Course structure for 2-Year P.G. program under NEP 2020

[w.e.f. ACADEMIC SESSION 2026-27]

Chemistry

Course structure for 2-Year P.G. program under NEP 2020 [w.e.f. ACADEMIC SESSION 2026-27] Chemistry M.Sc. First Year (I Semester)			
Course Category	**Course Name**	**Credits**	**MM**
DSC - 1 (Theory)	Inorganic Chemistry-I	3	100
DSC - 1 (Practical)	Laboratory Course Inorganic-I	2	100
DSC - 2 (Theory)	Organic Chemistry-I	3	100
DSC - 2 (Practical)	Laboratory Course Organic-I	2	100
DSC - 3 (Theory)	Physical Chemistry-I	3	100
DSC - 3 (Practical)	Laboratory Course Physical-I	2	100
SEC - 1	Group Theory & Spectroscopy	5	100
DSE - 1 (Theory) (Choice No. 1)	Instrumental Chemistry for Chemical Analysis	4	100
DSE - 1 (Theory) (Choice No. 2)	Industrial Chemistry		
	Total Credits	**24**	
AEC (Non-CGPA Course)	Indian Knowledge System	1	100
Important Note: The students will opt for only one paper out of two choices for DSE - 1 (Theory) papers in M.Sc. First Year (I Semester).			

Course structure for 2-Year P.G. program under NEP 2020 [w.e.f. ACADEMIC SESSION 2026-27] Chemistry M.Sc. First Year (II Semester)			
Course Category	**Course Name**	**Credits**	**MM**
DSC - 4 (Theory)	Inorganic Chemistry-II	3	100
DSC - 4 (Practical)	Laboratory Course Inorganic-II	2	100
DSC - 5 (Theory)	Organic Chemistry-II	3	100
DSC - 5 (Practical)	Laboratory Course Organic-II	2	100
DSC - 6 (Theory)	Physical Chemistry-II	3	100
DSC - 6 (Practical)	Laboratory Course Physical-II	2	100
SEC-2	Separation Methods and Spectroscopy	5	100
DSE - 2 (Theory) (Choice No. 1)	Chemical Transformations and Coupling Strategies	4	100
DSE - 2 (Theory) (Choice No. 2)	Chemistry of Materials		
	Total Credits	**24**	
AEC (Non-CGPA Course)	Constitutional, ethical, and moral values	1	100
Important Note: The students will opt for only one paper out of two choices for DSE - 1 (Theory) papers in M.Sc. First Year (II Semester).			

M.Sc. First Year

First Semester

Chemistry Syllabus

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSC - 1 (Theory)
Paper Name: Inorganic Chemistry-I

Credits: 03
Theory: 45 Hours

Unit I. Stereochemistry and Bonding in Main Group Compounds (10 Hours)

VSEPR model and its shortcomings. Hybridization and three-centre bonds. Bents rule and energetics of hybridization. Hybrid orbitals as Linear Combinations of Atomic Orbitals with a selected example. MO diagram of heteronuclear di-/tri-atomic molecules (NO, CO, HF, CO_2, BeH_2, H_2O), Walsh's diagrams for tri and tetra-atomic molecules. pπ-pπ and pπ-dπ bonding.

Unit II. Metal-Ligand Equilibria in Solution (10 Hours)

Thermodynamic and kinetic stability of complexes. Stepwise and overall formation constants and their interaction. Trends in K value. Irving-Willams series. Chelate effect and its thermodynamic origin. Factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand. Detection of complexes in solution. Determination of binary formation constants by pH-metry and spectrophotometric method.

Unit III. Reaction Mechanism of Transition Metal Complexes (15 Hours)

Energy profile of a reaction and reactivity of metal complexes. Inert and labile complexes. Ligand substitution reactions in octahedral complexes i.e., SN^1, SN^2, and SN^1CB mechanism. Anation reactions without metal ligand bond cleavage. Electron transfer reactions (Redox reactions). Outer and inner sphere mechanism (OSM and ISM). Reactions of coordinated ligands. Substitution reactions in square-planer complexes.

Unit IV. Theories of Coordination Compounds (10 Hours)

Crystal field theory, factors affecting the magnitude of Δ_0. Consequences of crystal field splitting. Merits and limitations of CFT Jahn-Teller distortion and its consequences on complex formation. Evidence of covalent character in Metal-Ligand bonding. Molecular orbital theory as applied to octahedral, tetrahedral and square planar complexes.

Books suggested:

1. Advanced Inorganic Chemistry Vth Ed., F.A. Cotton and G. Wilkinson, John Wiley, (1988).
2. Advanced Inorganic Chemistry VIth Ed., F.A. Cotton, G Wilkinson, C.A. Murillo and M. Bochmann, John Wiley, (1999).
3. Inorganic Chemistry, J.E. House, Academic Press, (2008)
4. Coordination Chemistry, IIIrd Ed., D Banerjea, Asian Book Pt. ltd., (2009)
5. Inorganic Chemistry, 3th Ed., G L Miessler and D.A. Tarr, Pearson Education, Inc. (2004)
6. Concise Inorganic Chemistry, J. D. Lee, 5th Ed., Chapman & Hall (1996).
7. Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
8. Inorganic Chemistry, 3rd Ed., Alan G. Sharpe, Addison-Wesley (1992).
9. Inorganic Chemistry, 4th Ed., J.E. Huheey, Harper & Row (2000).
10. Chemistry of the Elements, 2nd Ed., N.N. Greenwood and A. Earnshaw, Butterworth. Heinemann (1997).

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSC - 1 (Practical)
Paper Name: Laboratory Course Inorganic-I

Credits: 02
Practical: 60 Hours

Qualitative Analysis
Qualitative analysis of mixtures by semi-micro methods containing not more than six cations and anions.

Chromatography
Separation of cations and anions by-
Paper Chromatography
Thin Layer Chromatography
Ion Exchange Chromatography

References

1. Vogel's Qualitative Inorganic Analysis (7th Edition) by G. Svehla (Pearson)
2. Inorganic Semi-Micro Qualitative Analysis by Lap Lambert Academic Publishing (2025)
3. Vogel – A Textbook of Quantitative Inorganic Analysis – Longman
4. Kolthoff & Sandell - Textbook of Qualitative Inorganic Analysis
5. Techniques and Practice of Chromatography by Raymond P.W. Scott; Publisher : CRC Press.

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSC - 2 (Theory)
Paper Name: Organic Chemistry-I

Credits: 03
Theory: 45 Hours

Unit I. Nature of Bonding in Organic Molecules (10 Hours)

Hyperconjugation, bonding in fullerenes, tautomerism. Aromaticity in benzenoid and non-benzenoid compounds, alternant and non-alternant hydrocarbons. Huckel's rule, energy level of π-molecular orbitals, annulenes, antiaromaticity, homo-aromaticity, PMO approach. Bonds weaker than covalent bonds. Inclusion compounds.

Unit II. Stereochemistry (10 Hours)

Concept of chirality, R/S nomenclature, enantiotopic and diastereotopic atoms, groups and faces, optical purity, stereospecific and stereoselective synthesis. Asymmetric synthesis, chirality due to helical shape. Conformational analysis of cycloalkane, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding, Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Unit III. Reaction Mechanism: Structure and Reactivity (10 Hours)

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Effect of structure on reactivity – resonance and field effects, steric effect, quantitative treatments. Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

Unit IV. Aliphatic Nucleophilic Substitution (10 Hours)

SN1, SN2 and mixed SN1 and SN2 mechanism. The neighbouring group mechanism, neighbouring group participation (by π- and σ bonds). Anchimeric assistance. SN1 mechanism-Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon. Reactivity effects of substrate structure, attacking nucleophilic group, leaving group and reaction medium, ambident nucleophile.

Unit V. Aliphatic Electrophilic Substitution (5 Hours)

Bimolecular mechanism- SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shift. Effect of substrates, leaving group and the solvent polarity on the reactivity.

Books suggested:

1. Advanced Organic Chemistry, Reaction Mechanism & Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, Carey and Sundberg, Springer Verlag, Germany.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, Boyd and Morrison, Prentice Hall of India.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, Norman and Coxon, Blackwell.
8. Reaction Mechanism in Organic Chemistry, Mukherji and Singh, Macmillan.
9. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
10. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSC - 2 (Practical)
Paper Name: Laboratory Course Organic-I

Credits: 02
Practical: 60 Hours

- Identification of organic compounds in binary mixture (solid and solid or liquid and solid) using Chemical tests or Chromatographic techniques TLC, Paper Chromatography, and spectroscopic analysis.
- Synthesis of phthalimide (Nucleophilic substitution reaction)
- Synthesis of Aspirin (Friel-Craft acylation reaction)
- Preparation of hydrazone from carbonyl compounds.
- Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
- Reduction of carbonyl compounds using $NaBH_4$.

Books suggested:

1. Vogel's Text Book of Qualitative Analysis, ELBS
2. Vogel's Text Book of Quantitative Analysis, ELBS
3. Vogel's-Textbook-of-Practical-Organic-Chemistry
4. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York
5. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston
6. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington
7. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSC - 3 (Theory)
Paper Name: Physical Chemistry-I

Credits: 03
Theory: 45 Hours

Unit I. Quantum Chemistry: Introduction to Exact Quantum Mechanics (8 Hours)
The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems, viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

Unit II. Quantum Chemistry: Angular Momentum (7 Hours)
Ordinary angular momentum, generalised angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

Unit III. Quantum Chemistry: Electronic Structure of Atoms (10 Hours)
Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the pπ configuration, term separation energies for the dπ configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self-consistent field, the virial theorem.

Unit IV. Thermodynamics: Classical Thermodynamics (10 Hours)
Brief resume of concepts of thermodynamics law, free energy, chemical potential and entropy. Partial molar properties: partial molar free energy, partial molar volume and partial molar heat content and their significance.
Concept of fugacity and determination of fugacity. Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient. Debye-Hückel theory for the activity coefficient of electrolyte solutions: determination of activity and activity coefficients, ionic strength.

Unit V. Surface Chemistry: Adsorption (10 Hours)
Adsorption by solids, Types of adsorption isotherms. Single-layer adsorption -Langmuir adsorption isotherm and its derivation. Multilayer adsorption B.E.T. theory and its kinetic derivation. Application of the B.E.T. theory in the determination of the surface area of the solid. catalytic activities at surfaces.

Books suggested:

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw-Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice Hall.
4. Coulson's Valence, R. McWeeny, ELBS.
5. An Introduction to Chemical Thermodynamics, R.P. Rastogi and R.R. Misra, Vikas Publication.
6. Thermodynamics for Chemists, S. Glasstone, Affiliated East-West Press.
7. Principles Of Physical Chemistry, Puri. Sharma. Pathania, Vishal Publishing Co.

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSC - 3 (Practical)
Paper Name: Laboratory Course Physical-I

Credits: 02
Practical: 60 Hours

- Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.
- Determination of the strength of strong and weak acids in a given mixture conductometrically.
- Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.
- Determination of the velocity constant of hydrolysis of an ester.
- Determination of the effect of (a) Change of temperature (b) Change of concentration of reactants and catalyst and (c) ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reaction.
- Estimation of halide in mixture using potentiometry.
- Determination of the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid using pH metry.
- Determination of specific rotation for optically active substances by Polarimeter.

Books suggested:

1. Practical Physical Chemistry, A. Findary, T.A. kitchner (Longmans, Green and Co.)
2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.r. Denko. R.M.W. richett (Pergamon Press).
3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.)
4. Advanced Practical Physical Chemistry, J.B Yadav (Krishna Prakashan Media Pvt. Ltd)
5. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.
6. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.
7. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
8. Findley's Practical Physical Chemistry, B.P. Lavitt, Longman
9. Systematic experimental Physical Chemistry, T.K. Chandershekhar & S.K. Rajbhoj
10. Experimental Physical Chemistry, V.D.Athawale and Parul Mathur, New Age International
11. Practical Physical Chemistry, B.P. Levitt and Zindley's, Longman.
12. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill.

M.Sc. First Year (I Semester)
M.Sc. Chemistry
SEC - 1 (Theory)
Paper Name: Group Theory & Spectroscopy

Credits: 05
Theory: 75 Hours

Unit I. Symmetry and Group Theory in Chemistry (20 Hours)

Symmetry elements and symmetry operations, definitions of group, subgroup, relation between orders of a finite group and its subgroups, conjugacy relation and classes. Point symmetry group, Schonflies symbols, representations of groups by matrices (representation for the Cn, Cnv, Cnh, Dnh, etc. group to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use in spectroscopy.

Unit II. Unifying Principles (15 Hours)

Electromagnetic radiation. Interaction of electromagnetic radiation with matter. Absorption, emission, transmission, reflection, refraction, dispersion, polarization, and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, result of the time dependent perturbation theory, transition moment, selection rules, intensity of special lines, Born-Oppenheimer approximation, rotational, and electronic energy levels.

Unit III. Atomic Electronic Spectroscopy (05 Hours)

Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

Unit IV. Microwave Spectroscopy (10 Hours)

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor, Stark effect, nuclear and electron spin interaction and effect of external field. Applications.

Unit V. Infrared Spectroscopy (20 Hours)

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, Zero-point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, vibration-rotation spectroscopy; P, Q, R branches. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region, metal-ligand vibrations.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
3. Chemical Applications of Group Theory, F.A. Cotton.
4. Introduction of Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Symmetry and Spectroscopy of Molecules, K. Veera Reddy, New Age International.

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSE - 1 (Theory)
Choice No.: 01
Paper Name: Instrumental Chemistry for Chemical Analysis

Credits: 04
Theory: 60 Hours

Unit I. Chemical Analysis (15 Hours)

Principles of measuring and analysing chemical substances. Sampling methods and the importance of proper sampling. Preparing samples for analysis, including crushing, grinding, drying, and dissolving. Classical and Instrumental methods.

Unit II. Thermal Methods of Analysis (10 Hours)

Principle, instrumentation and application: Thermogravimetry [TG], Differential thermal analysis [DTA], Differential Scanning calorimetry [DSC], Thermomechanical analysis [TMA], Thermometric titrations.

Unit III. Electrogravimetry (05 Hours)

Important terms used in electro-gravimetric methods, overpotential, electro-gravimetric methods, Instrumentation, electrolysis using a mercury cathode, spontaneous electrolysis, electrography.

Unit IV. Coulometry (10 Hours)

Principle of coulometry, coulometric techniques, coulometer, coulometric titrations, coulometric determinations, advantages, instrumentation for coulometric titrators, applications, different types of coulometry.

Unit V. Polarography (05 Hours)

Principles, Factors affecting polarographic wave, pulse polarography, and differential pulse polarograph,

Unit VI. Voltammetry (15 Hours)

Voltametric principles, Hydrodynamic voltammetry, Stripping voltammetry, Cyclic voltammetry, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes, qualitative and quantitative analysis by these techniques.

Books suggested:

1. Introduction to instrumental analysis. R. D. Braun (1987).
2. Handbook of Atomic Absorption & Fluorescence Spectrometry by Michael Sargent & Gordan Kirkbright, Viridian Publishing.
3. Instrumental methods of chemical analysis, H. H. Willard, L. L. Merrit Jr., J. A. Dean and F. A. Settle, 6th Ed (1986).
4. Encyclopaedia of Analytical Chemistry (1995).
5. Fundamentals of Analytical Chemistry", D. A. Skoog and D. M. West, 4th Ed., CBS College Publishing, New York, Chapt. 1, pp 12–13, (1982).

M.Sc. First Year (I Semester)
M.Sc. Chemistry
DSE - 1 (Theory)
Choice No.: 02
Paper Name: Industrial Chemistry

Credits: 04
Theory: 60 Hours

Unit I. Silicate Industries **(20 Hours)**

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armored glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass. Ceramics: Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fiber. Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Unit II. Fertilizers **(05 Hours)**

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

Unit III. Surface Coatings **(20 Hours)**

Objectives of coating surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

Unit IV. Batteries **(05 Hours)**

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cells, and polymer cells.

Unit V. Alloys **(10 Hours)**

Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements in alloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorization) and surface treatment (argon treatment, heat treatment, nitriding, and carburizing). Composition and properties of different types of steels.

Books Suggested:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley
3. Publishers, New Delhi.
4. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley
5. Publishers, New Delhi.
6. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
7. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.

M.Sc. First Year

Second Semester

Chemistry Syllabus

Course structure for 2-Year P.G. program under NEP 2020 [w.e.f. ACADEMIC SESSION 2026-27] Chemistry M.Sc. First Year (II Semester)			
Course Category	**Course Name**	**Credits**	**MM**
DSC - 4 (Theory)	Inorganic Chemistry-II	3	100
DSC - 4 (Practical)	Laboratory Course Inorganic-II	2	100
DSC - 5 (Theory)	Organic Chemistry-II	3	100
DSC - 5 (Practical)	Laboratory Course Organic-II	2	100
DSC - 6 (Theory)	Physical Chemistry-II	3	100
DSC - 6 (Practical)	Laboratory Course Physical-II	2	100
SEC-2	Separation Methods and Spectroscopy	5	100
DSE - 2 (Theory) (Choice No. 1)	Chemical Transformations and Coupling Strategies	4	100
DSE - 2 (Theory) (Choice No. 2)	Chemistry of Materials		
	Total Credits	**24**	
AEC (Non-CGPA Course)	Constitutional, ethical, and moral values	1	100
Important Note: The students will opt for only one paper out of two choices for DSE - 1 (Theory) papers in M.Sc. First Year (II Semester).			

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSC - 4 (Theory)
Paper Name: Inorganic Chemistry-II

Credits – 03
Theory: 45 Hours

Unit I. Electronic and Magnetic Properties of Transition Metal Complexes (15 Hours)

Types of absorption spectra. Spectral terms. Russell-Saunders states. Selection rules for electronic transitions in complexes. Width of absorption spectral bands, Terms generated in ligand fields. Orgel and Tanabe-Sugano correlation diagrams for d1 to d9 states. Racah parameters. Charge transfer spectra. Magnetic moments, magnetic exchange coupling and spin crossover.

Unit II. Metal-π-Complexes and organometallic Compounds (15 Hours)

Metal carbonyl complexes. Preparation, properties and uses. Nature of bonding in metal carbonyls and carbon monoxide analogs i.e. nitrosyls and dinitrogen complexes. Evidence for back bonding in complexes. Nature of M-C bond Synthesis, bonding and uses of organometallic compounds, two-electron ligands (olefinic and acetylenic complexes), three electron ligands (allylic complexes), four electron ligand (butadiene and cyclobutadiene complexes), five-electron ligands (ferrocene complexes).

Unit III. Metal Clusters (10 Hours)

Polyhedral boranes and boran anions. Synthesis, reactivity, bonding and topology of boranes. Wade's rules. Carboranes, metalloboranes and metallocarboranes. Metal carbonyls and halides as clusters. Metal carbonyl hydrides.

Unit IV. Emerging Inorganic Materials (05 Hours)

Principles of silicates. Structure and classification of silicates. Asbestos, Zeolites and Ultramarines as silicate materials. Silicates in technology. Structure and bonding of poly-oxo metallates of Ru, Os, and Mo containing π-acceptor ligands, Metal Organic Frameworks (MOFs).

Books suggested:

1. Advanced Inorganic Chemistry Vth Ed., F.A. Cotton and G. Wilkinson, John Wiley, (1988).
2. Advanced Inorganic Chemistry VIth Ed., F.A. Cotton, G Wilkinson, C.A. Murillo and M. Bochmann, John Wiley, (1999).
3. Inorganic Chemistry, J.E.House, Academic Press, (2008)
4. Inorganic chemistry, A Unified Approach, W W. Porterfield, Academic Press, (1993).
5. Coordination Chemistry, IIIrd Ed., D Banerjea, Asian Book Pt. ltd.,(2009)
6. Inorganic Chemistry, 3th Ed., G L Miessler and D.A.Tarr, Pearson Education,Inc. (2004)
7. Concise Inorganic Chemistry, J.D. Lee, 5th Ed., Chapman & Hall (1996).
8. Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
9. Inorganic Chemistry, 3rd Ed., Alan G. Sharpe, Addison-Wesley (1992).
10. Inorganic Chemistry, 4th Ed., J.E. Huheey, Harper & Row (2000).
11. Chemistry of the Elements, Greenwood and Earnshaw, Butterworth Heinemann (1997).
12. Inorganic Electronic Spectroscopy, 2nd Ed., A.B.P. Lever, Elsevier (1986).
13. Comprehensive Coordination Chemistry Eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon (1987).

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSC - 4 (Practical)
Paper Name: Laboratory Course Inorganic-II

Credits: 02
Practical: 60 Hours

Quantitative Analysis

Quantitative Analysis of mixtures of two metal ions involving Volumetric (by complexometric titration using masking and demasking agents) and gravimetric analysis.

Preparations of Inorganic complexes

Preparation of selected inorganic complexes:

$VO(acac)_2$

cis-$K[C(C_2O_4)_2\ (H_2O)_2]$

$Na[Cr(NH_3)_2(SCN)_4]$

$Mn(acac)_3$

$K_3[Fe(C_2O_4)_3]\ 3H_2O$

Prussian Blue, Tumbull's Blue

$Co[(NH_3)_6]Cl_3$

$[Cu(en)_2(H_2O)_2]I_2$

Cu_2HgI_4

$[Co(Py)_2Cl_2]$

$[Ni\ (NH_3)_6]Cl_2$

Tris-(thiourea) copper (I) sulphate $[Cu\ (tu)_3]SO_4.2H_2O$

$K_3[Cr(C_2O_4)_3]$

References

1. Vogel – A Textbook of Quantitative Inorganic Analysis – Longman
2. G. Schwarzen Back ―Complexometric Titration‖ Interscience.
3. Practical Inorganic Chemistry: Preparations, reactions and instrumental methods by G. Pass and H. Sutcliffe.
4. Practical Inorganic Chemistry, by Shikha Gulati, JL Sharma, Shagun Manocha, Cbs Publishers and Distributors Pvt Ltd.

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSC - 5 (Theory)
Paper Name: Organic Chemistry-II

Credits: 03
Theory: 45 Hours

Unit I. Aromatic Electrophilic Substitution (05 Hours)

Orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrate and electrophiles. Diazonium coupling, Vilsmeir Haak reaction, Gattermann-Koch reaction.

Unit II. Aromatic Nucleophilic Substitution (05 Hours)

The SNAr, SN1, benzyne and SRN1 mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleophile. The von Rictor, Sommelet-Hauser, and Smiles rearrangements.

Unit III. Free Radical Reactions (10 Hours)

Types of free radical reactions, free radical substitution mechanism, mechanism of an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity. Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

Unit IV. Addition to Carbon-Carbon Multiple Bonds (5 Hours)

Mechanism and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

Unit V. Addition to Carbon-Hetero Multiple Bonds (5 Hours)

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Wittig reaction. Mechanism of condensation reactions involving enolates- Knoevenagel, Claisen, Mannich Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

Unit VI. Elimination Reactions (05 Hours)

Elimination reactions E2, E1 and Ei mechanisms and their stereochemistry. Orientation of the double bond. Reactivity- effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination.

Unit VII. Pericyclic Reactions (10 Hours)

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann. Correlation diagrams. FMO and PMO approach. Electrocyclic reactions-conrotatory and suprafacial additions, 4n, and 4n+2 systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1, 3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements- suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5- sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements. Fluxional tautomerism. Ene reaction.

Books suggested:

1. Advanced Organic Chemistry- Reaction, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackwell.
8. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.
10. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
11. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSC - 5 (Practical)
Paper Name: Laboratory Course Organic-II

Credits – 02
Practical: 60 Hours

- Aromatic electrophilic Substitutions: Friedel-Crafts reaction (acylation and alkylation).
- Cannizzaro reaction: Benzaldehyde or substituted benzaldehyde as substrate.
- Acetoacetic ester Condensation: Synthesis of ethyl-n-butylacetoacetate by A.E.E. condensation.
- Preparation of derivatives. Oxime, 2,4 – DNP, acetyl, benzoyl, semicarbazide and aryloxyacetic acid, Anilide, Amide.
- The above products may be characterized by Spectral Techniques where possible.
- Synthesis of 7-hydroxy-4-methyl coumarine (Pechmann reaction)
- Synthesis of 1,2,3,4-tetrahydrocarbazole (Fisher-Indole synthesis)
- Synthesis of Hippuric acid (Schotten-Bouman reaction)
- Synthesis of Anthracene-maleic anhydride adduct (Diles-Alder reaction)

Book Suggested:

- Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
- Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
- Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSC - 6 (Theory)
Paper Name: Physical Chemistry-II

Credits: 03
Theory: 45 Hours

Unit I. Chemical Dynamics (12 Hours)

Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions. Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction), homogeneous catalysis, kinetics of enzyme reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method. Dynamics of molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions).

Unit II. Statistical Thermodynamics (11 Hours)

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws- (using Lagrange's method of undetermined multipliers). Partition functions: translational, rotational, vibrational, and electronic. Calculation of thermodynamic properties in terms of partition functions. Applications of partition functions. Heat capacity behaviour of solids- chemical equilibria and chemical equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metals. Bose-Einstein statistics – distribution law and application to helium.

Unit III. Non-Equilibrium Thermodynamics (11 Hours)

Thermodynamic criteria for non-equilibrium states, Phenomenological laws and Onsager's reciprocal relation, Entropy production due to heat flow and chemical reactions. coupled reactions, electrokinetic phenomena, transformations of the generalised fluxes and forces, microscopic reversibility and Onsager's reciprocity relations, non-equilibrium stationary states, irreversible thermodynamics for biological systems.

Unit IV. Electrochemistry (11 Hours)

Electrochemistry of solutions, Debye-Hückel, Onsager treatment and its extension, ion-solvent interactions. Thermodynamics of electrified interface equations. Structure of electrified interfaces. Guoy Chapman, Stern. Overpotentials, exchange current density, derivation of the Butler-Volmer equation, and Tafel plot. Semiconductor interfaces: theory of the double layer at semiconductor, electrolyte solution interfaces, structure of the double layer interfaces. Electrocatalysis – influence of various parameters. Hydrogen electrode. Bioelectrochemistry, threshold membrane phenomena. Polarography theory, Ilkovic equation, half-wave potential and its significance. Introduction to corrosion, homogeneous theory, forms of corrosion, corrosion monitoring and prevention methods.

Books suggested:

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Coulson's Valence, R. McWeeny, ELBS.
3. Modern Electrochemistry, Vol. I & II, J.O.M. Bockris and A.K.N. Reddy, Plenum.
4. Principles Of Physical Chemistry, Puri. Sharma. Pathania, Vishal Publishing Co.
5. Non-equilibrium Thermodynamics, C. Kalidas, M. V. Sangaranarayanan, Macmillan India Limited
6. Introduction to Statistical Thermodynamics, H. Dole. Prentice-Hall, New York
7. Theoretical Chemistry, S. Glasstone, Affiliated East-West Press.

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSC - 6 (Practical)
Paper Name: Laboratory Course Physical-II

Credits – 02
Practical: 60 Hours

- Determination of the strengths of halides in a mixture potentiometrically.
- Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
- Acid-base titration in a non-aqueous medium using a pH meter.
- Determination of activity and activity coefficient of electrolytes.
- Determination of the dissociation constant of monobasic/dibasic.
- Determination of the molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method, and to determine the activity coefficient of an electrolyte.
- Determination of the degree of dissociation of a weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.
- Kinetic decomposition of diacetone alcohol by dilatometry.
- Determination of the order of a reaction.
- Kinetics of Bronsted primary salt effect.
- Determine the refractivity and molar refractivity of some organic liquids by Refractometry.

Books Suggested:

13. Practical Physical Chemistry, A. Findary, T.A. kitchner (Longmans, Green and Co.)
14. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.r. Denko. R.M.W. richett (Pergamon Press).
15. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.)
16. Advanced Practical Physical Chemistry, J.B Yadav (Krishna Prakashan Media Pvt. Ltd)
17. Experimental Physical Chemistry, R.C. Das and B. Behera, Tata McGraw Hill.
18. Practical Physical Chemistry, S.R. Palit and S.K. De, Science Book Agency.
19. Practical Physical Chemistry, A.M. James and F.E. Prichard, Longman.
20. Findley's Practical Physical Chemistry, B.P. Lavitt, Longman
21. Systematic experimental Physical Chemistry, T.K. Chandershekhar & S.K. Rajbhoj
22. Experimental Physical Chemistry, V.D.Athawale and Parul Mathur, New Age International
23. Practical Physical Chemistry, B.P. Levitt and Zindley's, Longman.
24. Experiments in Physical Chemistry, Shoemaker and Gailand McGraw Hill.

M.Sc. First Year (II Semester)
M.Sc. Chemistry
SEC - 2 (Theory)
Paper Name: Separation Methods and Spectroscopy

Credits: 05
Theory: 75 Hours

Unit I. Chromatographic Methods (20 Hours)

Principle, instrumentation, and applications of gas chromatography and HPLC. Ion exchange chromatography: cationic and anionic exchanges and their applications. Van-Deemter equation and its significance (no derivation), HEPT-plate and rate theories and their applications.

Unit II. Radio Analytical Methods (05 Hours)

Basic principles and types of measuring instruments, isotope dilution techniques: principle of operations and applications.

Unit III. Molecular Electronic Spectroscopy (15 Hours)

Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of excited states, Franck-Condon principle, Dissociation and pre-dissociation, electronic spectra of polyatomic molecules. Emission spectra, radiative and non-radiative decay, internal conversion.

Unit IV. Raman Spectroscopy (10 Hours)

Classical and quantum theories of Raman effect. Pure rotational, vibrational, and vibrational-rotational Raman spectroscopy, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS).

Unit V. Nuclear Magnetic Resonance Spectroscopy (25 Hours)

Principle of NMR, Nuclear spin, gyromagnetic ratio, Larmour equation, saturation, shielding and deshielding of magnetic nuclei, chemical shift and its measurement, factor influencing chemical shift, spin-spin interaction and coupling constant 'J', scalar coupling (geminal and vicinal) and dipolar coupling, factors influencing coupling constant. Classification of spin systems (AB, A2B2, ABC, ABX, AMX, etc.), spin decoupling, NMR studies of nuclei other than proton ^{13}C, ^{19}F, and ^{31}P. Basic ideas about the instrument: CW NMR and FT NMR, advantages of FT NMR. NMR in medical diagnostics.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.
3. Physical Method for Chemistry, R.S. Drago, Saunders Company.
4. Introduction of Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
7. Introduction to Magnetic Resonance, A. Carrington, A.D. Maclachalan, Harper & Row.
8. High Performance Liquid Chromatography, Heinz Engelhardt.
9. Instrumental Methods of Chemical Analysis, Willard, Meritt, Dean & Settle (Wiley Eastern).

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSE - 2 (Theory)
Choice No.: 01
Paper Name: Chemical Transformations and Coupling Strategies

Credits: 04
Theory: 60 Hours

Unit I. Oxidation Reagents (15 hours)

Importance of oxidation reactions, detailed mechanisms and applications of Jones oxidation, PCC, PDC, TEMPO, Corey-Kim oxidation, Swern oxidation, DMP, MnO_2, Fetizon's reagent, SeO_2, DDQ, OsO_4, LTA, Woodward oxidation, Prevost oxidation.

Unit II. Reduction Reagents (15 hours)

Importance of reduction reactions, detailed mechanisms and applications of $LiAlH_4$ and derivatives, $NaBH_4$ and derivatives, Grignard (RMgX), Alkyl Lithium (RLi), Gillmann (R_2CuLi), Borane (BH_3), Alane (AlH_3), Wilkinson catalyst, Birch reduction, Wolf Kishner reduction.

Unit III. Advance Named Reactions (15 hours)

Importance, applications, and mechanistic pathways of following reactions. Diels Alder Reaction, Shapiro reaction, Mannich reaction, Stork-Enamine reaction, Eschenmoser-Tanabe fragmentation, Robinson annulation, Baylis-Hillman reaction, Mukayama aldol reaction, Mistunobu reaction, Peterson olefination, Julia olefination, and Ugi reaction

Unit IV. Metal Catalyzed Coupling Reactions (15 hour)

Importance of Cross-coupling reactions in C-C and C-X bond formation using transition metal catalysts. Detailed mechanism and applications of Suzuki coupling, Heck coupling, Stille coupling, Sonogishira coupling, Negishi coupling, Kumada coupling, Hiyama coupling, Ullman coupling, Henry coupling, Buchwald Hartwig coupling, McMurrey coupling, and Click reaction.

Books suggested:

1. Modern methods of organic synthesis by William Carruthers and Iain Colhdham
2. Modern Organic Synthesis: An introduction by George. S. Zweifel and Michael H. Nanzt
3. Transition Metal catalyzed coupling reactions by Ionnis D Kostas
4. Advanced Organic Chemistry, Carey and Sundberg, Springer Verlag, Germany.
5. Modern Organic Reactions, H.O. House, Benjamin.
6. Organic reaction mechanism by V.K Ahluwalia and Rakesjh Kamar Parashar

M.Sc. First Year (II Semester)
M.Sc. Chemistry
DSE - 2 (Theory)
Choice No.: 02
Paper Name: Chemistry of Materials

Credits: 04
Theory: 60 Hours

Unit I. Structure of Solid Materials (10 Hours)

Fundamentals, ionic, covalent, hydrogen bonded and molecular solids; Crystal symmetry, translation, glide plane and screw axis, Bravais lattice, space groups and its determination, Diffraction of X-Ray by crystal, Laue and Bragg condition, concept of reciprocal lattice. Structure of perovskite, ilmenite, and rutile; spinel and inverse spinel.

Unit II. Properties of Solid Materials (15 Hours)

Conductors, insulators, semiconductors, superconductors; ferroelectricity, antiferroelectricity, pyroelectricity, piezoelectricity. Basic principles of magnetism, Magnetic properties, paramagnetism, ferro- and antiferromagnetism, diamagnetism, Pascal constants, Curie equation, Magnetic properties of coordination compounds. Visible Light and the Electromagnetic Spectrum, Scattering Processes: Reflection, Diffraction and Interference, Luminescence and Phosphorescence.

Unit III. Chemistry of Nanomaterials (10 Hours)

History of Nanoscience, Nano-world definitions, Properties of Nanomaterials, Typical synthetic strategies for nanomaterials, Modern characterization methods, and Applications of nanomaterials in different areas.

Unit IV. General synthesis techniques of materials (10 Hours)

Synthesis of materials: ceramic methods, precursor method, and sol-gel synthesis, physical and chemical vapour depositions (CVD), Solvothermal techniques, Electrodeposition, Microwave-Assisted Synthesis, Mechanochemical Synthesis.

Unit V. Analytical characterization techniques of materials (15 Hours)

Thermal analysis: definition and uses. Thermogravimetry: application, TGA curve analysis. Differential Thermogravimetry: DTA, DSC, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), X-Ray Diffraction Methods: The Powder Method – Principles and Uses. Vibrational Spectroscopy: IR and Raman. Gas adsorption theories and techniques.

Books suggested:

1. Solid State Chemistry and Its Applications by Anthony R. West. John Wiley & Sons, Ltd.
2. C. N. R. Rao and J. Gopalakrishnan, New directions in Solid State Chemistry, Cambridge University Press: Cambridge, 1997.
3. A. K. Cheetham, Solid state chemistry: compounds, Oxford University Press, 1992.
4. J. S. Miller and M. Drillon (Eds), Magnetism: Molecules to Materials, Molecule-based Magnets, Wiley-VCH, Weinheim, 2005.
5. Essentials of Inorganic Materials Synthesis, C.N.R. Rao, K. Biswas, Wiley & Sons, Inc.
6. Introduction To Solid State Physics, Charles Kittel, John Wiley & Sons, Inc.
7. An Introduction to Nanomaterials and Nanoscience, Asim K. Das and Mahua Das, CBS Publishers and Distributors Pvt Ltd.