SYLLABUS

FOR

TWO-YEAR FOUR-SEMESTER COURSE IN

CHEMISTRY

2014

UNIVERSITY OF CALCUTTA
# COURSE STRUCTURE

<table>
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*Special Courses (S) in Four Branches of Chemistry are

(i) Analytical Special (SA)
(ii) Inorganic Special (SI)
(iii) Organic Special (SO)
(iv) Physical Special (SP)
### SEMESTER – I (Marks – 250)

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*General (G): Compulsory
**One Special course to be opted and continued systematically

### SEMESTER – IV (Marks – 250)

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*Project work
** One Special course to be opted and continued systematically
Course Structure and Marks Distribution

1. Theoretical Papers

Full Marks: 50, each paper
Each Unit: 10 marks, two questions per unit to be set and any one to be answered

2. Practical Papers

Full Marks: 100, each paper

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<tr>
<th>Course ID</th>
<th>Experiment</th>
<th>General laboratory performance</th>
<th>*Seminar</th>
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*Topic should be outside the UG curriculum of CU; use of overhead /LCD projector is mandatory; time 10 m, followed by discussion

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<tr>
<th>Course ID</th>
<th>Grand viva</th>
<th>$Continuous assessment</th>
<th>Write-up, Oral presentation and discussion</th>
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*Project work, throughout the practical hours of the semester; topic should be outside the UG/PG curriculum of CU; use of LCD projector is mandatory; time 20 m, followed by discussion

$To be assessed by the guide
SYLLABUS

Semester – I

Course ID: CHEM–G11

Unit-1: Symmetry

Unit-2: Coordination Chemistry 1
Crystal field theory. Splitting of d-orbitals in linear, triangular, tetrahedral, square planar, trigonal bipyramidal, square pyramidal and octahedral fields of similar and dissimilar ligands. Crystal field stabilization energies in weak field and strong field environments. Octahedral site preference energy. Tetragonal distortion and Jahn Teller effect. Effect of crystal field stabilization on ionic radii, lattice energy, hydration enthalpy and stability of complexes (Irving Williams order). Kinetic aspects of crystal field stabilization. Crystal field activation energy. Labile and inert complexes. Limits of applicability of crystal field theory. Shapes of complexes.

Unit-3: Bioinorganic Chemistry 1

Unit-4: Solid-state Chemistry 1
Defects in solids. Point, line and plane defects. Determination of equilibrium concentration of Schottky and Frenkel defects, stoichiometric imbalance in crystals and non-stoichiometric phases, colour centres in ionic crystals. Band theory: band gap, metals, insulators, semiconductors (intrinsic and extrinsic), hopping semiconductors; rectifiers and transistors.

Unit-5: Electrochemical Analyses
Voltammetry: cyclic voltammetry, polarography, anodic stripping voltammetry; amperometry, coulometry, electrogravimetry.
Course ID: CHEM-G12

Unit-1: Structure-Activity Relationship
MO treatment of acyclic and cyclic conjugated systems; Huckel’s rule and concept of aromaticity, annulenes, heteroannulenes, fullerenes (C_{60}), alternate and non-alternate hydrocarbons, anti-aromaticity, pseudo-aromaticity, homo-aromaticity; graphical methods- Frost diagram. Huckel treatment – applications to ethylene, allyl, cyclopropenyl, butadiene, cyclobutadiene, Hammett equation and its modifications.

Unit-2: Stereochemistry 1
Winstein-Holness equation, Curtin-Hammett principle; Conformational analysis of cyclohexane, cyclohexene, decalin and their derivatives; perhydroanthracene, perhydrophenanthrene etc., Felkin-Anh, Cieplak and Zimmerman-Traxler Models; Addition Reactions to Carbonyl Compounds.

Unit-3: Pericyclic Reactions
Classification and stereochemical modes. Thermal and photopericyclic reactions, Selection rules and stereochemistry of electrocyclic reactions, 2-component cycloadditions, sigmatropic rearrangements, carbene addition. Rationalization based on Frontier M.O. approach, correlation diagrams, Dewer-Zimmermann approach, Mobius and Huckel systems. Sommelet, Hauser, Cope and Claisen rearrangements, Ene reaction, Wittig rearrangement.

Unit-4: NMR Spectroscopy 1
Principle, instrumentation and different techniques (CW & FT) of NMR spectroscopy, factors influencing chemical shift, spin-spin interactions, coupling constant(J), spin decoupling, spin tickling, classification of ABX, AMX, ABC, A_2B_2 in proton NMR. Introduction to \textsuperscript{13}C-NMR spectroscopy. Application of NMR spectroscopy and other spectroscopical techniques to simple structural and mechanistic problems.

Unit-5: Natural Products 1 – Terpenoids
Isoprene rule, Structure elucidation (by chemical and spectroscopical methods), Synthesis, Biogenesis and Biosynthesis of representative examples of acyclic, monocyclic and bicyclic monoterpenes. Structural types: general introduction to sesqui-, di- and triterpenoids.

Course ID: CHEM-G13

Unit-1: Thermodynamics

Unit-2: Atomic Structure
Zeeman effect, fine structure, spin-orbit interaction. Effect of high magnetic field. Lande g factor. Atomic (and molecular) terms.
Unit-3: Quantum Mechanics 1

Unit-4: Kinetics 1

Unit-5: Absorption Spectroscopy
\( \pi \rightarrow \pi^* \), \( n \rightarrow \pi^* \) and \( d \rightarrow d \) transitions. Solvent effects. Weak and CT interactions. Vibronic and spin-orbit coupling.

Course ID: CHEM–G14

Practical Chemistry 1
Spectrophotometric, ion exchange and complexometric estimations. Identification of single organic liquid with one or more functional groups. Numerical, kinetic and equilibrium experiments.
Unit-1: Chemical Bonding
Different types of bonding including weak interactions. Variation method. LCAO method. Molecular orbital of $\text{H}_2^+$, $\text{H}_2$, homo and hetero diatomic, triatomic and polyatomic molecules/ions (including $T_d$, $O_h$, and $D_{4h}$ coordination complexes). Molecular term symbols. Electron pair wave function, VB theory and its application to $\text{H}_2$ molecule. Comparison of VB and MO theories.

Unit-2: Coordination Chemistry 2
Metal-centered electronic spectra of transition metal complexes: microstates, determination of ground and all excited state terms of $d^n$ ions, splitting of $d^n$ terms in octahedral and tetrahedral fields, Orgel diagrams (qualitative approach), hole formalism – inversion and equivalence relations, selection rule for spectral transitions, d-d spectra and crystal field parameters, nephelauxetic series. Qualitative idea of Tanabe-sugano diagrams, Charge transfer spectra. Magnetic properties of coordination compounds: spin and orbital moment, spin-orbit coupling, quenching of orbital moment, spin only formula, room temperature and variable-temperature magnetic moments.

Unit-3: Organometallics 1
Application of 18-electron and 16-electron rules to transition metal organometallic complexes, isolobal and isoelectronic relationships with examples. Metal-alkyl, -allyl, -carbene, -carbonyl, -carbide and cyclopentadienyl complexes. Structure and bonding in $\eta^2$-ethylenic and $\eta^3$-allylic compounds with typical examples, structure and bonding of $\text{K}[\text{Pt}(\text{C}_4\text{H}_4)\text{Cl}_3]$, $[(\text{Ph}_3\text{P})_2\text{Pt}(\text{Ph-})\equiv\text{C-Ph})]$ and $[\text{Co}_2(\text{CO})_6(\text{Ph-C})\equiv\text{C-Ph})]$. Reactions of organometallic complexes: substitution, oxidative addition, reductive elimination, insertion and elimination, electrophilic and nucleophilic reactions of coordinated ligands.

Unit-4: Chemistry of the Elements 1
Polymorphism of C, P and S. Structure and bonding in higher boranes based on Lipscomb’s topological concept, Wade’s rules, borohydride $\text{B}_n\text{H}_{2n}$ anions, carboranes, metalloboranes, hydroboration reactions. Alkali metal complexes with macrocyclic ligands (crown ethers, cryptates and spherand). Aqueous and complex chemistry of beryllium and aluminium, basic beryllium compounds. Main group organometallics: classification, syntheses, reactions, structure and bonding and applications of typical examples.

Unit-5: Statistical Error and Radiochemical Analyses
Course ID: CHEM-G22

Unit-1: Photochemistry
Basic principles, Jablonski diagram, photochemistry of olefinic compounds, cis-trans isomeriation, Paterno-Buchi reaction, Norrish type I and II reactions, photoreduction of ketones, di-pi-methane rearrangement, photochemistry of arenes, Photoreaction in solid state. Method of generation and detection (ESR), radical initiators, reactivity pattern of radicals, substitution and addition reactions involving radicals, synthetic applications; cyclisation of radicals.

Unit-2: Synthetic Methodology 1
Organoboron - Chemistry of organoboron compounds, carboranes, hydroboration, reactions of organoboranes, unsaturated hydrocarbon synthesis, allyl boranes, boron enolates.
Organophosphorus - Chemistry of organophosphorus compounds, Phosphorus ylides and chiral phosphines.

Unit-3: Heterocyclic Chemistry 1
Synthesis and reactivity of pyridine, quinoline, isoquinoline, indole, pyrazole, imidazole, oxazole, thiazole, isooxazole and their applications in organic synthesis.

Unit-4: Synthetic Methodology 2
Organosulphur- Chemistry of organosulphur compounds, Sulphur- stabilized anions and cations, sulphonium salts, sulphonium and sulphoxonium ylides, chiral sulphoxides, umpolung
Nitrogen ylide, oxonium ylide

Unit-5: Natural Products 2 - Alkaloids
Familiarity with methods of structure elucidation (chemical & spectroscopical method), biosynthesis, synthesis and biological activity of alkaloids (nicotine, atropine, coniine and papaverine).

Course ID: CHEM - G23

Unit-1: Quantum Mechanics 2
Bound-states. Box with finite walls; the Kronig-Penney model and formation of bands. Harmonic oscillator (wavefunction and operator methods). Elements of variational method and perturbation theory.

Unit-2: The H-atom Problem
Unit-3: Kinetics 2

Unit-4: Statistical Thermodynamics

Unit-5: Interfacial Chemistry

Course ID: CHEM - G24

Practical Chemistry 2
Qualitative analyses of mixture of inorganic compounds. Organic preparations. Instrumental experiments and computer programming.
Suggested Books for Semesters I and II

Course ID: CHEM–G11 and CHEM–G21

Advanced Inorganic Chemistry - F. A. Cotton & G. Wilkinson
Inorganic Chemistry - J. E. Huheey, E. A. Keiter & R. L. Keiter
Chemistry of the Elements – N. N. Greenwood & A. Earnshaw
An Introduction to Inorganic Chemistry – K. L. Purcell & J. C. Kotz
Concepts and Models in Inorganic Chemistry – Douglass, McDaniell & Alexander
Coordination Chemistry – S. F. A. Kettle
Valence – C. A. Coulson
Chemical Application of Group Theory – F.A.Cotton
Theoretical Approach to Inorganic Chemistry – A. F. Williams
Bioinorganic Chemistry – R. W. Hay
Introduction to Bioinorganic Chemistry – D. R. Williams
Elements of Bioinorganic Chemistry – G. N. Mukherjee & A. Das
Instrumental Methods of Analysis – Williard, Meritt, Dean & Sett
Electroanalytical Chemistry –A. J. Bard
Electrochemical Techniques for Inorganic Chemistry – J. B. Headri
Comprehensive Coordination Chemistry - G. Wilkinson, R. A. Gillard & J. A. McCleverty
Inorganic Chemistry –A. G. Sharpe
Inorganic Chemistry – Modern Introduction – T. Moeller
Supramolecular Chemistry - Jean-Marie Lehn
Supramolecular Chemistry Series - Edited by Jean-Marie Lehn
Self-Assembly in Supramolecular Systems - L. F. Lindoy and I. M. Atkinson
Vogel’s Textbook of Quantitative Chemical Analysis - G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney
Analytical Chemistry – G.D. Christian
Radiochemistry and nuclear methods of analysis - William D. Ehmann, Diane E. Vance
Fundamentals of Analytical Chemistry – D.A. Skoog, D.M. West and F.J. Holler
Statistics for Analytical Chemistry – J.C. Miller and J.N. Miller
Nuclear and Radiochemistry- Friedlander, Kennedy and Miller
Essentials of Nuclear Chemistry – H.J. Arnikar
Nuclear Chemistry and its Application - Hossinsky

Course ID: CHEM–G12 and CHEM–G22

Advanced Organic Chemistry - J. March.
Physical Organic Chemistry - J. Hine
Hammett equation - C. D. Johnson.
Pericyclic Chemistry - S. M. Mukherjee.
Applications of Nuclear magnetic Resonance Spectroscopy in Organic Chemistry L. M. Jackman.
Organic Synthesis - The Disconnection Approach – S. Warren
Designing Organic Synthesis – S. Warren
Hydroboration - H. C. Brown
Radical Chemistry – M. J. Perkins.
Heterocycles in Synthesis – A. I. Meyers.
Natural Products – A. Pelter.
The Alkaloid - S. W. Pelletier
The Alkaloids - G. F. Cordell.
Relevant parts from Natural Products; Vols. I & II - P. S. Kalsi.
Relevant parts from Advanced Organic Chemistry - F.A. Carey and R.J. Sandberg; Vols. I & II.
Relevant parts from Comprehensive Heterocyclic Chemistry- A.R. Katritzky.

Course ID: CHEM–G13 and CHEM–G23

Physical Chemistry: A Molecular Approach – D. A. McQuarrie, J. D. Simon
Physical Chemistry – R. S. Berry, S. A. Rice, J. Ross
Introduction to Quantum Mechanics – L. Pauling, E. B. Wilson
Quantum Mechanics – J. L. Powell, B. Crasemann
Quantum Chemistry – I. N. Levine
Chemical Kinetics – K. J. Laidler
Foundations of Chemical Kinetics – S.W. Benson
Fundamentals of Molecular Spectroscopy – C.W. Banwell
Introduction to Molecular Spectroscopy – G. M. Barrow
Theoretical Chemistry – S. Glasstone
Statistical and Thermal Physics – F. Reif
Statistical Mechanics – R. K. Pathria
The Principles of Chemical Equilibrium – K Denbigh
Thermodynamics and an Introduction to Thermostatics – H. B. Callen
Course ID: CHEM–G14 and CHEM–G24

Macro and Semimicro qualitative Analysis – A. I. Vogel
Spot Tests in Inorganic Analysis – F. Feigel & V. Anger (translated by R. Oesper)
Quantitative Inorganic Analysis – A. I. Vogel
Quantitative Inorganic Analysis – G. Charlot & D. Bezier (translated by R. C. Murray)
Quantitative Chemical Analysis – I. M. Kolthoff, E. B. sandel, J. Meehan & S. Bruckenstein

Experimental Organic Chemistry - Principles & Practice - L.M. Harwood & C.J. Roodey
Qualitative Organic Analysis - A.I. Vogel
Text Book of Practical Organic Chemistry - A. I. Vogel
Hand Book of Organic Analysis - R.T. Clark
Systematic Qualitative Organic Analysis- H. Middleton.

Practical Physical Chemistry – A. M. James, F. F. Prichard
Findlay’s Practical Physical Chemistry – B. P. Levitt
Experimental Physical Chemistry – Shoemaker and Garland
Computer Programming on Fortran IV – V. Rajaraman
Programming with Fortran – S. Lepschutz, A. Poe
Unit-1: EPR and Mössbauer Spectra
Principle of EPR and spin Hamiltonian (comparison to NMR spectra), spectrometer, external standard, line-width, nuclear hyperfine interactions, anisotropy in Lande g factor and hyperfine interaction, magnetically equivalent and nonequivalent set of nuclei, intensity, structural information of organic radicals and inorganic molecules from EPR spectra.
Mössbauer activity: principle, experiment, line-width, center shift, quadrupole interaction, magnetic interaction; information of spin and oxidation states, structure and bonding, spin transition from spectra of different Mössbauer active nuclei in varieties of environments.

Unit-2: PES and Diffraction Methods
Photoelectron spectroscopy: Photoexcitation and photoionization, core level (XPS, ESCA) and valence level (UPS) photoelectron spectroscopy, XPS and UPS experiment, chemical shift, detection of atoms in molecules and differentiation of same element in different environments from XPS, information about the nature of molecular orbital from UPS, UPS of simple diatomic molecules e.g. N₂, O₂, CO, HCl etc.. Principles of electron, neutron and X-ray diffraction methods in determining the structure of molecules – a comparative approach.

Unit-3: Mass Spectroscopy
Principles, instrumentation and applications of mass spectrometry. Methods of generation of ions in EI, CI, FD and FAB and other techniques. Detection of ions, ion analysis, ion abundance, molecular ion peak, metastable peak, isotopes, ion-molecule interaction and analysis of fragmentation patterns. Applications of mass spectroscopy to simple structural and mechanistic problems.

Unit-4: Emission Spectroscopy

Unit-5: FT Spectroscopy
Advantages of time-domain vs. frequency-domain studies. Principles of FT-IR and pulse-FT-NMR with instrumentation.
**Course ID: CHEM-SA32**

**Unit-1: Statistical analysis of Data**
Nature of error - systematic & random error; Random walk problem and probabilistic treatment of random errors; Confidence Intervals and Confidence Levels; Least square method for calibration plots; Regression and Correlation analysis.

**Unit-2: Synthetic polymers and Biopolymers**
Introduction to polymers - synthetic polymers, carbohydrates, proteins, and nucleic acids; Molecular weights and molecular weight distributions and their determinations (viscometry, osmometry, light scattering, size-exclusion chromatography; Principles of macromolecular synthesis: step-growth vs. chain-growth polymerizations.

**Unit-3: Elements of Electronics and Instrumentation 1**

**Unit-4: Elements of Electronics and Instrumentation 2**
Nonlinear and digital circuits – basic binary, logic gates counters, microprocessor, Application to specific chemical instruments.

**Unit-5: Instrumentation and Application of Absorption Spectroscopy**
Basic instrumentation for UV-VIS and IR spectroscopy – radiation source, Optical dispersive system, Detectors. Atomic Absorption Spectrometry – Radiation sources, different type atomizers, background correction, application.

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**Course ID: CHEM-SI32**

**Unit-1: Group Theory 1**
Group theory and quantum mechanics (elementary ideas), representation of point groups, reducible and irreducible representations, definitions of classes and character, statement of Grand Orthogonality Theorem, construction of character table, reduction formula, direct product representation and its uses, symmetry of normal modes, normal mode analysis, selection rules for IR and Raman transitions. Hybridization.

**Unit-2: Solid State Chemistry 2**
Bonding in metal crystals: free electron theory, electronic specific heat, Hall effect, electrical and thermal conductivity of metals, superconductivity, Meissner effect, basic concept of BCS (Bardeen-Copper-Schiffer) theory, Application of DTA, DSC and TGA methods. X-ray diffraction analysis (spectral analysis, particle-size determination, etc.).
Unit-3: Organometallics 2
Stereochemical non-rigidity and fluxional behaviour of organometallic compounds with typical examples.
Catalysis by organometallic compounds: Hydrogenation of unsaturated compounds, Wilkinson’s catalyst, Tolman catalytic loop; Syntheses gas-water gas Shift reaction; Hydroformylation (oxo process); Monsanto acetic acid process; Wacker process, synthetic gasoline-Fischer-Tropsch process and Mobile process; polymerization, oligomerization and metatheses reaction of alkenes and alkynes, Ziegler-Natta catalysis, photodehydrogenation catalyst (platinum POP).

Unit-4: Bioinorganic Chemistry 2

Unit-5: Inorganic Rings, Cages and Clusters
Metal-metal bonding (MO approach), metal-metal single and multiple bonded compounds. Low nuclearity (M₃, M₄) and high nuclearity (M₅-M₁₀) carbonyl clusters: skeletal electron counting, Wade-Mingos-Louher rule, Application of isolobal and isoelectronic relationships, capping rules, carbide, nitride, chalcogenide and halide containing clusters. Nb and Ta clusters, Mo and W clusters. Cluster compounds in catalysis.

Course ID: CHEM-SO32

Unit-1: Stereochemistry 2
Advanced course involving conformation and reactivity- acyclic system, monocyclic systems- 3 to 10 member rings, 6-6, 6-5, 6-4, 5-5 bicyclic systems, 6-6-6, 6-5-6, 5-6-5, 5-5-5 tricyclic systems. Introductory course on molecular mechanics computations.

Unit-2: NMR Spectroscopy 2
Advanced Techniques and Applications of NMR: ¹H and ¹³C NMR principles, rules for carbon 13 calculations, principles of decoupling, gated and inverse gated decoupling techniques, NOE, relaxation processes, population transfer, selective polarization transfer, NMR shift reagents and their applications, basic two-dimensional sequence.

Unit-3: Asymmetric Synthesis 1
Principles and newer method of asymmetric synthesis (including enzymatic and catalytic nexus), enantio- and diastereoselective synthesis. Reactions of enolates (α–substitution), Addition to C=C double bonds (electrophile induced cyclisation, iodolactonisation, Hydroboration, Conjugate additions.
Unit-4: Heterocyclic Chemistry 2
Nomenclature of bicyclic and tricyclic fused systems; Introduction to the chemistry of azepins, oxepins, thiepins and their aza-analogues; Phosphorus and selenium containing heterocycles.

Unit-5: Medicinal Chemistry 1

Course ID: CHEM-SP32

Unit-1: Angular Momentum

Unit-2: Group Theory 1
Reducible and irreducible representations; classes and characters; grand orthogonality theorem and related theorems; projection operators; direct product representation; construction of SALC; selection rules in spectroscopy; study of normal modes.

Unit-3: Valency

Unit-4: Mathematical Concepts

Unit-5: Kinetics 3
Rate processes and some physical phenomena. Statistical approach to rate theory: Hinshelwood, RRK and RRKM theories.

Course ID: CHEM-SA33

Unit-1: Fundamentals of Chemical Analysis
Unit-2: Solvent Extraction and Concept of Chromatography
Liquid-Liquid extraction – Cross and counter current process, multiple batch extraction, solvent extraction of metal ion, solid-phase extraction. Classification of chromatographic separation. Aqueous biphasic and supercritical fluid extraction. Band broadening and column efficiency, Theoretical plate model and the Rate theory of Chromatography.

Unit-3: Complex Equilibrium

Unit-4: Kinetics in Analytical Chemistry

Unit-5: Thermal Analysis

Course ID: CHEM–SI33

Unit-1: Crystallography 1
X-ray (related fundamentals), crystal forms, lattice, primitive cell, crystal systems and symmetry, non-primitive lattices, crystal classes, space groups, crystals and their properties, Diffraction of X-ray, lattice planes, indices, Brag’s condition, reciprocal lattice, Bragg’s law in reciprocal space.

Unit-2: Magnetochemistry 1
Definition of magnetic properties, types of magnetic bodies, experimental arrangements for determination of magnetic susceptibility: Gouy method, Faraday method, vibrating sample magnetometer, SQUID, NMR method. Anisotropy in magnetic susceptibility, diamagnetism in atoms and polyatomic systems, Pascal’s constants, two sources of paramagnetism, spin and orbital effects, spin-orbit coupling, Lande interval rule, energies of J levels, Curie equation, Curie’s law and Curie-Weiss law.

Unit-3: Inorganic Reaction Mechanism

**Unit-4: Complex Equilibria 1**

**Unit-5: Chemistry of the Elements 2**
Dinitrogen and dioxygen complexes of transition metals: syntheses, structures, bonding and reactivity.
Iso- and heteropolyoxometalates with respect of V, Mo and W: syntheses, reactions, structures, uses.
Metal-metal bonding (M.O. concept), metal-metal bonded dinuclear d-metal complexes—typical examples. Bonding in dirhenium complexes.
Syntheses, properties, reactions, structures and bonding as applicable in respect of molybdenum blues, tungsten blue, ruthenium blue, platinum blue, tungsten bronze, ruthenium red, Crutz-Taube complex, Vaska’s complex.

**Course ID: CHEM-SO33**

**Unit-1: Applications of MO Theory**
MO theory and its applications to organic molecules, Construction of MOs: linear and cyclic conjugated systems; *ab initio* methods. Walsh orbitals of cyclopropane and cyclobutane. Stability of carbocations, pi-facial selectivities, Cieplak model; strained organic molecules: calculation of strain energies; synthesis of strained cyclic molecules.

**Unit-2: Homo or Heteroatomic bond activation and functionalization: Metallic or non-metallic approach**

**Unit-3: Synthetic Methodology 3**
Chemistry of organosilicon compounds, Synthetic uses of silyl ethers, silylenol ethers, TMSCN, alkene synthesis, alkyne, vinyl, aryl, allyl and acyl silanes; Brook rearrangement, silicon Baeyer Villiger rearrangement

**Unit-4: Medicinal Chemistry 2**
Pharmacodynamics: different types of drugs and drug targets, drug binding forces, role of

**Unit-5: Natural Products 3**
Steroids: General methods of study and structural types. Chemistry of cholesterol, hormones, bile acids, Vitamins of D-group, Diosgenin. Terpenoids: General study and structural features of sesquiterpenes, diterpenes, triterpenes; carotinoids; chemistry of representative members from the diterpenoid and triterpenoid series, carotenoids.

**Course ID: CHEM-SP33**

**Unit-1: Biophysical chemistry**

**Unit-2: Electrochemistry**

**Unit-3: Polymer chemistry**

**Unit-4: Vibration-rotation Spectra**

**Unit-5: NMR Spectroscopy 2**
Product-Operator formalism of 1 D and 2D NMR. Coherence and polarization transfer experiments. Determination of three-dimensional structure of molecules using NMR spectroscopy.
Course ID: CHEM-SA34

Practical Analytical Chemistry:
2. Physico-chemical experiments.
3. Quantitative estimation of alloys, ores and minerals.

Course ID: CHEM-SI34

Practical Inorganic Chemistry:
1. Quantitative estimation of alloys and ores.
2. Physicochemical experiments.
3. Syntheses and characterization of coordination compounds.

Course ID: CHEM-SO34

Practical Organic Chemistry:
1. Chromatographic separation and identification of the components of a binary mixture of organic solids
2. Name-Reactions-Based Organic Preparations
3. Multistep Organic Preparations

Course ID: CHEM-SP34

Practical Physical Chemistry:
1. Selected analytical experiments.
2. Selected numerical experiments: algorithms and programming.
3. Selected instrumental experiments.
Semester - IV

Course ID: CHEM-SA41

Unit-1: Electrochemical Analysis
Introduction to non-faradic and faradic analysis. Non faradic method – High frequency titration. Faradic method – electrode kinetics, General feature of diffusion, Laplace transformation, Solution of diffusion equation under different initial conditions – Polarography, Tast method.

Unit-2: Advanced Topics in Polymer Chemistry
Advanced synthetic techniques for controlling molecular weight dispersity in synthetic polymers- Living polymerization (living ionic, living radical and living ring-opening polymerizations); block copolymers-synthesis, microstructure, and applications; Conjugated polymers and their electrical and opto-electronic properties.

Unit-3: Nuclear Chemistry

Unit-4: Liquid Chromatography
Reverse and normal phase, gradient elution, solvent selection and classes, ion exchange and ion chromatography.
HPLC: Basic equipment, pumping and injection system, column stationary phase and structural types of column packing, Detector systems (UV, IR, Conductometric, Fluorescence), Sample preparation and applications.

Unit-5: Other Types of Chromatography
Gas chromatography: gas-liquid and gas-solid chromatography, types of column and selection. Basic equipment, Injection systems, Detectors (FID, TCD, ECD, NPD) for GC, sample separation and applications.
Characteristics and applications of Size exclusion Chromatography, Affinity chromatography, Supercritical Fluid Chromatography, Capillary Electrophoresis.

Course ID: CHEM-SI41

Unit-1: Group Theory 2
Splitting of orbitals and free ion terms in weak crystal fields, symmetries and multiplicities of energy levels in strong crystal fields, correlation diagram, Tanabe-Sugano diagram. Effect of lowering of symmetry on the orbitals and energy levels, correlation table. Justification of Laporte selection rule, vibronic coupling and vibronic polarization,
polarization of electronically allowed transitions. Symmetry adapted linear combinations (SALCs) and the M. O. description of organic, inorganic and organometallic molecules.

**Unit-2: Crystallography 2**

Geometric data collection (simple examples), structure factor, systematic absence, heavy atom method. Fourier synthesis, Patterson function, experimental diffraction methods (Laue method, rotating crystal method).

**Unit-3: Bioinorganic chemistry 3**

Metalloproteins catalyzing oxygen atom transfer reactions: Iron systems such as cytochrome P-450, methane monooxygenase, catechol and other dioxygenases, etc.; Molybdenum systems such as xanthine oxidase, sulphite oxidase, nitrate reductase, etc. Protective metalloenzymes such as superoxide dismutase, catalase and peroxidase. Other selected metalloproteins of various metal ions. Biological function of nonmetallic elements (other than C, H, O, N, S, P). Interaction of metal ions with bioligands. Structural/functional models of some of the above mentioned systems.

**Unit-4: Chemistry of the Elements 3**

Nuclear stability, terrestrial abundance and distribution; relativistic effect, electronic configuration and oxidation states; aqueous, redox and complex chemistry in different oxidation states as applicable; electronic spectra and magnetic properties- comparisons with those of the d-block elements.

Preparations. Properties and reactivities of the lanthanide and actinides elements and variation within the lanthanide and actinide series; lanthanide and actinide contraction and consequences. Separation of lanthanides and actinides.

**Unit-5: Nuclear Chemistry**


**Course ID: CHEM-SO41**

**Unit-1: Stereochemistry 3**


**Unit-2: Asymmetric Synthesis 2**

Reduction of C=C double bonds, Aldol Reaction, Diels Alder Cycloaddition, Cyclopropanation, Oxidation, Epoxidation, dihydroxylation and aminohydroxylation; Rearrangement: [3,3]-Sigmatropic, (2,3)-Wittig, alkene isomerisation.
Unit-3: Heterocyclic Chemistry 3
Pyrimidines, pyridazines, pyrazines, purines, pteridines, compounds with oxygen and sulfur hetero atoms. Role of heterocyclic compounds in biological systems.

Unit-4: Organometallic Chemistry of Transitional Elements
Application of organotransition metals in organic synthesis-preparative, structural and mechanistic aspects. Davies rule, catalytic nucleophilic addition and substitution reaction, Coupling reaction-Heck, Stille, Suzuki coupling Ziegler Naata reaction, Olefin metathesis, Tebbe’s reagent, Pauson-Khand reactions, Volhsr dt co-trimerisation, functional organometallic compounds. Use of nontransition metal Indium, tin, zinc.

Unit-5: Supramolecular Chemistry
From molecular to supramolecular chemistry: factors leading to strong binding (non-covalent interactions). New molecular receptors: crown ethers, siderophores, cyclophanes, cyclodextrin and their application in specific recognition processes. Supramolecular reactivity and catalysis, switching devices. self-assembly of supramolecular aggregates, crystal engineering.

Course ID: CHEM-SP41

Unit-1: Quantum mechanics 3

Unit-2: Perturbation theory

Unit-3 : Time-dependent Quantum Processes

Unit-4: Quantum Chemistry 1

Unit-5: Quantum Chemistry 2
HF theory and Koopman’s theorem. Problems with open-shell systems. Restricted and unrestricted Hartree-Fock methods (elementary idea). Limitation of IPM: electron

Course ID: CHEM-SA42

Unit–1: Forensic Analysis
Adulterated chemicals, explosives and pattern recognition. Forensic medicine – post-mortem and antemortem analysis, Narcotic drugs and psychotropic substances. Toxicology – poisons and venoms, Measurement of toxicity and toxicants, Drugs toxicity, Food toxicity.

Unit-2: Bioanalytical Methods
Serology and DNA finger printing, Immunoassay – radio immunoassay of hormones, Fluoro immunoassay, Enzyme immunoassay,. Biosensors – cell based biosensors, electrochemical methods and biosensors, thermoionic, biooptical and piezoelectric biosensors.

Unit-3: Atmospheric Chemistry and Air Pollution

Unit-4: Environmental Chemistry of Hydrosphere

Unit-5: Environmental Chemistry of Lithosphere

Course ID: CHEM – SI42

Unit-1: Spectroscopy 1
Survey of metal centered transitions of 3d, 4d, and 5d metal ion complexes. f-f spectra of lanthanides and actinides. Bonding parameters and structural evidences from electronic spectra. Charge transfer spectra. CD, ORD, and MCD spectra and absolute configuration
of coordination compounds. Cotton effect and Faraday effect, stereoselective and stereospecific effects.

Unit-2: Inorganic Photochemistry
Excitation modes in transition metal complexes, fate of photo-excited species, fluorescence and phosphorescence applied to Inorganic systems, intramolecular energy transfer, vibrational relaxation, internal conversion and intrasystem crossing. Photochemical processes: photosubstitution and photoelectron transfer reactions in Co, Cr, and Rh complexes.

Unit-3: Complex Equilibria 2

Unit-4: Magnetochemistry 2
First order and second order Zeeman effects, temperature independent paramagnetism, simplification and application of van Vleck susceptibility equation, quenching of orbital moment, magnetic properties of transition metal complexes in cubic and axially symmetric crystal fields, low spin-high spin crossover, magnetic behaviour of lanthanides and actinides, magnetic exchange interactions, magnetic materials.

Unit-5: Chemistry of the Elements 4
Electronic configuration, oxidation states, aqueous, redox and coordination chemistry, spectral and magnetic properties in different oxidation states, horizontal and vertical trends in respect of 3d, 4d and 5d elements with particular reference to Ti-Zr-Hf, V-Nb-Ta, Cr-Mo-W, Mn-Tc-Re, Ru-Rh-Pd, Os-Ir-Pt. Occurrence, isolation and purification in respect of V, Mo, W, Re; Pt group metals from Pt concentrate. Noble character of Pt group metals.

Course ID: CHEM-SO42

Unit-1: NMR Spectroscopy 3
Application of DEPT, $^1$H-$^1$H COSY, $^1$H-$^13$C HETCOR, HMBC, HMQC, HSQC, TOCSY, NOESY in structure elucidation of organic compounds, reaction monitoring etc., Solid state NMR ($^{13}$C-CP-MAS), Chemical Shift Anisotropy and Cross Polarisation.

Unit-2: Bio-organic Chemistry
Molecular models of biological receptors, biomimetic chemistry, design, synthesis and binding studies of synthetic receptors. Enzyme models, micelles, polymers, cyclodextrins, remote functionalization reactions, catalytic antibodies, principle of gene synthesis. Proteins, peptides & amino acids.

Unit-3: Medicinal Chemistry 3
Drug design and synthesis, Molecular and quantum mechanics; Drawing chemical structures, equations, and diagrams; 3D structures; Molecular modelling and Energy
Minimization; Molecular properties, Conformational analysis, Docking Procedures, *De novo* design, Molecular Recognition, Receptor Based Molecular Modeling, QSAR studies, Antineoplastic agents, cardiovascular drugs, Local anti-infective drugs, Antimalarial, Antibiotics, Anticholenergic and CNS-active drugs.

**Unit-4: Carbohydrate Chemistry**
Basic structure and type of sugars. Protection and deprotection. Deoxy-sugars, amino sugars, glycal sugars and their synthetic aspects. Synthetic approach (Combinatorial) towards polysaccharides of biological and industrial importance. Carbohydrates as chiral pools in organic synthesis.

**Unit-5: Natural Products 4**
Structure, transformation and biosynthesis of alkaloids from terrestrial and marine sources; Chemistry of quinoline alkaloids with special reference to cinchona group; Chemistry of isoquinoline alkaloids – morphine group; Alkaloids derived from pyrrolidines and piperidine ring systems, and from ring systems containing two nitrogen atoms. Peptide alkaloids and Macrocyclic alkaloids.

**Course ID: CHEM-SP42**

**Unit-1: Statistical Mechanics 1**
Phase space; ergodic hypothesis; Liouville’s theorem. Concepts of different ensembles with applications to selected systems. Fluctuations. Perfect gas and the Sackur-Tetrode equation. System of interacting molecules; treatment of imperfect gases.

**Unit-2: Statistical Mechanics 2**
Formulation of Quantum statistical mechanics: pure and mixed states; density matrix; quantum Liouville theorem and its consequences. Quantum statistics and ensembles. The specific heat of electron gas; Debye theory; Bose condensation.

**Unit-3: Mean field theories**

**Unit-4: Statistical Mechanics 3**

**Unit-5: Reaction Dynamics**
Basic concepts in classical mechanics of collisions. Intermolecular potential from scattering experiments. Features of potential energy surfaces. Experimental methods. Study
of molecular energy transfer and state-to-state reactions. Macroscopic rate from microscopic rate coefficients.

Course ID: CHEM-SA43

Unit-1: NMR Spectrometer

Unit-2: Instrumentation and Application of Emission Spectroscopy
Fluorescence and Phosphorescence: Structural factors, Photoluminescence Power as related to concentration, Instrumentation, Fluorescence Lifetime time measurements. Room Temperature Phosphorescence, comparison of Luminescence and UV Absorption Methods.
Atomic emission spectroscopy: Instrumentation, Typical application, ICP Atomic Fluorescence Spectroscopy, comparison of Methods: ICP verses AAS.

Unit-3: Advanced Techniques in Microscopy

Unit-4: Chemistry of Superheavy Elements
Production and nuclear properties of transactinide elements. Fundamental and experimental aspects of one-atom-at-a-time chemistry, gas phase and liquid phase chemistry, methods of their estimation.

Unit-5: Nanochemistry
Theoretical aspects; preparation, characterization, and applications of nanomaterials. Properties of nanomaterials and nanoparticles.

Course ID: CHEM-SI43

Unit-1: Spectroscopy 2
Application of IR, Raman, ESR, Mössbauer and PES in inorganic chemistry (examples with simple and complex inorganic compounds including organometallic and cluster compounds and bioinorganic systems).
NMR Spectroscopy: \(^1\text{H}\) NMR spectra of paramagnetic coordination compounds, dipolar and contact shifts, magnetic susceptibility and resonance shifts. \(^{11}\text{B},
^{13}\text{C},
^{19}\text{F},
^{27}\text{Al},
^{31}\text{P}-\)NMR Spectroscopy with typical examples.
NQR Spectroscopy: Principle, nuclear quadrupole coupling constant, structural information from nqr spectra.

Unit-2: Chemistry of the Elements 5
Compounds of Sc, Y, La, and Ac; Ce(III) and Ce(IV) compounds and their reaction. Lanthanide compounds as high temperature superconductor and nmr shift reagent and MRI reagent.
Isolation and purification of uranium from natural source; aqueous, redox and complex chemistry of uranium in different oxidation states, simple and complex uranium compounds-their preparation, properties, and reactions, organo-metallic compounds of uranium. Transuranium and trans-actinium elements. Nuclear reactors and atomic energy, nuclear fuel reprocessing. Indian scenario.

Unit-3: Chemistry of the Elements 6
Chemistry of Ti, V, Mo, W, Re; Cu, Ag, Au in common and unusual oxidation states. Mixed valence compounds of Fe, Cu, Pt; Fe-S compounds, cobaloxime related compounds, conformational changes and thermochromism of Ni(II) compounds, Ru(II) and Ru(III) compounds, oxo compounds of Ru and Os, Rh(I) and Ir(I) carbonyl halide and carbonyl hydrides.

Unit-4: Materials Chemistry 1
Syntheses, structures and bonding features and technical applications in respect of polymeric inorganic materials: polysilanes, polyoxysilanes, polyphosphazenes, polyphosphates, silicates, aluminosilicates with special reference to talc, mica, asbestos, zeolite, coordination polymers, dendritic macromolecules based on inorganic elements, Zintl phases, halogen X_n^+ ions and their compounds, charge transfer complexes with halogens and halogen bridges or as ligands. Clathrates. Perxenic acid and its salts. Metal alkoxides and aryl oxides, metal complexes with oxo anions as ligands. One dimensional solids, solid state extended arrays, cheveral phases.

Unit-5: Nanochemistry
Theoretical aspects; preparation, characterization, and applications of nanomaterials. Properties of nanomaterials and nanoparticles.

Course ID: CHEM-SO43

Unit-1: Nanoscience and Organic Electronics
Basic concept on nanoparticles, quantum dot and nanocluster, surface atom effect, quantum size effect, nonmetal to metal transition, special properties of nanoparticles, important routes for fabrication of nanoparticles and porous nanomaterial, method of characterization, their application as smart catalyst in organic synthesis (e.g. C-C, C-N, C-O coupling reactions under reductive and oxidative conditions), Fabrication of J- and H-aggregates with organic compounds, their characterization and development of their optoelectronic properties. Designing organic electronic devices such as OFET, OLED, solar cell etc. and their efficiency as high-tech devices.

Unit-2: Green Chemistry
Green chemistry- overview, Twelve Principles, Green synthetic methods, Catalytic methods, Organic synthesis in aqueous media, Ionic liquid, Supercritical fluids and microwave. Solvent free organic reactions.
Unit-3: Nucleoside and Nucleotide
Chemical synthesis of nucleosides and oligonucleotides; Biosynthesis of nucleotides and folic acids; Amino-acids-protein biosynthesis. Covalent interactions of nucleic acids with small molecules. Structural features of DNA and RNA.

Unit-4: Natural Products as Lead Drug
Synthesis and mechanism of, anti-tumor, antiviral, anti-sense and DNA cleaving agents.

Unit-5: Natural Products
Structure, transformations, synthesis of simple and monoterpenoid derived indole alkaloids – yohimbine, reserpine, strychnine, ellipticine, lysergic acid, representative examples of Iboga and Aspidosperma type indole alkaloids.

Course ID: CHEM-SP43

Unit-1: Solids

Unit-2: Group Theory 2
MO theory with applications to $\sigma$ and $\pi$ bonding and construction of hybrid orbitals. LFT with applications to splitting of terms and levels in different coordination environments and construction of energy level diagrams. Applications of symmetry principles in Woodward-Hoffman type reactions like dimerization of ethylene, and Diels-Alder reaction.

Unit-3: Chemistry of Excited States

Unit-4: Lasers

Unit-5: Theoretical Spectroscopy
Selection rule for vibrational spectra, anharmonic correction by perturbation – appearance of overtones; selection rule for rotational spectra, nuclear spin and rotational energy levels, stark effect. Raman scattering, selection rule for rotational vibrational Raman effect. Non-linear scattering – hyper-Raman, stimulated Raman and resonance Raman spectra.
Suggested Books for Semesters III and IV

Course ID: CHEM-SA32, CHEM-SA33, CHEM-SA41, CHEM-SA42, CHEM-SA43

Vogel’s Textbook of Quantitative Chemical Analysis - Jeffery, Bassett, Mendham and Denney
Analytical Chemistry – G.D. Christian
Fundamentals of Analytical Chemistry – D.A. Skoog, D.M. West and F.J. Holler
Instrumental Methods of Chemical Analysis – G.W. Ewing
Instrumental Methods of Analysis – H.H. Willard, L.L. Meritt, J.A. Dean and F.A. Settle
Treatise on Comprehensive Analytical Chemistry – Wilson and Wilson
The mathematics for Physics and Chemistry(Vol-1)- H. Marganau and G.M. Murphy
Mathematics for Chemists – D.M. Hirst
Statistics for Analytical Chemistry – J.C. Miller and J.N. Miller
Nuclear and Radiochemistry- Friedlander, Kennedy and Miller
Essentials of Nuclear Chemistry – H.J. Arnikar
Nuclear Chemistry and its Application - Hossinsky
Electrochemical Methods – A.J. Bard and L.R. Raukner
Electroanalytical Chemistry – H.W. Nurnberg (Ed)
Electroanalytical Chemistry- A.J. Bard
Electroanalytical Techniques for Inorganic Analysis – J. B. Headridge
Radiochemistry – A. N. Nesmeyanev
Radioactivity applied to chemistry – A. C. Wahs and N. A. Bonner (Ed)
Non-aqueous Solvents – L. F. Audrieth
Non-aqueous Solvents – T. C. Waddington
Atomic Absorption Spectrometry – B. Welz
Atomic Absorption Spectrometry – J. W. Robinson
Analytical Chemistry, Principles – J. H. Kennedy
Analytical Chemistry, Principles and Techniques – L. G. Hargis
Basic Concepts of Analytical Chemistry- S. M. Khopkar
Chemical Separation Methods – J. A. Dean
Solvents Extraction of chelates – Morrison and Freiser
Practical Clinical Biochemistry – A. H. Gowenlock
Toxicological Chemistry – Vora
Environmental Toxicology - Ed. J. Rose
Environmental Chemistry – A. K. De
Environmental Chemistry – C. Baired, W. H. Freeman
The Chemistry of our Environment – R. A. Horn
Environmental Chemistry, An Introduction – L. I. Pryde
Electron Microscopy - J.J. Bozzola, L.D. Russell
Atomic Force Microscopy: Understanding … - Greg Haugstad
Confocal Microscopy Methods and Protocols, Ed.: Stephen W. Paddock
Fundamentals of Light Microscopy and Electronic Imaging, Doulgas B. Murphy

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Single Molecule Spectroscopy, R. Rigler, M. Orrit, T. Basche
Handbook of Single Molecule Fluorescence Spectroscopy, C Gell, D. Brockwell, A. Smith
Principles of Fluorescence Spectroscopy, J. Lakowicz
Principles of Polymer Chemistry, P.J. Flory
Semiconducting and Metallic Polymers, A.J. Heeger
Fundamentals of Polymer Science – An Introductory Text, M.M. Coleman & P.C. Painter
The Hydrophobic Effect : Formation of Micelles and Biological Membranes, C. Tanford
Polymer Chemistry: An Introduction, M.P. Stevens
Fundamentals of Polymerization, B.M. Mandal
The Chemistry of Polymers, J.N. Nicholson
Polymers in Solution: Their Modelling and Structure, J. Cloizeaux & G. Zanninu
Nucleic Acids, S. Doonan
Biophysical Chemistry of Proteins (An Introduction to Laboratory Methods), E. Buxbaum

Course ID: CHEM–SA34
Quantitative Inorganic Analysis – A. I. Vogel
Quantitative Inorganic Analysis – G. Charlot & D. Bezier (translated by R. C. Murray)
Quantitative Chemical Analysis – I. M. Kolthoff, E. B. Sandel, J. Meehan & S. Bruckenstein

Course ID: CHEM-SI32, CHEM-SI33, CHEM-SI41, CHEM-SI42, CHEM-SI43
Chemical Application of Group Theory – F. A. Cotton
Molecular Symmetry and Group Theory – Robert L. Carter
Group Theory and chemistry – D. M. Bishop
Introduction to Ligand Fields – B. N. Figgis
Introduction to Ligand Fields Theory – C. J. Ballhausen
Valence - C. A. Coulson
Chemical Crystallography – L. W. Bunn
Crystal & X-ray – K. Lansdale
Crystal Structure Analysis – M. J. Buerger
X-ray Crystal Structure – D. Melachlan
Elements of X-ray Crystallography - Azaroff
Introduction to Metal – Complex Chemistry – M.Tsutsui
Modern Inorganic Chemistry – J. J. Lagowski
Introduction to Solids – Azaroff
Solid State Physics – A. J. Dekker
Principle of Solid state – H. V. Keev
Ionic Crystal Lattice & Non-Stoichiometry – N. N. Greenwood
Solid State Chemistry – N. B. Hannay
Solid State Chemistry & Its Application – A. R. West
Thermal Methods of Analysis – W. W. Wendlandt
Symmetry in Molecules – J. M. Hollar
Orbital Interactions in Chemistry – T. A. Albright, J. K. Burdt & M. H. Whangbo
Comprehensive Coordination Chemistry – G. Wilkinson, R. D. Gillard & J.A. McCleverty
Inorganic Reaction Mechanism – M. L. Tobe
Mechanism of Inorganic Reaction – F. Basolo & R. G. Pearson
Mechanism of Inorganic Reaction – Katakis & Gordon
Chemistry of Complex Equilibria – M. T. Beck & V. I. Nagypal
Treatise on Analytical Chemistry – Koltzoff & Elving
Photochemistry of Coordination Compounds – V. Balazani & V. Carassiti
Determination and use of Stability Constants – A. E. Martell & R. J. Motekaitis
Critical Stability Constants – A. E. Martell
Chemistry – S. F. A. Kettle
Magnetometry – A. Selwood
Introduction to Magnetometry – Earnshaw
Physical Methods in Inorganic Chemistry – R. S. Drago
Concepts of Inorganic Photochemistry – A. W. Adamson & P. D. Fleishauer
An Introduction to Bioinorganic Chemistry – R. J. P. Williams
Inorganic Chemistry of Biological Processes – M. N. Hughes
Bioinorganic Chemistry – E. I. Ochiai
Bioinorganic Chemistry – R. W. Hay
Inorganic Aspects of Biological and Organic Chemistry – R. P. Hanzlik
General Principles of Biochemistry of the elements – E. I. Ochiai
Introduction to Bioinorganic Chemistry – D. R. Williams
Organo Transition metal Chemistry – S. G. Davies
Nuclear and Radiochemistry – Friedlander, Kennedy & Miller
Essentials of Nuclear Chemistry – H. J. Armikar
Nuclear Chemistry – Williams
Nuclear Chemistry and its Applications – Hossinsky
Radiochemistry – A. N. Nesmeyanev
Radioactivity Applied to Chemistry – A. C. Wahl & N. A. Bonner
Organometallic Chemistry of Transition Metals – R. H. Crabtree
Ions in Biological Systems – H. Siegel (Ed.)
An Introduction to Inorganic Chemistry – K. F. Purcell & J. C. Kotz
Elements of Magnetochemistry – R. L. Dutta & A. Shyamal
Principles of Organometallic Chemistry – R. L. Crabtree
Homogeneous Catalysis; Wiley: New York, 1980 – G. W. Parshall
Heterogeneous Catalysis –
Applied Homogeneous Catalysis with Organometallic Compounds – W. A. Herrmann
Catalyst Handbook – B. B. Pearce
Homogeneous Catalysis - G. W. Parshall and S. D. Ittel
Applied Homogeneous Catalysis with Organometallic Compounds – B. Cornils & W. A. Herrmann
Kinetics and Mechanism of Reaction of Transition Metal Complexes - R. G. Wilkins
X-RAY Structure Determination – A Practical Guide-George H. Stout and Lyle H. Jensen
Structure Determination by X-ray Crystallography, MFC Ladd and R. A. Palmer
Crystal Structure Analysis for Chemists and Biologists, Jenny P. Glusker with Michell Lewis Miriam Rossi

Course ID: CHEM–SI34

Quantitative Inorganic Analysis – A. I. Vogel
Quantitative Inorganic Analysis – G. Charlot & D. Bezier (translated by R. C. Murray)
Quantitative Chemical Analysis – I. M. Kolthoff, E. B. Sandel, J. Meehan & S. Bruckenstein
Instrumental Methods in Analysis – Willard, Merritt and Dean
Instrumental methods in Chemical Analysis – G. W. Ewing

Course ID: CHEM-SO32, CHEM-SO33, CHEM-SO41, CHEM-SO42, CHEM-SO43

Advanced Organic Chemistry - J. March.
Organic Reaction Mechanics- A. Gallego, M.Gomer & Sierra, M.A
Hammett equation - C. P. Johnson.
Symmetry in Chemistry - Orchin & Jaffe.
Orbital Interactions in Chemistry - T. A. Albright, J. K. Burdt & M. H. Whangbo.
Pericyclic Chemistry - S. M. Mukherjee.
Frontier Orbitals and properties of Molecules - V. F. Tranen.
Huckel M.O. Theory - K. Yates.
Pericyclic Chemistry - Gill & Willis.
A Handbook of Computational Chemistry - Tim Clark.
Radical Chemistry – M. J. Perkins.
Hammert Equation - C. D. Johnson.
Applications of Nuclear magnetic Resonance Spectroscopy in Organic Chemistry L. M. Jackman.
NMR in Chemistry - A Multinuclear A approach - W. Kemp.
The Nuclear Overhauser Effect in Structural & Conformational Analysis - D. Neuhaus.
NMR: The Toolkit – P. J. Hore; J. A. Jones & S. Wimperis
Two-dimensional Nuclear Magnetic Resonance in Liquids - A. Bax.
Mass Spectroscopy - K.G. Das
Modern Organic Reactions - H.O. House – Benjamin
Application of Organotransition Metals in Organic Synthesis - S.G. Davies.
Organotransition Metal Chemistry – R. F. Heck.
Synthetic Coordination and Organometallic Chemistry- A. D. & Kharisov, B. I.
Palladium in Organic Synthesis – Tsuji, J.
Palladium in Heterocyclic Chemistry: A Guide for the Synthetic Chemist- Li, J. J. & Gribble, G.W.
Supramolecular Chemistry - Concepts and Perspectives - J. -M. Lehn
Principles and Methods in Supramolecular Chemistry – Schneider, H.-J; Yatsimirski
Organic Synthesis - The Disconnection Approach - Stuart Warren
Designing Organic Synthesis - Stuart Warren
Hydroboration - H. C. Brown
Radical Chemistry - M. J. Perkins.
The Chemistry of Sugar – Levy, D. E.; Fugedi, P.
Glycoscience: Chemistry and Chemical Biology - Fraser-Reid, B. O.; Tatsuta, K.; Thiem, J.
Heterocycles in Synthesis – A. I. Meyers.
Natural Products: Chemistry, and Biological Significance - J. Mann; R. S. Davidson, J. B.
Hobbs, D.V. Banthorpe; J.B. Harbome & Longman, E.
Relevant portions from -Chemistry of Alkaloids- edtd. By RH.F. Manske.
The Alkaloids - J.A. Cordell.
The Alkaloid – S. W. Pelletier.
Natural Products - A. Pelter.
Relevant portions from Burger's Medicinal Chemistry and Drug Discovery; Ed. M. E.
Wolff, John Wiley.
The Organic Chemistry of Drug Synthesis vol. I-VI, - Lednicer, A; Dand Lester, A. M.
Fundamentals of Medicinal Chemistry -Thomas; G.
Classics in Total Synthesis by K. C. Niclaou & E. J. Sorenson
Introduction to Medicinal Chemistry - A. Gringuage; Willey-VCR.
An Introduction to Medicinal Chemistry – G.L. Patrick, 3rd Edn
Instant Notes: Medicinal Chemistry- Patrick G.
Handbook of Anticancer Drug Development – Budman, D. R.; Calvert, A. H. and
Rowinsky, E. K.
Surface and Nanomolecular Catalysis – R. Richards
The Nanoscope Encycoprdia of Nanoscience & Nanotechnology, Vol-I to VI; Diwan P. &
Bharadwaj, A.
Microwave Assisted Synthesis of heterocycles – R. R. Gupta; V. E. Eric & Kappe, C.
Oliver
Microwaves in Organic and Medicinal Chemistry –Kappe; C: Oliver & Stadler
Solvent-free Organic Synthesis – K. Tanka
Green Chemistry - V. K. Ahluwalia
Green Chemistry – P. T. Anastas & T. C. Williamson

Course ID: CHEM–SO34

Qualitative Organic Analysis - A.I. Vogel.
Quantitative Analysis - A.I. Vogel.
An Introduction to Experimental Organic Chemistry - Roberts,
Gilbert, Rodewaid & Wingrove.
Systematic Qualitative Organic Analysis- H. Middleton.
Thin Layer Chromatography - Egon Stahl.

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Course ID: CHEM-SP32, CHEM-SP33, CHEM-SP41, CHEM-SP42, CHEM-SP43

Elementary Quantum Chemistry – F. L. Pilar
Quantum Chemistry – I. N. Levine
Modern Quantum Chemistry – A. Szabo, N. S. Ostlund
Molecular Quantum Mechanics – P. W. Atkins
Quantum Mechanics – J. L. Powell, B. Crasemann
Introduction to Quantum Mechanics – D. J. Griffiths
The Feynman Lectures in Physics, Vol. 3 – R. P. Feynman, R. B. Leighton, M. Sands
Chemical Applications of Group Theory – F. A. Cotton
Group Theory and Chemistry – D. M. Bishop
Coulson’s Valence – R. McWeeny
Thermodynamics and an Introduction to Thermostatics – H. B. Callen
Elements of Classical Thermodynamics – A. B. Pippard
Theories of chemical reaction rates – K. J. Laidler
Theory of rate processes – S. Glasstone, K. J. Laidler, H. Eyring,
Principles of Physical Biochemistry – K. E. van Holde, C. Johnson, P. S. Ho
Physical Chemistry of Macromolecules – C. Tanford
Polymer Chemistry – P. J. Flory
Molecular Spectroscopy – I. N. Levine
Molecular Spectroscopy – J. D. Graybeal
Principles of Fluorescence Spectroscopy – J. R. Lakowicz
Introduction to Magnetic Resonance - A. Carrington, A. D. McLachlan
Statistical and Thermal Physics – F. Reif
Statistical Mechanics - D. A. McQuarrie
Statistical Mechanics – S. K. Ma
Statistical Mechanics – K. Huang
Statistical Mechanics – R. K. Pathria
Statistical Mechanics – B. B. Laud
Chemical Kinetics and Dynamics – J. I. Steinfeld, J .S. Francisco, W. L. Hase
Molecular Reaction Dynamics – R. D. Levine.
Molecular Reaction Dynamics and Chemical Reactivity – R. D. Levine, R. B. Bernstein
Introduction to Solid State Physics – C. Kittel
Introduction to Solid State Theory – O. Madelung
Solid State Physics – A. J. Dekker
Molecular Modelling: Principles and Applications – A. R. Leach
Photodissociation Dynamics - R. Schinke
Modern Spectroscopy – J. M. Hollas
Symmetry and Spectroscopy - D. C. Harris, M. D. Bertolucci
Molecular Vibrations - E. B. Wilson Jr., J. C. Decius, P. C. Cross
Microwave Spectroscopy – C. H. Townes and A.L. Schawlow
Laser Spectroscopy – W. Demtroder
Advanced Engineering Mathematics – E. Kreyszig
Mathematical Methods in the Physical Sciences – M. L. Boas
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Practical Physical Chemistry – A. M. James, F. F. Prichard
Findlay’s Practical Physical Chemistry – B. P. Levitt
Experimental Physical Chemistry – Shoemaker and Garland
Computer Programming in Fortran IV – V. Rajaraman
Programming with Fortran – S. Lepschutz, A. Poe
Genetic Algorithm in Search Optimization and Machine Learning – D. E. Goldberg
Computational Intelligence – A. Konar
Numerical Recipes in Fortran – W. H. Press et al