Four Year Under Graduate programme (FYUP) under NEP 2020

[FOR STUDENTS ENROLLED IN 2022, 2023 & 2024]

Chemistry

B.Sc. 4th Year (7th Semester) Chemistry Honors with Research

Course Name	**Course Type**	**Credits**
Inorganic Chemistry-I	Core Major -I (Theory)	5
Organic Chemistry-I	Core Major –II (Theory)	5
Physical Chemistry-I	Core Major Elective –I (Theory) (Choice No. 1)	4
Group Theory & Spectroscopy	Core Major Elective –I (Theory) (Choice No. 2)	
Instrumental Chemistry for Chemical Analysis	Core Major Elective –I (Theory) (Choice No. 3)	
Industrial Chemistry and Materials	Core Major Elective –I (Theory) (Choice No. 4)	
Major Practical (Lab VII Honours with Research)	Core Practical	5
Research Methodology for Chemistry	Core	5
Minor - I: General Chemistry-I	Minor - I (Theory)	2
Minor Practical – I	Minor Practical - I	2
	Total Credits	**28**

Important Note:

- The students will opt for only one paper out of four choices for Core Major elective-I papers.
- Chemistry Minor (Theory) and Minor Practical can be selected by the students who studied Chemistry as his/her second core subject up to 6th semester, or they have pursued Chemistry in the first and second year of their U.G. Programme.
- The minor course opted by any learner should be different from the Core Major offered by the Department in B.Sc. 4th Year Chemistry Honors with Research.

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major - I (Theory)
Paper Name: Inorganic Chemistry-I

Credits: 05
Theory: 75 Hours

Unit I. Stereochemistry and Bonding in Main Group Compounds (15 Hours)

VSEPR model and its shortcomings. Hybridization and three-centre bonds. Bents rule and energetics of hybridization. Walsh's diagrams for tri and tetra-atomic molecules. pπ-pπ and pπ-dπ bonding.

Unit II. Metal-Ligand Equilibria in Solution (20 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 (20 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 (20 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. Inorganic chemistry, A Unified Approach, IInd Ed., 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, 2nd Ed., N.N. Greenwood and A. Earnshaw, Butterworth. Heinemann (1997).
12. Comprehensive Coordination Chemistry Eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon (1987).

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major - II (Theory)
Paper Name: Organic Chemistry-I

Credits: 05
Theory: 75 Hours

Unit I. Nature of Bonding in Organic Molecules (15 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 (20 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 (15 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 (20 Hours)

S_N1, S_N2 and mixed S_N1 and S_N2 mechanism. The neighbouring group mechanism, neighbouring group participation (by π- and σ bonds). Neighbouring group participation. in S_N1 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 (05 Hours)

Electrophilic substitution reaction mechanism-for SE2 and SEi. Reaction. 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 and Structure, Jerry March, 6th Ed., John Wiley.
1. Advanced Organic Chemistry, Carey and Sundberg, Springer Verlag, Germany.
2. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes.
3. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
4. Organic Chemistry, Boyd and Morrison, Prentice Hall of India.
5. Modern Organic Reactions, H.O. House, Benjamin.
6. Principles of Organic Synthesis, Norman and Coxon, Blackwell.
7. Reaction Mechanism in Organic Chemistry, Mukherji and Singh, Macmillan.
8. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
9. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major Elective - I (Theory)
Choice No.: 01
Paper Name: Physical Chemistry-I

Credits: 04
Theory: 60 Hours

Unit I. Quantum Chemistry: Introduction to Exact Quantum Mechanics (10 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 (15 Hours)

Ordinary angular momentum, generalized 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 (15 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 viral theorem.

Unit IV. Thermodynamics: Classical Thermodynamics (20 Hours)

Brief resume of concepts of laws thermodynamics, free energy, chemical potential and entropies. Partial molar properties: partial molar free energy, partial molar volume and partial molar heat content and their significance. Determination of these quantities. Concept of fugacity and determination of fugacity. Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient. Debye-Huckel theory for activity coefficient of electrolytic solutions, determination of activity and activity coefficients, ionic strength.

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.

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major Elective - I (Theory)
Choice No.: 02
Paper Name: Group Theory & Spectroscopy

Credits: 04
Theory: 60 Hours

Unit I. Symmetry and Group Theory in Chemistry (15 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 C_n, C_{nv}, C_{nh}, D_{nh}, 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 (05 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.

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major Elective - I (Theory)
Choice No.: 03
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).

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major Elective - I (Theory)
Choice No.: 04
Paper Name: Industrial Chemistry and Materials

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:

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

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Core Major Practical

Credits: 05
Practical: 150 Hours

Inorganic Chemistry **(50 Hours)**

- Qualitative analysis of mixtures by semi-micro methods containing not more than six cations and anions, including: (i) Rare-earth elements, (ii) Anions, which have not been done in the practical of previous semesters.
- Separation of cations and anions by Paper Chromatography/Thin Layer Chromatography/Ion Exchange Chromatography.

Organic Chemistry **(50 Hours)**

- Preparation of hydrazone from carbonyl compounds.
- Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.
- Reduction of carbonyl compounds using $NaBH_4$.
- Separation, purification and identification of compounds of binary mixture (solid-solid or liquid and solid) using TLC and Paper Chromatography, Chemical tests and spectroscopic analysis.

Physical Chemistry **(50 Hours)**

- 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.
- 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.

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. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
5. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
6. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
7. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.
8. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi.

B.Sc. Fourth Year (VII Semester)
Chemistry Honours with Research
Research Methodology (Theory)
Paper Name: Research Methodology for Chemistry

Credits: 05
Theory: 75 Hours

Unit I. Literature Survey **(15 Hours)**

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital: Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki- Databases, Chem Spider, Science Direct, Sci Finder, Scopus.

Information Technology and Library Resources: The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Unit II. Methods of Scientific Research and Writing Scientific Papers **(20 Hours)**

Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers - justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, and publications of scientific work. Writing ethics. Avoiding plagiarism.

Unit III. Chemical Safety and Handling of Chemicals **(15 Hours)**

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric-safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

Unit IV. The Investigative Approach **(10 Hours)**

Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments. Understanding the difference between accuracy and precision. Errors in measurement: systematic errors and random errors. Systematic data recording, including units, precision, and uncertainty in analysis and reporting. Hypothesis testing.

Unit V. Analysis and Presentation of Data **(15 Hours)**

Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

Books Suggested:

- Dean, J. R., Jones, A.M., Holmes, D., Reed, R., Weyers J. &Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.

- Hibbert, D.B. & Gooding, J.J. (2006) Data analysis for chemistry. Oxford University Press.
- Topping, J.(1984) Errors of observation and their treatment Fourth Ed., Chapman Hall, London.
- Harris,D.C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5. Levie,R.de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
- Chemical safety matters-IUPAC-IPCS, Cambridge University Press, 1992.
- OSU safety manual 1.01.

B.Sc. Fourth Year (VII Semester)
Honours with Research
Chemistry, Minor – I (Theory)
Paper Name: General Chemistry-I
Note: This paper will be chosen by the students with a major other than Chemistry

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Credits: 02
Theory: 30 Hours

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

VSEPR model and its shortcomings. Hybridization and three-centre bonds. Bents rule and energetics of hybridization. Walsh's diagrams for tri and tetra-atomic molecules. pπ-pπ and pπ-dπ bonding. Crystal field theory, factors affecting the magnitude of Δ^0. Consequences of crystal field splitting. Merits and limitations of CFT. Evidence of covalent character in Metal-Ligand bonding. Molecular orbital theory as applied to octahedral, tetrahedral and square planar complexes.

Unit II. Aromaticity and Stereochemistry (10 Hours)

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. Concept of chirality, R/S nomenclature, enantiotopic and diastereotopic atoms, groups and faces, optical purity, chirality due to helical shape, stereospecific and stereoselective synthesis, and asymmetric synthesis.

Unit III. Surface Chemistry: Adsorption (10 Hours)

Surface tension, capillary actions, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces.

Books suggested:

1. Advanced Inorganic Chemistry VIth Ed., F.A. Cotton, G Wilkinson, C.A. Murillo and M. Bochmann, John Wiley,(1999).
2. Inorganic Chemistry, J.E. House, Academic Press, (2008)
3. Coordination Chemistry ,IIIrd Ed., D Banerjea, Asian Book Pt. ltd.,(2009)
4. Inorganic Chemistry, 3th Ed., G L Miessler and D.A. Tarr, Pearson Education, Inc. (2004)
5. Concise Inorganic Chemistry, J.D. Lee, 5th Ed., Chapman & Hall (1996).
6. Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
7. Organic Chemistry, Boyd and Morrison, Prentice Hall of India.
8. Modern Organic Reactions, H.O. House, Benjamin.
9. Principles of Organic Synthesis, Norman and Coxon, Blackwell.
10. Reaction Mechanism in Organic Chemistry, Mukherji and Singh, Macmillan.
11. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
12. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.
13. Physical Methods for Chemistry, R.S. Drago, Saunders Company.

B.Sc. Fourth Year (VII Semester)
Honours with Research
Chemistry, Minor Practical - I

Note: This paper will be chosen by the students with a major other than Chemistry.

Credits: 02
Practical: 60 Hours

Inorganic Chemistry **(20 Hours)**

- Qualitative analysis of mixtures by semi-micro methods containing not more than six cations and anions, including: (i) Rare-earth elements and (ii) Anions, which have not been done in the practical of previous semesters.

Organic Chemistry **(20 Hours)**

- Separation, purification, and identification of compounds of binary mixture (solid-solid or liquid and solid) using TLC and Paper Chromatography, Chemical tests, and spectroscopic analysis.

Physical Chemistry **(20 Hours)**

- 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.
- Determination of the strength of strong and weak acids in a given mixture conductometrically.

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. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
5. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
6. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
7. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.
8. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi.

Four Year Under Graduate programme (FYUP) under NEP 2020

[FOR STUDENTS ENROLLED IN 2022, 2023 & 2024]

Chemistry

B.Sc. 4th Year (8th Semester) Chemistry Honors with Research

Course Name	**Course Type**	**Credits**
Inorganic, Organic and Physical Chemistry	Core Major -I (Theory)	5
Separation Methods and Spectroscopy	Core Major Elective -II (Theory) (Choice No. 1)	4
Chemistry of Materials	Core Major Elective -II (Theory) (Choice No. 2)	
Major Practical (Lab VIII Honours with Research)	Core Major Practical	3
Dissertation	Chemistry	12
Minor - II: General Chemistry-II	Minor -II (Theory)	2
Minor Practical – II	Minor Practical - II	2
	Total Credits	**28**

Important Note:

- The students will opt for only one paper out of two choices for Core Major elective-II papers.
- Chemistry Minor (Theory) and Minor Practical can be selected by the students who studied Chemistry as his/her second core subject up to 6th semester, or they have pursued Chemistry in the first and second year of their U.G. Programme.
- The minor course opted by any learner should be different from the Core Major offered by the Department in B.Sc. 4th Year Chemistry Honors with Research.

B. Sc. Fourth Year (VIII Semester)
Chemistry Honours with Research
Core Major - I (Theory)
Paper Name: Inorganic, Organic and Physical Chemistry

Credits: 05
Theory: 75 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 ligand (ferrocene complexes).

Unit II. Addition to Carbon-Hetero Multiple Bonds (10 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 IV. Pericyclic Reactions (15 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.

Unit V. Electrochemistry (20 Hours)

Electrochemistry of solutions, Debye-Huckel, Onsager treatment and its extension, ion solvent interactions. Thermodynamics of electrified interface equations. Structure of electrified interfaces. Guoy Chapman, Stern. Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot. Semiconductor interfaces-theory of double layer at semiconductor, electrolyte solution interfaces, structure of 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. 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.

3. Bochmann, John Wiley, (1999).
4. Inorganic Chemistry, J.E.House, Academic Press, (2008)
5. Inorganic chemistry, A Unified Approach, W W. Porterfield, Academic Press, (1993).
6. Coordination Chemistry, IIIrd Ed., D Banerjea, Asian Book Pt. ltd.,(2009)
7. Inorganic Chemistry, 3th Ed., G L Miessler and D.A.Tarr, Pearson Education,Inc. (2004)
8. Concise Inorganic Chemistry, J.D. Lee, 5th Ed., Chapman & Hall (1996).
9. Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
10. Inorganic Chemistry, 3rd Ed., Alan G. Sharpe, Addison-Wesley (1992).
11. Inorganic Chemistry, 4th Ed., J.E. Huheey, Harper & Row (2000).
12. Chemistry of the Elements, Greenwood and Earnshaw, Butterworth Heinemann (1997).
13. Inorganic Electronic Spectroscopy, 2nd Ed., A.B.P. Lever, Elsevier (1986).
14. Comprehensive Coordination Chemistry Eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon (1987).
15. Advanced Organic Chemistry- Reaction, Mechanism and Structure, Jerry March, John Wiley.
16. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
17. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
18. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
19. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
20. Modern Organic Reactions, H.O. House, Benjamin.
21. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackwell.
22. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
23. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.
24. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
25. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.
26. Physical Chemistry, P.W. Atkins, ELBS.
27. Coulson's Valence, R. McWeeny, ELBS.
28. Modern Electrochemistry, Vol. I & II, J.O.M. Bockris and A.K.N. Reddy, Plenum.
29. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
30. Quantum Chemistry, Ira N. Levine, Prentice Hall.

B.Sc. Fourth Year (VIII Semester)
Chemistry Honours with Research
Core Major Elective - II (Theory)
Choice No.: 01
Paper Name: Separation Methods and Spectroscopy

Credits: 04
Theory: 60 Hours

Unit I. Chromatographic Methods **(15 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 **(10 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 **(20 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, A_2B_2, 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).

B.Sc. Fourth Year (VIII Semester)
Chemistry Honours with Research
Core Major Elective - II (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 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, Oxford, 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, Kanishka Biswas, John 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.

B.Sc. Fourth Year (VIII Semester)
Chemistry Honours with Research
Core Major Practical

Credits: 03
Practical: 90 Hours

Inorganic Chemistry **(30 Hours)**

- Quantitative Analysis of mixtures of two metal ions involving Volumetric (by complexometric titration using masking and demasking agents) and gravimetric analysis.
- Preparation of selected inorganic compounds: $K_3[Fe(C_2O_4)_3]3H_2O$, $Co[(NH_3)_6]Cl_3$, Cu_2HgI_4, $[Co(Py)_2Cl_2]$, $[Ni(NH_3)_6]Cl_2$, $K_3[Cr(C_2O_4)_3]$, Prussian Blue, Turnbull's blue.

Organic Chemistry **(30 Hours)**

- Aromatic electrophilic Substitutions: Friedel-Crafts reaction (acylation and alkylation).
- Cannizzaro reaction: Benzaldehyde or substituted benzaldehyde as substrate.
- The above products may be characterized by Spectral Techniques where possible.
- Estimation of amines/phenols using bromate bromide solution/or acetylation method.
- Determination of Iodine and Saponification values of an oil sample.

Physical Chemistry **(30 Hours)**

- Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.
- Acid-base titration in a non-aqueous media using a pH meter.
- Determination of activity and activity coefficient of electrolytes.
- Determination of the dissociation constant of monobasic/dibasic

Books Suggested:

1. Vogel's Text Book of Qualitative Analysis, ELBS.
2. Vogel's Text Book of Quantitative Analysis, ELBS.
3. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
4. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
5. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
6. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
7. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.

B.Sc. Fourth Year (VIII Semester)
Chemistry Honours with Research
Dissertation

Credits: 12

Practical work, thesis submission and presentation.

Note: The topic of the dissertation will be decided by the supervisor with understanding of the students.

B.Sc. Fourth Year (VIII Semester)
Honours with Research
Chemistry, Minor – II (Theory)
Paper Name: General Chemistry-II
Note: This paper will be chosen by the students with a major other than Chemistry.

Credits: 02
Theory: 30 Hours

Unit I. Metal Clusters and Silicates (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. Principles of silicates. Structure and classification of silicates. Asbestos, Zeolites and Ultramarines as silicate materials. Silicates in technology

Unit II. Aromatic Electrophilic and Nucleophilic Substitution (10 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. Vilsmeir-Haak reaction, Gattermann-Koch reaction.

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

Unit III. Electrochemistry (10 Hours)

Electrochemistry of solutions, Debye-Huckel, Onsager treatment and its extension, ion solvent interactions. Thermodynamics of electrified interface equations. Structure of electrified interfaces. Guoy Chapman, Stern. Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot.

Semiconductor interfaces-theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces.

Electrocatalysis – influence of various parameters. Hydrogen electrode. Introduction to corrosion, homogeneous theory, forms of corrosion, corrosion monitoring and prevention methods.

Books Suggested:

1. Advanced Inorganic Chemistry VIth Ed., F.A. Cotton, G Wilkinson, C.A. Murillo and M. Bochmann, John Wiley, (1999).
2. Inorganic Chemistry, J.E.House, Academic Press, (2008)
3. Inorganic Chemistry, 3th Ed., G L Miessler and D.A.Tarr, Pearson Education,Inc. (2004).
4. Concise Inorganic Chemistry, J.D. Lee, 5th Ed., Chapman & Hall (1996).
5. Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
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. Physical Chemistry, P.W. Atkins, ELBS.
7. Modern Electrochemistry, Vol. I & II, J.O.M. Bockris and A.K.N. Reddy, Plenum.

B.Sc. Fourth Year (VIII Semester)
Honours with Research
Chemistry, Minor Practical - II
Note: This paper will be chosen by the students with a major other than Chemistry.

Credits: 02
Practical: 60 Hours

Inorganic Chemistry **(20 Hours)**

- Quantitative Analysis of mixtures of two metal ions involving Volumetric (by complexometric titration using masking and demasking agents) and gravimetric analysis.
- Preparation of selected inorganic compounds: $K_3[Fe(C_2O_4)_3]3H_2O$, $Co[(NH_3)_6]Cl_3$, Cu_2HgI_4, $[Co(Py)_2Cl_2]$, $[Ni\ (NH_3)_6]\ Cl_2$, $K_3[Cr(C_2O_4)_3]$, Prussian Blue, Trumbull's Blue.

Organic Chemistry **(20 Hours)**

- Aromatic electrophilic Substitutions: Friedel-Crafts reaction (acylation and alkylation).
- Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method.
- Determination of Iodine and Saponification values of an oil sample

Physical Chemistry **(20 Hours)**

- Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.
- Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
- Determination of the dissociation constant of monobasic/dibasic.

Books Suggested:

8. Vogel's Text Book of Qualitative Analysis, ELBS.
9. Vogel's Text Book of Quantitative Analysis, ELBS.
10. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
11. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.
12. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
13. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
14. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.