and drug discovery.	Critical thinking
2	Develops knowledge in synthetic pathways of major drug classes.	Research-related skills
3	Hands on experience in synthesizing organic compounds and analysis	Digital and technological skills

NCO: 2262.0100 and 2262.0101 (Chemist, Pharmaceuticals), 2113.0200 (Chemist, Organic), 3213.0200 (Laboratory Assistant, Pharmaceutical), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

SEC COURSE (Physical Chemistry-II) [Code: Code: SEC CH03CT and SEC CH03CP] Advanced Instrumentations and BASIC to Python Programming Credits: 1 (15 L, Theory) + 2 (60 L, Practical) [F.M. 75 (25 + 50)]

Unit I: Introduction to advanced experimental Instrumentations: (15 lecture)
Basic principles and applications of UV-VIS spectroscopy, Electron Microscopy: Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), X-ray Photoelectron Spectroscopy (XPS), Atomic Force Microscopy (AFM).

PRACTICAL

- Acquiring UV-Visible spectra of standard samples ($KMnO_4$, $K_2Cr_2O_7$)
- Analysis of the spectra with the help of Origin software.
- Basics of Python Programming and to evaluate, visualize several important relationships in the light of Physical Chemistry.

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. Lymen, P. Echlin, C. Fiori, D. C. Joy, and E. Lifshin

Objective of the Course

(1) Knowledge & Understanding: Understand the principles of basics of electron microscopy.
(2) Application of Knowledge & Skills: Gain theoretical knowledge about the microscopy and spectroscopy techniques to perform UV-Visible spectra analysis. Understand basics of python to visualize the basic relationships in physical chemistry.
(3) Technical & Professional Skills: Learners will acquire technical skills related to python programming and UV-visible spectrophotometer.
(4) Employability and Job Ready Skills: Develop laboratory discipline and documentation practices suitable for industrial, research, and academic labs. Gain foundational skills essential for roles in computational chemistry, and education.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Evaluate experimental errors and optimize procedures for accurate and reproducible results. Writing python scripts to verify fundamental relationships in physical chemistry.	Critical thinking
2	Design and conduct experiments using classical techniques, and instrumental analysis. Understand and apply instruments to find electronic energy levels of a molecule. Apply python programming to verify fundamental relationships in physical chemistry.	Research-related skills
3	Work effectively in pairs or small groups, sharing responsibilities and communicating findings. Follow safety protocols and ensure cooperative use of shared lab resources.	Coordinating/collaborating with others
4	Use digital tools for data recording and analysis where applicable (e.g., origin software, Microsoft excel, python).	Digital and technological skills

NCO: 3116.0200 (Laboratory Assistant, Food & Beverages/ Chemist/ Analytical Supervisor/Lab Chemist), 2330.0200 (Senior Secondary and Secondary School Teacher, Science), 2310.0600 (University and College Teacher, Science Subjects/Professors/Assistant Professors, Science Subjects).

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.

Objective of the Course

(1) **Knowledge & Understanding**: To provide students with a comprehensive understanding of the fundamental principles of chemistry as applied in daily life, including agriculture, environment, food, cosmetics, drugs, polymers, and energy. The course aims to deepen awareness of the chemical nature of common products and processes, and the implications of their use on health and the environment.

(2) **Application of Knowledge & Skills**: To enable students to relate theoretical chemical concepts to practical real-life scenarios such as water purification, weather prediction, food preservation, drug action, and personal care product formulation. Learners will apply scientific reasoning to understand pollution, global warming, and sustainability issues from a chemical perspective.

(3) **Technical & Professional Skills**: To develop technical competencies related to the chemical formulation of everyday products, interpretation of environmental data (e.g., BOD, COD, air quality), understanding of polymer properties, and functioning of batteries and refrigeration systems. This will equip students with scientific problem-solving skills in diverse interdisciplinary contexts.

(4) **Employability and Job Ready Skills**: To enhance career readiness by familiarizing students with industrial and laboratory practices linked to agriculture, pharmaceuticals, cosmetics, food processing, and environmental monitoring. The course builds a foundation for roles in quality control, product development, regulatory affairs, environmental safety, and science communication.

Expected Outcome from the Course

After completion of the course, the learners will be able to-

Sl No	Learning outcome	Attributes Covered
1	Students will critically evaluate the chemical basis and societal impact of everyday substances—such as pesticides, drugs, fuels, and preservatives—to make informed decisions on their safe and effective use.	Critical thinking
2	Students will develop the ability to explore and analyze scientific literature, environmental data, pollution parameters, and product labels to understand chemical formulations and assess potential risks or benefits.	Research-related skills
3	Through group discussions, case studies, and practical applications, students will learn to collaborate effectively to solve real-world problems involving food safety, pollution control, and sustainable practices.	Coordinating/collaborating with others
4	Students will enhance their learning by utilizing digital tools and simulations to study processes like weather prediction, water purification, and chemical reactions in daily appliances, fostering independent and lifelong learning habits.	Digital and technological skills

NCO: 3257.0400 (Environmental Compliance Inspector), 6116.0101 (Agriculture Extension Executive), 2131.1400 (Food Chemist), 2113.0200 (Chemist, Organic), 2131.1300 (Chemist, Biological/Biochemist), 2145.1400 (Technologist, Plastics), 2112.0000 (Meteorologist), 7514.0700 [Cook, General (Food Preserving)].