UNIVERSITY OF CALCUTTA

Notification No. CSR/ 68/18

It is notified for information of all concerned that the Syndicate in its meeting held on 13.07.2018 (vide Item No.11) approved the Syllabus of Two-Year (Four-Semester) M.Sc. Course of Study in Chemistry under CBCS in the Post-Graduate Departments of the University and in the affiliated Colleges offering Post-Graduate Courses under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 17th August, 2018

(Debabrata Manna)
Deputy Registrar (Acting)
UNIVERSITY OF CALCUTTA
# DEPARTMENT OF CHEMISTRY

# UNIVERSITY OF CALCUTTA

## TWO YEAR FOUR-SEMESTER M.Sc. COURSE IN CHEMISTRY

### COURSE STRUCTURE

<table>
<thead>
<tr>
<th>DURATION</th>
<th>SEMESTER</th>
<th>TOTAL MARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td></td>
<td>JULY-DEC</td>
<td>JAN-JULY</td>
</tr>
<tr>
<td>MARKS</td>
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<td>250</td>
</tr>
<tr>
<td>COURSE TYPE</td>
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<td>PRACT</td>
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<tr>
<td></td>
<td>(12)</td>
<td>(8)</td>
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<tr>
<td>GENERAL (G)</td>
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<td>CREDIT POINTS</td>
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<table>
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<tr>
<th>SPECIAL (S)</th>
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<tr>
<td>Total Marks</td>
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<td>100</td>
<td>150</td>
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<td>1000 (80)</td>
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Total credit points: **80**

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)

<table>
<thead>
<tr>
<th>Course ID</th>
<th>Marks/Credit</th>
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<tr>
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<td>CHEM – G12</td>
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<tr>
<td>CHEM – G13</td>
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<tr>
<td>CHEM – G14</td>
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### SEMESTER – II (Marks – 250)

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### SEMESTER – III (Marks – 250)

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**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
### Course Details

<table>
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<tr>
<th>Course ID</th>
<th>Experiment</th>
<th>General Laboratory performance</th>
<th>*Seminar</th>
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<td>10</td>
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<tr>
<td>CHEM – SA31/SI31/SO31/SP31</td>
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- Topic should be outside the UG curriculum of CU; use of overhead/LCD projector is mandatory; time 10m, followed by discussion

<table>
<thead>
<tr>
<th>Course ID</th>
<th>*Continuous assessment</th>
<th>Review</th>
<th>Project</th>
<th>Grand Viva</th>
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</table>

*Continuous assessment to be assessed by the guide

Review (maximum 3000 words excluding references and figures) and Project to be assessed by External Expert

Grand Viva to be taken by Sectional Faculty members and assessed by them

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**SYLLABUS**
SEMESTER – I

Course ID: CHEM-G11

Unit-1: Symmetry

Symmetry elements; Symmetry operations; Group theory; Group multiplication table;

Point group; Schönflies symbols; Classes of point groups; Platonic solids; Stereographic Projections

Unit-2: Coordination Chemistry

Crystal field theory, Splitting of d orbitals in linear, triangular, tetrahedral, square planar, trigonal bipyramidal, square pyramidal, octahedral and pentagonal bipyramidal 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. Shapes of complexes. 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.

Electronic spectra of transition metal complexes – determination of free ion terms of d1 to d9, microstates, determination of ground and all excited state terms of d0 terms in octahedral and tetrahedral fields, Orgel diagrams (qualitative approach), hole formalism, inversion and equivalence relations, selection rules for spectral transitions, d-d spectra and crystal field parameters, Nephelauxetic series, qualitative idea of Tanabe–Sugano diagrams, charge transfer spectra. Magnetic properties – elementary idea.

Unit-3: EPR and Mössbauer Spectroscopy

Principle of EPR and spin Hamiltonian(comparison to NMR spectroscopy), spectrometer, external standard, line-width, nuclear hyperfine interactions, anisotropy in Lande g factor and hyperfine interaction, magnetically equivalent and non-equivalent set of nuclei, intensity, structural information of organic radical and inorganic molecules from EPR spectra. Mössbauer activity:
principle, experiment, line-width, center shift, quadruple interaction, magnetic interaction; information of spin and oxidation states, structure and bonding, spin transition from spectra of different Mossbauer active nuclei in variety of environments.

Unit-4: Bioinorganic Chemistry – 1


Unit-5: Electrochemical Analysis

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 I

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


Unit-4: NMR Spectroscopy I

Principle, instrumentation and different techniques (CW & FT) of NMR spectroscopy, classification of $A_2$, $A_3$, ABX, AMX, ABC, $A_2B_2$ in proton NMR. Introduction to $^{13}$C-NMR spectroscopy, application of NMR spectroscopy and other spectroscopical techniques to simple structural and mechanistic problems. Rules for carbon13 calculations, principles of decoupling, gated and inverse gated decoupling techniques, NOE, relaxation processes, problems on NOE, nuclei with negative NOE.

Unit-5: Natural Products

Familiarity with methods of structure elucidation (chemical & spectroscopical method), biosynthesis, synthesis and biological activity of alkaloids (nicotine, atropine, coniine and papaverine).

COURSE ID: CHEM-G13
Unit-1: Interfacial Chemistry


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

Postulates and their analysis. Properties of operators and commutators. Equation of motion. Stationary states, Quantization Schemes, Ehrenfest’s theorems, Some properties of one-dimensional systems, Barrier problems and tunneling.

Unit-4: Kinetics 1


Unit-5: Polymer Chemistry


Course ID: CHEM-G14
Practical Chemistry 1

Spectrophotometric, ion exchange and complexometric estimations.

Identification of single organic liquid with one or more functional groups.

Experiments (Kinetics, equilibrium, electrochemistry, spectroscopy)

SEMESTER – II

Course ID: CHEM-G21

Unit-1: Chemical Bonding

Different types of bondings including weak interactions; Valence bond and molecular orbital theories – comparative account; Group orbitals in molecular orbital approach; Molecular orbital description of varieties of dinuclear, trinuclear and oligonuclear molecules, radicals and ions, including metal complexes having geometries such as tetrahedral \(T_d\), square planar \(D_{4h}\), octahedral \(O_h\), etc; Walsh diagram; Evidence of MO pictures from spectra and reactivity; Explanation of spectrochemical and Nephelauxetic series; Molecular term symbols.

Unit-2: Complex Equilibria


Unit-3: Organometallic Chemistry – 1

Applications of 18-electron and 16-electron rules to transition metal organometallic complexes. Isolobal and isoelectronic relationships with examples. Structure and bonding in metal-alkyl, -alkene, -alkyne, -allyl \(\eta^1\&\eta^3\), -carbonyl, -carbide and cyclopentadienyl complexes with typical examples. Structure and bonding of \([\{PPh_3\}_2Pt(C_7H_5)\], [Mo(porphyrin)(C_7H_5)], [Co_2(CO)_8(C_7H_5)], [Ni(\eta^3-C_3H_5)_2] and [FeCp_2]. Reactions of organometallic complexes: Substitution, oxidative addition,
reductive elimination, insertion and elimination, electrophilic and nucleophilic reactions of coordinated ligands.

Unit-4: Selected topics on the chemistry of s and p block elements

Structure and bonding in higher boranes based on Lipscomb’s topological concept, Wade’s rules, borohydride $\text{B}_n\text{H}_{n-2}$ anion, carboranes, metalloboranes, hydroboration reactions. Alkali metal complexes with macrocyclic ligands (crown ethers, cryptates and spherand). Aqueous and complex chemistry of beryllium and aluminium. Main group organometallic chemistry: classification, synthesis, reaction, structure and bonding, and application of typical examples.

Unit-5: Nuclear chemistry


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 I

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: Synthetic Methodology II**

Chemistry of organosilicon compounds, Synthetic uses of silyl ethers, silylenol ethers, TMSCN, alkene synthesis, alkynyl, vinyl, aryl, allyl and acyl silanes; Brook rearrangement, silicon Baeyer Villiger rearrangement

**Unit-4: Synthetic Methodology III**

Organosulphur- Chemistry of organosulphur compounds, Sulphur- stabilized anions and cations, sulphonium salts, sulphonium and sulfoxonium ylides, chiral sulphoxides, umpolung

Nitrogen ylide, oxonium ylide

**Unit-5: Heterocyclic Chemistry I**

Synthesis and reactivity of pyridine, quinoline, isoquinoline, indole, pyrazole, imidazole, oxazole, thiazole, isooxazole and their applications in organic synthesis.

**COURSE ID: CHEM-G23**

**Unit-1: Valency**


**Unit-2: H-atom Problem**

**Unit-3: Group Theory 1**

Reducible and irreducible representations, Classes and Characters, Great Orthogonality theorem and related theorem, Projection operators, Direct product representation, Construction of SALC, Selection rules in spectroscopy, Study of normal modes, IR and Raman activity.

**Unit-4: Statistical Thermodynamics**


**Unit-5: Biophysical Chemistry**


**Course ID: CHEM - G 24**

**Practical Chemistry 2**

Qualitative analysis of mixture of compounds.

Organic preparations.

Experiments (Kinetics, equilibrium, electrochemistry, spectroscopy)

**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, McDanniel & Alexander

Coordination Chemistry – S. F. A. Kettle


Chemical Application of Group Theory – F. A. Cotton

Theoretical Approach to Inorganic Chemistry – A. Williams


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 (eds)

Inorganic Chemistry – A. G. Sharpe

Inorganic Chemistry – Modern Introduction – T. Moeller

Supramolecular Chemistry - Jean-Marie Lehn Supramolecular Chemistry Series - Edited by Jean-Mari 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

Fundamentals of Analytical Chemistry – D. A. Skoog, D. M. West and F. J. Holler

Nuclear and Radiochemistry- Friedlander, Kennedy and Miller
Essentials of Nuclear Chemistry – H.J. Arnikar

Nuclear Chemistry and its Application – Hossinsky

Bioinorganic Chemistry – R. W. Hay

Introduction to Bioinorganic Chemistry – D. R. Williams


General Principles of Biochemistry of Elements – E. I. Ochiai

Inorganic Aspects of biological and Organic Chemistry – R. P. Hanzlik

Principles of Bioinorganic Chemistry – S. J. Lippard, J. M. Berg

Inorganic Chemistry of Biological Process – M. N. Hughes

An Introduction to Bioinorganic Chemistry – R. J. P. Williams

Organometallics A concise Introduction – Ch. Elschenbroich, A. Salzer

Inorganic Chemistry – Catherine E. Housecroft and A. G. Sharpe

Macro cyclic Chemistry, Current Trend and Future Perspectives – Karsten Gloe

Organometallic Chemistry of transition Metals – R. H. Crabtree

Basic Organometallic Chemistry – B. D. Gupta & A. J. Elias

C. P. Horwitz & D. F. Shriver, Advances in Organometallic Chemistry, Vol. 23, 1984


Mossbauer Spectroscopy and Transition Metal Chemistry (Fundamentals and Applications) – Philipp Guetlich, Eckhardt bill, A. X. Trautwein

Nuclear and Radiochemistry – Friedlander, Kennedy & Miller

Essentials of Nuclear Chemistry – H. J. Arnikar
Nuclear Chemistry – Williams

Nuclear Chemistry and its Applications – Hossinsky
Radiochemistry – A. N. Nesmeyanev

Radioactivity Applied to Chemistry – A. C. Wahl & N. A. Bonner


(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 I 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 Atomic Spectra – H.E. White

Quantum Mechanics- J.L.Powell, B. Crasemann
Introduction to Quantum Mechanics- D. J. Griffiths
Introduction to Quantum Mechanics – L.Pauling, E.B.Wilson
Quantum Chemistry – I.N. Levine
Coulson’s Valence- R. McWeeny
Chemical Application of Group Theory- F. A. Cotton
Group theory and chemistry- D. M. Bishop
Chemical Kinetics – K.J. Laidler
Foundations of Chemical Kinetics – S.W. Benson
Theoretical Chemistry – S. Glasstone
Fundamentals of Statistical and Thermal Physics – F. Reif
Statistical Mechanics – R.K. Pathria
The Principles of Chemical Equilibrium – K. Denbigh
Thermodynamica and Introduction to Thermostatics – H.B. Callen
Physics and Chemistry of Surfaces – N.K. Adams
Physical Chemistry of Surfaces – A.W. Adamson
Principles of Physical Biochemistry – K.V. van Holde, C. Johnson, P.S. Ho
Physical Chemistry of Macromolecules – C. Tanford
Polymer Chemistry – P.J. Flory

**COURSE ID: CHEM-G14 and CHEM-G24**

Practical Physical Chemistry – A.M. James, F.F. Prichard
Findlay’s Practical Physical Chemistry – B.P. Levitt
Experimental Physical Chemistry – Shoemaker and Ga
Unit-1: IR, Raman, NMR and NQR spectroscopy of inorganic molecules

Applications of IR and Raman spectroscopy in inorganic chemistry (examples with organometallic, cluster and bioinorganic compounds). NMR spectroscopy of inorganic compounds: $^1$H spectra of paramagnetic complexes, dipolar and contact shifts, magnetic susceptibility and resonance shifts. $^{11}$B, $^{13}$C, $^{19}$F, $^{27}$Al, $^{31}$P NMR spectroscopy with typical examples. NQR spectroscopy: Principle, nuclear quadrupole coupling constant, structural information from NQR spectra.

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., $\text{N}_2$, $\text{O}_2$, 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: Absorption spectroscopy**

L-B’s Law and its limitations, Einstein’s two level transition model. Transition moment and its relation to molar extinction coefficient. Different types of transitions ($\pi\pi^*$, $\sigma\pi^*$, $n\pi^*$ etc.), Selection rules with symmetry arguments, Solvent perturbation method, Weak and CT transition, Vibronic and spin orbit coupling.

**Unit-5: Emission spectroscopy**

Basic principle and instrumentation, FC principle, Mirror-image symmetry and its violation, Radiative and radiationless deactivation, Polarization characteristics of emission, Fluorescence Quenching (static and Dynamics), Fluorescence lifetime measurement.

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**CBCS PAPER**

**CBCS CHEM (50 marks, credit 04)**

**Unit-I: Environmental Chemistry (10 marks, 10 lecture-hours)**

Environmental Hazards and Green Chemistry
Environmental Hazards and Pollution (their sources and remedies),
Green Chemistry-definition, need for Green Chemistry, limitations in the pursuit of Green Chemistry, basic principles, Applications of Green Chemistry to Chemical Synthesis.

**Unit-II: Organometallic Chemistry and Catalyses (10 marks, 10 lecture hours)**

(a) Organometallic Chemistry

(b) Catalysis by Organometallic Compounds
Definition and importance of catalyst with special emphasis on Organometallic catalysts. Use of Organometallic catalysts with reference to industrially important processes.

Unit-3: Absorption and Emission spectroscopy (10 marks, 10 lecture hours)
Basic principle, instrumentation and application of absorption and emission spectroscopy (atomic and molecular): Fundamental Laws of photometry, Limitation of absorption and emission measurement, Photometric titration, Fluorescence quenching (Static and Dynamic), Time resolved measurement, Qualitative and quantitative analysis.

Unit-4: Nanoscience (10 marks, 10 lecture hours)
Introduction to nanoworld, Fundamental theories of nanoparticles (NPs), 0D, 1D and 2D nanoparticles and their physical, optical, electronic, magnetic properties, Methods of fabrication of metal organic and composite NPs, Application of NPs, nanoelectronics and devices.

Unit-5: Analytical Methods (10 marks, 10 lecture hours)
Basic Principles and Applications:
Optical spectroscopy for chemical analysis, Atomic Absorption Spectrometry,
Radiochemical Analysis, Electrochemical Analysis: Voltammetry, Thermogravimetric Analysis

SPECIAL PRACTICAL (THIRD SEMESTER)

CHEM SA-31

Practical Analytical Chemistry:

2. Physico-chemical experiments.
3. Quantitative estimation of alloys, ores and minerals.

CHEM SI-31

Practical Inorganic Chemistry:

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

CHEM SO-31

Practical Organic Chemistry

1. Chromatographic separation and identification of the components of a binary mixture of organic solids, mixture of organic liquids
2. Organic Preparation I
3. Organic Preparation II
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: Principles of Polymer Chemistry

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.

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: Advanced Techniques in Microscopy

Electron Microscopy - Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM); Atomic Force Microscopy (AFM); Fluorescence Confocal Microscopy; Fluorescence Correlation Spectroscopy.

Unit-4: Instrumentation and Application of Absorption & Emission 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.
Fluorescence and Phosphorescence: Structural factors, Photoluminescence Power as related to concentration, Instrumentation, Fluorescence Life 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-5: Electrochemical Analysis**

Non-faradic and faradic circuits; Electrode Processes – Diffusion controlled current under different initial conditions; Butler-Volmer equation and its Limiting Forms; Polarographic Techniques and Voltammetry and their various applications.

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**Course ID: CHEM-SI41**

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**Unit – 1: Chemical application of Group Theory**

Splitting of orbitals and free-ion terms in various environments; Correlation diagrams; Tanabe-Sugano diagrams; Metal centered spectral transitions (d-d and f-f) – selection rules, vibronic coupling, polarization, spectral parameters; Utilization of group theory in molecular orbital description; Charge transfer transitions.

**Unit – 2: Varieties of inorganic and metallo-organic systems**

Varieties of organic and inorganic ligands based on number and types of donor atoms, acyclic/cyclic nature, diamagnetic/paramagnetic property, σ/π-donor/acceptor aspect, strong-field/weak-field aspect, etc.); Metal ion specific ligands; Thermodynamic and kinetic aspects; Varieties and metal compounds; Geometries of the coordination environment; Design of ligands and metal compounds to get targeted properties (e.g. structural, magnetic, spectroscopic, electrochemical, catalytic, biomimetic, sensing, gas storage, superconducting, etc.); Uncertainties in predicting the composition and structure; Characterization and studies; Structure-property correlations; Important and path-breaking discoveries; Recent scenario and trends in national and international level.

**Unit – 3: Solid state chemistry**
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, 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- Schriffer) theory.

Unit – 4: Inorganic rings and clusters

Metal-metal bonding (MO approach), metal-metal single and multiple bonded compounds. Bonding in dimolybdenum and dirhenium complexes. Synthesis, structure, reactions and bonding as applicable in respect of molybdenum blue, tungsten blue, ruthenium blue, platinum blue, tungsten bronze, ruthenium red. Iso- and hetero-polyoxometalates of V, Mo and W: synthesis, structure, reactions and uses. Low nuclearity ($M_3, M_4$) and high nuclearity ($M_{9-10}$) 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.

Unit – 5: Chemistry of f block elements

Terrestrial abundance and distribution; relativistic effect, oxidation states; aqueous, redox and complex chemistry in different oxidation states as applicable. Preparations, isolation, purification, properties and reactivities of the lanthanide and actinide elements and variations within the lanthanide and actinide series; lanthanide and actinide contraction and consequences; separation of lanthanides and actinides. Lanthanide compounds as high temperature superconductor, NMR shift reagent and MRI reagent. Organometallic compounds of lanthanides.

Course ID: CHEM-SO41

Unit-I: Stereochemistry-II

Advanced course involving conformation and reactivity- acyclic system, bicyclic systems, tricyclic systems.
Chiroptical properties of organic molecules, CD, ORD-principles and applications, haloketone rules, sector rules. Chiral analysis by Polarimeter, NMR, GC, HPLC and

Unit-2: Asymmetric Synthesis

Enantio- and diastereoselective synthesis. Reactions of enolates (αα substitution), Addition to C=C double bonds (electrophile induced cyclisation, iodolactonisation, Conjugate additions. 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-II

Nomenclature of fused heterocycles. Reactivity and synthesis of pyrimidine, pyridazines, pyrazines, purines, pteridines with and without oxygen and/or sulfur atoms, and their role in biological systems. Introduction to the chemistry of seven-membered heterocyclic compounds: azepines, oxepines, thiepines and their aza-analogues.

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, Volhsrdt co-trimerisation,

functional organometallic compounds. Use of nontransition metal Indium, tin, zinc.

Unit-5: Medicinal Chemistry-I

Antibiotics – Penicillins, Cephalosporins, tetracyclins, newer generation of antibiotics. Chemistry of porphyrins

**Pharmacokinetics** - drug absorption, distribution, metabolism (Phase-I and Phase-II transformations), excretion, drug formulation and others.

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**COURSE ID: CHEM-SP41**

**Unit-1: Quantum Mechanics 2**


**Unit-2: Quantum Mechanics 3**


**Unit-3: Perturbation Theory**


**Unit-4: Quantum Chemistry 1**


**Unit-5: Quantum Chemistry 2**

Rudiments of Density Functional Theory: Expectation Value calculation using density: Kohn-Hohenberg Theorems; Kohn-Sham equation for the gound state of many body systems; Fermi and Coulomb holes; exchange correlation functional.

COURSE ID: CHEM-SA42

Unit-1: Fundamentals of Chemical Analysis


Classical methods of analysis: Gravimetry and titrimetry including neutralization, complexation and oxidation-reduction. Complex acid-base equilibrium. Separation of metal ions as their hydroxides, sulphides and chelates. Examples of gravimetric and complexometric 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: Liquid Chromatography and Other Types of Chromatography:

Reverse and normal phase chromatography, 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.

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.

Unit- 4: Kinetics in Analytical Chemistry & Thermal Analysis


Unit-5: NMR Spectroscopy

Spin resonance, g Values and resonance frequencies for different nuclei. Larmor precession, relaxation times, chemical shift, coupling constant. Simplification of complex spectra: shift reagents, double resonance, NOE, spin tickling. NMR of nuclei other than $^1$H (e.g. $^{13}$C, $^{31}$P, $^{19}$F, $^{29}$Si, $^{103}$Rh, $^{129}$Xe, $^{195}$Pt, $^{11}$B etc.). Integration and quantitative analysis. Spectra and Molecular Structure.

COURSE ID: CHEM-SI42

Unit – 1: Magnetochemistry

Definition of magnetic properties, types of magnetic bodies, experimental determination of magnetic susceptibility: Gouy method, Faraday method, vibrating sample magnetometer, SQUID, NR 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, Curie-Weise law, van Vleck equation and its application, Bleaney Bowers equation, first order and second order Zeeman effects, temperature independent paramagnetism, magnetic properties of transition metal complexes in cubic and axially symmetric crystal fields, low spin-high spin cross-over, magnetic behaviours of lanthanides and actinides, magnetic exchange interactions, Heisenberg-Dirac-van Vleck equation and its applications, magnetic materials.

Unit – 2: Crystallography
Crystal and lattice, process of crystallizations, crystal form, habit, defect, lattice planes, indices, crystal systems and symmetry, primitive and non-primitive lattice, diffraction of X-ray, Brag’s condition, reciprocal lattice, Brag’s law in reciprocal lattice, Ewald sphere, X-ray Crystallography Instrumentation, goniometer, geometric data collection, lunes, crystal mosaicity and beam divergence, completeness of data collection, crystal to detector distance vs resolution, atomic scattering factor, structure factor, intensity of diffracted beam, Friedel’s Law, systematic absences, temperature factor on the intensity of diffracted beam.

Unit – 3: Inorganic Reaction Mechanism

Introduction, Different types of reactions, Four broad classes of mechanism of substitution—“D”, “A”, “I,” and “I,“; Mechanism of substitution reactions in square planar, tetrahedral and octahedral geometries with special reference to d⁰ ion complexes; Solvent exchange, aquation, anation, base hydrolysis, acid catalyzed aquation; Mechanism of isomerization reaction—linkage isomerism, cis-trans isomerisms, intermolecular and intramolecular recimization; trans and cis effect and trans influence; Mechanism of electron transfer reactions: outer sphere and inner sphere reactions.

Unit – 4: Supramolecular chemistry of inorganic molecules

Terrestrial abundance and distribution; relativistic effect, oxidation states; aqueous, redox and complex chemistry in different oxidation states as applicable. Preparations, isolation, purification, properties and reactivities of the lanthanide and actinide elements and variations within the lanthanide and actinide series; lanthanide and actinide contraction and consequences; separation of lanthanides and actinides. Lanthanide compounds as high temperature superconductor, NMR shift reagent and MRI reagent. Organometallic compounds of lanthanides.

Unit – 5: Selected topics on the chemistry of d block elements

Electronic configuration, common and unusual oxidation states, aqueous, redox and coordination chemistry of 3d, 4d and 5d elements. Conformational changes and thermochromism of Ni(II), Co(II) and other recently reported compounds. Mixed valence compounds of Fe, Cu, Pt, Fe-S compounds. Dinitrogen and dioxygen complexes of transition metals, Crutz-Taube complex, Vaska’s complex.

Course ID: CHEM-SO42

Unit-1: NMR Spectroscopy-II
NMR shift reagents and their applications, basic two-dimensional sequence.

Application of $^1$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, MRI as a diagnostic tool.

**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 -II**

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


COURSE ID: CHEM-SP42

Unit-1: Kinetics 2

Rate processes and some physical phenomena. Statistical approach to rate theory: Hinshelwood, RRK and RRKM theories.

Unit-2: FT-NMR Spectroscopy

Introduction to pulsed-FT-NMR. Product-operator formalism of 1D and 2D NMR. Determination of three-dimensional structure of molecules using NMR spectroscopy.

Unit-3: Statistical Mechanics 1

Phase space, ergodic hypothesis, Liouville’s theorem, Concepts of different ensembles with applications to selective systems. Fluctuations. Prefect gas and the Sackur-Tetrode equation, System of interacting molecules, treatment of imperfect gases.

Unit-4: 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-5: Mathematical concepts


COURSE ID: CHEM-SA43

Unit-1: Nuclear Models & 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-2: Bioanalytical Methods & 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.

Serology and DNA fingerprinting, 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

Characteristics of the atmosphere, radiation balance in the atmosphere, contribution of trace gases to Green House Effect. Atmospheric stability and meteorology. Gas phase atmospheric chemistry of N, S and volatile organic compounds, Photochemical smog and Acid rain. Particles in the

**Unit-4: Environmental Chemistry of Hydrosphere & Lithosphere**


**Unit-5: Materials chemistry and nanochemistry**

Classification of materials, semiconducting materials, organic soft materials, ceramics, composites, material characterization techniques, correlation between materials structure and their properties, structure and properties of technologically important crystalline and amorphous materials, recent breakthroughs in materials chemistry, synthesis and characterization of nanomaterials, properties and applications of nanomaterials.

**COURSE ID: CHEM-SI43**

**Unit – 1: Advanced Inorganic Spectroscopy**


**Unit – 2: Bioinorganic chemistry -2**

proteins in biology. Metalloproteins catalysing oxygen atom transfer reaction: iron containing enzymes such as methane monooxygenase, nitric oxide reductase; Molybdenum containing enzymes such as xanthane, sulphite oxidase and nitrate, trimethylamine-N-oxide, DMSO reductase. Other selected metalloproteins of various metal ions. Structure/function analogue of above mentioned systems.

Unit – 3: Organometallic chemistry – 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: Sensing of Analytes

Preamble, Jablonski diagram, photoexcitation, fluorescence, phosphorescence, photosensitization, quenching, charge and energy transfer, substitution, fragmentation, isomerisation, exchange and redox reactions; chemiluminescence, photochromism; determination of quantum yield, inorganic photochemistry in biological processes and their model studies; applications of photochemical reactions of coordination compounds - synthesis and catalysis, solar energy conversion and storage, sensing of biologically relevant cations and anions: chemosensors and chemodosimeters.

Unit – 5: Materials chemistry and Nanochemistry

Classification of materials, semiconducting materials, organic soft materials, ceramics, composites, material characterization techniques, correlation between materials structure and their properties, structure and properties of technologically important crystalline and amorphous materials, recent breakthroughs in materials chemistry, synthesis and characterization of nanomaterials, properties and applications of nanomaterials.
Unit-1: Nanoscience and Organic Electronics

Basic concept on nanoparticles, quantum dot and nanocluster, surface atom effect, quantum size effect, non-metal 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 and Supramolecular 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.

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.

Unit-3: Nucleoside & 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: Advanced Organic Synthesis

Key Ring Forming Reactions: Robinson Annulation, Intramolecular Nucleophilic Alkylation, Intramolecular Michael Reaction, Cation-Olefin Cyclization, Anionic Cyclization, Nazarov Cyclization, Divinylcyclopropane Rearrangement, Oxy-Ene Reaction (Conia Reaction), Cyclopentanone Annulation Methodology, Pauson-Khand Reaction, Carbonylation Cyclization, Olefin Ring Closing Metathesis.

COURSE ID: CHEM-SP43

Unit-1: Solids

Reciprocal lattice, Structure factor, Fourier synthesis, Band theory, band gap, metals and semiconductors –intrinsic and extrinsic semiconductors, superconductors.

Unit-2: Group Theory 2

MO theory with applications to $\sigma$ and $\sigma^*$ 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: Quantum Mechanics 4

Unit-4: Principle of Lasers and its applications


Unit-5: Theoretical Spectroscopy

Selection rule for vibrational spectra, anharmonic correction by perturbation - appearance of overtones, selection rule for rotational spectra, nuclear spin and energy levels, Stark effect, Raman scattering, selection rule for rotation-vibrational Raman effect. Nonlinear scattering- hyper –Raman, Stimulated and Resonance Raman spectra.

SUGGESTED BOOKS for SEMESTERS III & IV

COURSE ID: CHEM-G31, CBCS, 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(Vil-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
Chemical Separation Methods – J. A. Dean
Solvents Extraction of chelates – Morrison and Freiser
Practical Clinical Biochemistry – A. H. Gowanlock
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 the Basic Modes and Advanced Applications, Greg Haugstad
Confocal Microscopy Methods and Protocols, Ed.: Stephen W. Paddock
Fundamentals of Light Microscopy and Electronic Imaging, Douglas B. Murphy
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. Buxbaun
Introduction to Materials Chemistry by Harry R. Alcock, John Wiley and Sons
Materials Chemistry by Bradley D. Fahlman, Springer.
Nanomaterials and Nanochemistry by Catherine Brechignac and Philippe Houdy, Springer.
Nanochemistry by Kenneth Klabunde Gleb Sergeev, Elsevier.

COURSE ID: CHEM-G31, CBCS, CHEM-SI41, CHEM-SI42, CHEM-SI43
Chemical Application of Group Theory – F. A. Cotton Group Theory
and chemistry – D. M. Bishop

Electron Paramagnetic Resonance – Elementary Theory and
Practical Applications – John A. Weil, James R. Bolton & John E. Wertz
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

Symmetry in Molecules – J. M. Hollar


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 – Kolthoff 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


Magnetochemistry – A. Selwood

Introduction to Magnetochemistry – Earnshaw

Physical Methods in Inorganic Chemistry – R. S. Drago


Concepts of Inorganic Photochemistry – A. W. Adamson & P. D. Fleishauer


Bioinorganic Chemistry – R. W. Hay

Introduction to Bioinorganic Chemistry – D. R. Williams

General Principles of Biochemistry of Elements – E. I. Ochiai

Inorganic Aspects of biological and Organic Chemistry – R. P. Hanzlik

Principles of Bioinorganic Chemistry – S. J. Lippard, J. M. Berg

Inorganic Chemistry of Biological Process – M. N. Hughes

An Introduction to Bioinorganic Chemistry – R. J. P. Williams


Organo Transition metal Chemistry – S. G. Davies

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


G. W. Parshall Heterogeneous Catalysis


Homogeneous Catalysis - G. W. Parshall and S. D. Ittel

Applied Homogeneous Catalysis with Organometallic Compounds – B. Cornils & W. A. Herrmann


Crystal Structure Analysis for Chemists and Biologists, Jenny P. Glusker with Michell Lewis
Miriam Rossi

Crystal Structure Analysis for Chemists and Biologists - Jenny P. Glusker, Mitchell Lewis, Miriam Rossi

Crystal & X-ray – K. Lansdale

Crystal Structure Analysis – M. J. Buerger

X-ray Crystal Structure – D. Melachian

Elements of X-ray Crystallography – Azaroff

Advance Inorganic Chemistry - F. A. Cotton & G. Wilkinson

Chemistry of Elements – N. N. Greenwood & Earnshaw

Inorganic Chemistry – Catherine E. Housecroft and A. G. Sharpe


COURSE ID: CHEM-G31, CBCS, 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.


Hammett 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 Spectrometry - 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; Academic Press.

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.


Surface and Nanomolecular Catalysis – R. Richards

The Nanoscope Encycloprdia of Nanoscience & Nanotechnology, Vol-I to VI; Diwan P. & Bharadwaj, A.

Microwave Assisted Synthesis of heterocycles – R. R. Gupta; V. E. Eric & Kappe, C.

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-SO31**


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.


**COURSE ID: CHEM-G31, CBCS, CHEM-SP41, CHEM-SP42, CHEM-SP43**

Introduction to Quantum Mechanics- D. J. Griffiths

Quantum Mechanics- J.L.Powell, B. Crasemann

Molecular Quantum Mechanics- P.W.Atkins

The Feynman Lecturers in Physics, Vol. 3- R. P. Feynman, R.B. Leighton, M. Sands

Modern Quantum Chemistry- A. Szabo, S. N. Ostlund

Elementary Quantum Chemistry- F. L. Pilar
Quantum Chemistry- I. N. Levine

Coulson's Valence- R. McWeeny

Chemical Application of Group Theory- F. A. Cotton

Group theory and chemistry- D. M. Bishop

Thermodynamics and introduction to Thermostatics- H. B. Callen

Element 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

Fundamentals of Molecular Spectroscopy – C.W. Banwell

Fundamentals of Molecular Spectroscopy – G.M. Barrow

Molecular spectroscopy- I. N. Levine

Molecular Spectroscopy – J. D. Graybeal

Principle of Fluorescence Spectroscopy- J. R. Lakowicz

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

Laser Spectroscopy – W. Demtroder

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

Advanced Engineering Mathematics – E. Kreyszig

Mathematical Methods in the Physical Sciences – M.L. Boas

**COURSE ID: CHEM-SP31**

Programming with Fortran – S. Lepschutz, A. Poe

UNIT-I

Environmental Chemistry (10 marks, 10 lecture-hours)

Environmental Hazards and Green Chemistry
Environmental Hazards and Pollution (their sources and remedies),
Green Chemistry-definition, need for Green Chemistry, limitations in the
pursuit of Green Chemistry, basic principles, Applications of Green Chemistry
to Chemical Synthesis.

UNIT-II

Organometallic Chemistry and Catalyses (10 marks, 10 lecture hours)

(c) Organometallic Chemistry

Definition of organometallic compounds. Brief history. Concept of hapticity of
organic ligands. 18-electron and 16-electron rules. Applications of 18-electron
rule to metal carbonyls. General methods of preparation of mono and
binuclear carbonyls of 3d series. Structures of mononuclear and binuclear
carbonyls. pi-acceptor behaviour of CO, synergic effect and use of IR data to
explain extent of back bonding. Reactions of organometallic complexes:
substitution, oxidative addition, reductive elimination and insertion reactions.

(d) Catalysis by Organometallic Compounds

Definition and importance of catalyst with special emphasis on Organometallic
catalysts. Use of Organometallic catalysts with reference to industrially
important processes.

UNIT-III

Absorption and Emission spectroscopy (10 marks, 10 lecture hours)
Basic principle, instrumentation and application of absorption and emission spectroscopy (atomic and molecular): Fundamental Laws of photometry, Limitation of absorption and emission measurement, Photometric titration, Fluorescence quenching (Static and Dynamic), Time resolved measurement, Qualitative and quantitative analysis.

UNIT-IV

Nanoscience (10 marks, 10 lecture hours)

Introduction to nanoworld, Fundamental theories of nanoparticles (NPs), 0D, 1D and 2D nanoparticles and their physical, optical, electronic, magnetic properties, Methods of fabrication of metal organic and composite NPs, Application of NPs, nanoelectronics and devices.

UNIT-V

Analytical Methods (10 marks, 10 lecture hours)

Basic Principles and Applications:

Optical spectroscopy for chemical analysis, Atomic Absorption Spectrometry, Radiochemical Analysis, Electrochemical Analysis: Voltammetry, Thermogravimetric Analysis

REFERENCE BOOKS:

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