B. SC. CHEMISTRY(Honours)
STRUCTURE OF SYLLABUS

1st Year 1st Semester

PAPER	UNIT	PERIODS/WEEK	MARKS
I	PC-101, OC-101, IC-101	3+3+3	50
II	PC-102, OC-102, IC-102		50
Chemistry Laboratory : IC-Lab. I		6	--

1st Year 2nd Semester

III	PC-103, OC-103, IC-103	3+3+3	50
IV	PC-104, OC-104, IC-104		50
Chemistry Laboratory : IC-Lab. II		6	25+25 [For two semesters]

2nd Year 1st Semester

V	PC-201, PC-202	2+2	50
VI	OC-201, OC-202	2+2	50
VII	IC-201, IC-202	2+2	50
Chemistry Laboratory : IC-Lab. III		8	--

2nd Year 2nd Semester

VIII	PC-203, PC-204	2+2	50
IX	OC-203, OC-204	2+2	50
X	IC-203, IC-204	2+2	50
Chemistry Laboratory : OC – Lab I		8	50+50 [For two semesters]

3rd Year 1st Semester

PAPER	UNIT	PERIODS/WEEK	MARKS
XI	PC-301, PC-302, PC-303	2+2+2	50
XII	OC-301, OC-302, OC-303	2+2+2	50
XIII	IC-301, IC-302, IC-303	2+2+2	50
XIV	AC-301	3	25
Chemistry Laboratory : AC-Lab I/OC-Lab II/ PC-Lab. I		18	

3rd Year 2nd Semester

XV	PC-304, PC-305, PC-306	2+2+2	50
XVI	OC-304, OC-305, OC-306	2+2+2	50
XVII	IC-304, IC-305, IC-306	2+2+2	50
XVIII	AC-302	3	25
Chemistry Laboratory : AC-Lab. I/OC-Lab II/ PC-Lab I		18	50+50+50 [For two semesters]
Grand Viva			50

GRAND TOTAL ⟶ 1200

Note : AC = Analytical Chemistry, IC = Inorganic Chemistry, OC = Organic Chemistry & PC = Physical Chemistry

B. SC. COURSE PLAN (HONOURS)

INORGANIC CHEMISTRY

FIRST YEAR

1st Semester : Paper I & Paper II (Group C each) Marks 16 + 16

Unit : IC - 101 – Atomic Structure and Periodic Table : 22 L

Unit : IC - 102 – Periodic Properties of Atoms : 22 L

2nd Semester : Paper III & Paper IV (Group C each) Marks 16 + 16

Unit : IC - 103 – Chemical Bonding – I : 22 L

Unit : IC - 104 – Ionic Equilibrium – I : 22 L

SECOND YEAR

1st Semester : Paper VII Marks 50

Unit : IC – 201 - A. Ionic equilibrium – II : 15L

B. Chemical Bonding – II : 15 L

Unit : IC – 202 - A. Atomic Nuclei and Radioactivity : 15 L

B. Comparative Study of Group

Elements-I (s block + noble gases) : 15 L

2nd Semester : Paper X Marks 50

Unit : IC – 203 –A. Introduction to Coordination Chemistry : 15L

B. Introduction to Solid State Chemistry : 15L

Unit : IC – 204 – Comparative Study of Group Elements–II : 30L

(p – block elements)

THIRD YEAR

1st Semester : Paper XIII Marks 50

Unit : IC – 301 –Nuclear Structure and Nuclear Chemistry, : 30L

Unit : IC– 302 –A. Molecular Symmetry and Point Groups :15L

B. Chemical Bonding – III :15L

(Crystal Field – Ligand Field Theory

and Applications)

Unit : IC – 303 – Comparative study of Group elements –III :30L

[The d–block (transition) elements].

2nd Semester : Paper XVII Marks 50

Unit : IC – 304– A. Comparative study of group elements – IV : 15L

(f–block elements – the Lanthanides and

Actinides).

B. Coordination Chemistry of non-transition

elements : 15L

Unit : IC – 305– A. Organometallic Chemistry – I : 15L

B. Transition metal Pi–acid Complexes : 15L

Unit : IC – 306 –A. Bio–inorganic Chemistry : 15L

B. Inorganic Polymer : 15L

ANALYTICAL CHEMISTRY

THIRD YEAR

1st Semester : Paper XIV : Marks 25

Unit : AC-301 **45 L**

2nd Semester : Paper XVIII : Marks 25

Unit : AC-302 **45 L**

INORGANIC CHEMISTRY(Honours)

1st Year 1st Semester

Unit : IC – 101 **22 L**

Atomic Structure and Periodic Table

A. Bohr's atomic model, its limitations, Zeeman effect,

Spectra of many electron system, etc. – Recapitulation only.

B. The de Broglieconcept of matter wave, the $\lambda = \frac{h}{p}$ equation (simple problems)

C. Quantum mechanical model – Schrodinger equation in spherical coordinate (r, θ) and its solutions for one electron case (only to write down the expressions for the radial, angular parts of s, p orbitals); significance of the n, l, m quantum numbers; probability interpretation of ψ^2 ; plot of F(…) against (r), shapes of s, p, d, A.O.'s (only drawing); spin motion of electron and the spin quantum number; many electron system and the Pauli exclusion principle, energy level of A. O.'s and writing of the electron configuration of atoms.

D. Long form of periodic Table in the light of electronic configurations; classification of elements as s–p block (the normal elements); d–block (the transition elements) and the f–block (lanthanides, actinides).

Unit : IC – 102 **22 L**

Periodic properties of Atoms :

A. The ionisation potentials of atoms – definition, examples; first, second etc. I. P. ; variation of the I. P. along the periodic table and explanation of the trends.

B. The electron affinity of atoms – Definition, illustration, variation of the values along the periodic table and explanation of the trends.

C. The atomic radii – The concept of various radii – ionic radii, convalent radii, van der Waal radii etc, with examples; variation of the atomic radii along the periodic table.

D. The electronegativity (E. N.) – The concept of electronegativity Pauling and its difference from electron affinity; E. N. scale, the postulation of arithmetic and geometric mean in the determination of E. N. values, ionic characters of bonds and the E. N. difference, other E. N. scales – the Mulliken, Allred – Rochow scales.

1st Year 2nd Semester

Unit : IC – 103 **22 L**

Chemical Bonding – I

A. General introduction to the electronic theory of bonding – the ionic, covalent, coordinate bonding : concept of bond energy; examples.

B. Ionic binding – (i) Energetics of Ionic binding leading to formation of solids; packing of ions, radius ratio effect, representative types of lattice, Born equation, Madelung constant, Born–Haber Cycle – its applications; calculation of ionic radii in crystal from the internuclear distance – examples.

ii) Polarising power and polarisability of ions, Fajan's rule, stabilisation of ions through hydration/solvation.

C. Covalent bonding – the V. B. and orbital hydridisation.

i) Qualitative principle of V. B. theory, concept resonating structures, directional characteristics of covalent bond, hybridisation of A. O. examples of molecules with sp, sp^2, sp^3, d^2sp^3 – hybrid A. O. with angular orientation,

ii) Valency shell electron pair repulsion (VSEPR) Theory; Linnett double quartet model; examples.

Unit : IC – 104 **22 L**

Ionic equilibrium – I

A. General principle of equilibrium, the equilibrium constant, examples of acid–base–, redox and distribution – (in two phases) equilibria; redox equilibrium and ion–electron method of balancing redox equations.

B. Strength of acids and bases in aqueous solution in terms of K_a, K_b; OH the pH scale, the poil, pK_w, pK_a, pK_b, etc. Hydrolysis of salts, pH of solutions of salts of strong acids – weak base, weak acid – strong base, weak acid–weak base, multistage equilibria involving salts of polybasic acids; Buffer solutions, calculation of pH of buffer solutions; acid base indicator.

C. Solid – solution equilibrium, the solubility and solubility product (K_{sp}), common ion effect, effect of H/OH^- and complexing agents. Application of the concept in qualitative analysis; calculation on pH condition and precipitation.

2nd Year 1st Semester

Unit : IC - 201 **30 L**

A. Ionic equilibrium – II

i) Theories of acids – bases : Bronsted – Lowry theory, conjugate acid – base pairs, solvent effect; Lewis theory of acids – bases, complex

formation as acid – base reaction; the concept of Hard and Soft Acids and Bases (H S A B); Reaction in liquid NH_3 and SO_2.

ii) Redox potential – The concept of oxidation and reduction potential, standard electrode potential, Nernst equation, E of a redox reaction; Free energy change and redox potential ($\Delta G = -nFE$); Redox potential values and their usefulness.

B. Chemical Bonding – II (Introduction to M. O. Theory)

i) The concept of moleculer orbital, LCAO–MO, positive overlap of A. O. leading to bond formation, negative overlap ledign to anti–bonding, σ, π, δ – type overlap.

ii) Energy level diagram for homo–nuclear diatomic molecules H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, O_2^+, O_2^-, F_2, Ne_2, also the isoelectronic analogues; bond–order concept.

iii) Energy level diagram for hetero–nuclear diatomic molecules – LiH, NO, NO^+, NO^-, CO, HF.

iv) Special case of 3–centre – 2 – electron bond (B_2H_6, O_2F_2 etc.)

v) Weak intermolecular interactions – Hydrogen – bonding and various interactions involving ions, dipoles, induced dipoles – their effects on molecular properties.

Unit : IC – 202 **30 L**

A. Atomic Nuclei and Radioactivity

i) Composition of the nuclei, isotope, isobar, isotone, isomer; nuclear binding energy, packing fraction, n/p ratio and nuclear stability; elementary idea of nuclear reaction, comparison between nuclear reactions and chemical reactions.

ii) Artificial Radioactivity – instability of nuclei, decay processes, K–capture, γ–transition and nuclear isomerism.

B. Comparative study of Group elements – I

(the s–block elements and the noble gases)

i) The s–block elements of Gr – I, Gr – II, their general electronic configuration, trends in I. P., ionic radii; reaction with H, O, N, C, and hydrolytic behaviour of the products.

ii) General metallurgical consideration of these elements.

iii) Differences of Li and Be from other members of their groups (the diagonal relationship).

iv) Extraction of Li and Be from their ores, Isolation and purification of Ra and their uses.

v) Isotopes of H, industrial preparation of deuterium, its properties, reactions and uses; ortho–para – hydrogen,.

vi) Separation and uses of the noble gases ; compounds of Kr and Xe – preparation, properties, structures.

2nd Year 2nd Semester

Unit : IC – 203 **30 L**

A. Introduction to Coordination Chemistry :

i) Historical account – the cobaltammines; Werner's theory – the primary, secondary valency, explanation of structures of cobal–tammines by Werner's theory. Equivalence of primary valency with ionic and secondary valency, with coordinate bonds.

ii) The ligands – examples of monodentate, polydentate, anionic, neutral and cationic ligands with structures showing the coordinating sites.

iii) IUPAC nomenclature of coordination compounds including the polynuclear ones, examples.

iv) Structure of coordination compounds from orbital hydridisation of central atoms – linear (sp), square planar (dsp^2) tetrahedral (sp^3, sd^3), trigonal bipyramidal (dsp^3), octahedral (d^2sp^3) etc. with examples.

v) Isomerism – different types.

vi) Stability of complex ions in solution – various factors; 'the chelate effect'.

vii) Approach to preparation of coordination compounds – by substitution reactions in aq. solution and non aq. solution, 'the *trans* effect' and synthesis of *cis*–trans isomers.

viii) Application of complex formation in analytical chemistry and industry.

B. Introduction to Solid State Chemistry

i) Structures of metal crystals, the h.c.p., f.c.c., b.c.c.

ii) Metallic bonds : thermal and electrical conductivity in metals, the band theory (qualitative).

iii) Structure of solid interstitial hydrides, oxides, nitrides and carbides – their physical and chemical properties.

iv) Defects in Cystals – stoichiometric (Frenkel, Shottsky) and nonstochiometric (metal excess, metal defficient) defects .

v) Introduction to super conductivity in solids.

vi) Conductor, semiconductor, insulator; n–type, p–type, semi–conductors, transistors.

vii) Reactions in solid state – thermal decomposition, solid – gas reactions, solid – liquid reactions, solid–solid reactions.

Unit : IC – 204 **30 L**

Comparative study of group elements – II

(The p–block elements)

i) Gr. III. (a) The general group properties *

(b) Boron Chemistry – preparation, properties of boranes; Structure and bonding of diborane, Boranine Boron nirides; electron deficient nature of hydrides, halides and their polymerisation.

ii) Gr. IV (a) The general group properties *

(b) Aspects of C and Si chemistry the difference of C and P from the rest of the group elements. Preparation, properties, uses of the fluoroecarbons, the silanes and the silicones.

iii) Gr. IV (a) The general group properties *

(b) N and P – Chemistry : The presence of lone pair and basicity of trivalent compounds; trends in bond angles of hydrides, halides, preparation, properties, structures and bonding of hydrazine, hydroxylamine, hydrazoic acids, the oxides and oxyacids of N, P; d–orbital participation in P–compounds.

iv) Gr. VI (a) The general group properties *

(b) S–Chemistry – Preparation, properties, structures and bonding of the oxides, oxyacids (including the thionous, thionic and per–acids), halides, oxy–halides and poly sulphides; d–orbital participation in S–Compounds.

v) Gr. VII (a) The general group properties *

(b) The halogen hydrides, their acidity; Preparation, properties, structures and bonding of the oxides and oxy acids; the inter hologen compounds including polyhalides, the pseudohalides – including their prepartion, properties, structures. The cationic compounds of iodine.

* Note : General group properties : –

For each group this includes discussion, on a comparative basis, of major physical and chemical properties, e.g. –

i) Physical properties – the electronic configuration; ionisation potential / electron affinity; m.p. – b.p. ; ionic/covalent radii etc.

ii) Chemical properties – Various oxidation states and their relative stability (redox behaviour in solution, wherever applicable), higher stability of the higher oxidation states for the heavier members; gradual changes of the ionic/covalent character of the compounds from lighter to heavier members; the relative acidity, amphoteric, basic characteris of the oxides and formation of oxocations (wherever applicable); examples of compounds in all the oxidation states, in particular, the unusual (rare) oxidation states being stabilised through coordination; hydrides, halides (including the halo complexes) and their hydrolytic behaviour; dimerisation and/or polymerisation through halogen bridges (wherever applicable) etc.

iii) Common natural sources of the elements.

3rd Year 1st Semester

Unit : IC – 301 **30 L**

Nuclear structure and nuclear chemistry :

i) Elements of nuclear structure –

a) Mass, charge, nuclear radii, nuclear spin and magnetic moments.

b) The liquid drop and the shell model of nuclear structure.

c) Forces in the nucleus, the pi–meson exchange theory.

ii) Accelerators, Mass–spectrograph.

iii) Nuclear reaction – Mechanism and energetic, compound nucleus, reaction cross–section, potential barrier, Oppenheimer–Phillips process, fission, fusion, spallation, chain reactions.

iv) Separation of isotopes.

v) Reactors – thermal and breeder type, their use for production of energy, nuclear weapons.

vi) Radiation hazard, disposal of radioactive wastes.

vii) Chemical effects of nuclear transformation–Szillard–chalmer effect, recoil energy, effects due to isomeric transitions, also nuclear spin effect leading to ortho–and para–forms of H_2, N_2, F_2 molecules.

viii) Applications : (a) Chronological and Geological application – Carbon – 14 dating, age of minerals, age of the earth, age of the Universe.

(b) Use of tracer in various fields –chemistry, medicine, therapeutic, agriculture etc.

Unit : IC – 302 **30 L**

A. Molecular symmetry and Point Groups :

i) The concept of symmetry in three dimensional objects, in molecules.

ii) Symmetry elements and symmetry operations – C_n, S_n, σ_h, σ_v, σ_d, i, E.

iii) Finding the complete collection of the symmetry elements (of various orders) in molecules and regular polyhedra (tetrahedron, octahedron, cube, icosahedron, reduction in symmetry on substitution in molecules or on deformation of regular polyhedra.

iv) Classification of molecules according to symmetry elements present into point groups. Schoenflies notations for the point groups.

v) Systematic identification of point groups of various molecules. Examples.

B. Chemical Bonding – III
(Crystal field – Ligand field theory)

a) Crystal Field Theory

i) Basic principles, splitting of d–orbital degeneracy due to electrostatic field of various symmetry–cotahedral, tetrahedral, tetragonally distorted octahedral, square planar, trigonal bipyramidal.

ii) Strong field, weak field cases and high spin–low spin electronic configurations in O_h, T_d symmetry. Spectrochemical series.

iii) Crystal field stabilisation energy (CFSE) the CFSE in the O_h, T_d field, their thermodynamic effects – the enthalpies of hydration of M^{+2} ions of first transition series, the lattice energies of MX_2 crystals, relative preference for normal or inverted spinel structures etc.

iv) Jahn–Teller theorem and the Jahn–Teller distortion in d^1–d^9 systems in O_h field.

b) Ligand Field Theory :

i) Demerits of the crystal field model, evidences of metal ligand bonding, Nephelauxetic effects.

ii) Qualitative approach to Ligand Field concept.

iii) General features of electronic spectra of transition metal complexes.

iv) Orgel diagram and discussion of spectra of first transition series metal complexes (weak field cases only, d^5 – excluded).

Unit : IC – 303 **30 L**

Comparative study of Group Elements – III :

[The d–block (transition) elements].

i) General characterstics of the transition metals – The characteristic electronic configurations, the high density, m.p. and b. p. variable valency; complex formation; the optical and magnetic properties of the compounds; the metal–metal bonds and the catalytic activity.

ii) Gr. IV. (a) The general group properties *

(b) Chemistry of Ti and its extractive metallurgy and uses. Close similarity of Zr and Hf and their separation.

iii) Gr. V. (a) The general group properties *

(b) Chemistry of V and its extractive metallurgy and uses of the metals; poly condensation of vanadates; close similarity of Nb and Ta and their separation.

iv) Gr. VI. (a) The general group properties *

(b) Chemistry of Cr; redox properties of Cr compounds in different oxidation states; Extractive metallurgy of Cr and U and the uses of the metals. Polycondensation of the chromates, molybdates, tungstates and uranates. MoS_2 – preparation, structure and uses.

v) Gr. VII. (a) The general group properties *

(b) Chemistry of Mn; redox properties of Mn–compounds in different oxidation states; Differences of Mn–and Re – chemistry in different oxidation states.

vi) Gr. VIII. a) The general group properties *

b) The horizontal comparison of ferrous metals and the Pt – metals; Separation of the Pt–metals; Extraction of Ni and its purification by Monds process; Uses of the metals.

vii) Gr. II. (a) The general group properties *

(b) Differences of these metals form the other d–block metals; The stability and structures of compounds in the Monovalent

states (Hg_2^{+2}, Cd_2^{+2} etc.) The Hg–ammine compounds; Millon's base and its derivatives

viii) Gr. I. (a) The general group properties *

(b) The non–reactive nature (nobility) of the metals and its explanation; complex formation in the various oxidation states and their bonding and structures. Extractive metallurgy of Ag, Au and their uses.

ix) Peroxo complexes of transition metals – peroxides as ligands; preparation, structures and bonding in peroxo compleses of Cr; peroxo complexes of others metals.

* Note. As per the note under ***Unit : IC - 204***

3rd Year 2nd Semester

Unit : IC – 304 **30 L**

A. Comparative study of group elements – IV

(f–block , the Lanthanides, Actinides)

i) The electronic configurations, oxidation states and ionic radii of the two series of elements.

ii) Lanthanides –

(a) Sources, extraction and separation of lanthanides (by different methods, specially the ion exchange method) and their uses.

(b) "Lanthanide contraction" and its consequences.

(c) Chemistry in various oxidation states including complex formation (magnetic and spectral properties excluded).

iii) Actinides –

(a) Nuclear synthesis of the transuranic elements and their isolation in pure states.

(b) Chemistry in various oxidation states and their redox behaviour in aquous solution.

iv) Lanthahides vs. actinides –

(a) Position of the actinides in the periodic table in relation to the position of the Lanthanides.

(b) Comparison of tendency to form compounds in different oxidation states – explanation of the differences.

B. Coordination Chemistry of Nontransition elements

i) General remarks – Comparison with transition metal complexes.

ii) Aquation and solvated ions of groups I, II and III as complexes, acidity of aqua ions, their hydrolysis, hydroxo complexes – mono–meric (e.g., aluminates and gallates) and polymeric. Lability of these aqua complexes.

iii) Group I, II, III Complexes (other than those with aqua and hydroxo ligands). Preference for donor atoms – selection of donor sites in biological systems. Complexes (where applicable) with monodentate and polydentate ligands – halides, nitrates, alkoxides, carboxylates, aminopolycarboxylates, polyhydroxy compounds, betadiketones, 8–quinolinol, cryptates, polyethers, amines (including heterocyclic macrocyclic polymines, biguanides). Encapsulating ligands.

iv) Complexes of B, Si, As, Sb, Te, Br and I (where applicable) with N and)–donor ligands with emphasis on cationic chemistry.

v) Stereochemistry of the complexes and their uses in analysis and medicine (e.g., tartaremetic, valinomycin etc.)

Unit : IC – 305 **30 L**

A. Organometallic Chemistry – I

i) General introduction to organometallic compounds – definition and classification.

ii) Elementary treatment of organometallic compounds of Li, Mg, B and Si – preparation, properties, structures and important applications.

iii) a) Introduction to (M–C) sigma bonded compounds of transition metal–preparation, properties and stability (compared to the main group analogues).

b) Metal olefinic and η^5- – cyclopentadienyl complex.

c) Introduction to homogeneous catalysis.

B. Transition metal Pi Acid Complexes

i) General introduction to π–Acid ligands and σ–π synergic effect in metal–ligand bonding.

ii) Carbonyl complexes – preparation, properties, bonding (18–electron rule, I.R. spectroscopic evidence) of mono and poly–nuclear carbonyls (with and without bridging CO – groups).

iii) Carbonyl halides, carbonyl hydrides, carbonylate anions. thioligands, substituted phosphines, arsines, and Iigands with extended π–systems.

iv) Reactions of metal carbonyls–substitution, photochemical reactions, nucleophilic and electrophilic attack on CO.

Unit : IC – 306 **30 L**

A. Bioinorganic Chemistry

i) Essential and trace elements in bio–system.

ii) Metal ion specificity in bio–systems–metal ion catalyzed hydrolysis and redox reactions in model systems.

iii) Elementary idea of the structures and functions of oxygen transport protein – Haemoglobin, myoglobin, haemocyanine and cytochromes.

iv) Metallo porphyrins–chlorophyll, elementary idea of photosynthesis.

v) Role of metals, non–metals in metabolism, their deficiency, toxicity.

B. Inorganic polymers including ring compounds

i) General introduction to polymerisation reactions, energetics, mechanism, control, linear–, branched–, cross linked polymers.

ii) Synthesis, structures, properties (thermal, electrical, mechanical, chemical) and uses of following polymers –

a) Silicones, b) Phosphonitrilic halides c) Polyphosphates, d) Tetrasulphur–tetranitrides, e) Condensed oxo–anions of Gr. V and VI metals, in particular, the iso–and hetero–poly Molybdates and Tungstates.

iii) Study of structures, bonding properties and uses of natural polymeric silicates – Asbestos, clay, micas, zeolites, quartz.

ANALYTICAL CHEMISTRY

A. Theoretical Paper

3rd Year 1st Semester

Unit : AC – 301 **45 L**

1. Different types of oxidants and reductants in Analytical Chemistry; Electrodeposition and electrolytic separation of metals.
2. Introduction to Polarography and Amperometry
3. Paper and Ion–exchange chromatographic separation of metal ions; Introduction to spectrophotometry and flame photometry
4. Analytical Chemistry of some selected metals, such as, Fe, Mn, Cu, Cr, Ni, Co etc.

3rd Year 2nd Semester

Unit : AC – 302 **45 L**

1. Analysis of rocks and silicate minerals, such as bauxite, chromite, cement etc.

2. Analysis of ferrous and non–ferrous alloys, such as brass, bronze, steel etc.

3. Use of Organic reagents in Inorganic analysis–Complexometric and chelatometric titrations.

4. Environmental pollution and analysis of pollutants; Water analysis.

INORGANIC CHEMISTRY PRACTICAL

FIRST YEAR

1st Semester + 2nd Semester

Unit : IC – Lab. I + IC – Lab. II

1. Inorganic Reaction Chemistry Qualitative analysis. Dry and wet tests of different cation and anions, viz, Hg^{2+} Pb^{2+}, Ag^{+}, Cu^{+2}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, As^{3+}, Al^{3+}, Fe^{3+}/Fe^{2+}, Cr^{3+}, Mn^{2+}, Zn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{+3}, Ca^{2+}, Mg^{2+}, NH_4^{+}, K^{+}, Na^{+}, F^{-}, Cl^{-}, Br^{-}, I^{-}, NO_2^{-}, NO_3^{-}, SO_3^{2-}, SO_4^{2-}, S^{2-}, $S_2O_3^{2-}$, PO_4^{3-}, BO_3^{2-}, SiO_4^{4-}, AsO_4^{3-}, AsO_3^{-3}, CrO_4^{2-}

2. Fusion tests for insoluble salts.

3. Qualitative detection of unknown Inorganic samples containing not more than two radicals selected form the above, including interfering anions.

4. Preparation of standard solution. Estimation of Fe^{2+} and Fe^{3+}.

SECOND YEAR

1st Semester
Unit : IC – Lab. III

1. Analysis of Mixture of Anions.
2. Qualitative detection of unknown salts containing not more than 4 radicals from among the cations and anions learnt in first year class.
3. Preparation of :
   (a) $NH_2OH.HCl$.

(b) $FeSO_4(NH_4)_2SO_46H_2O$.

(c) Potash alum.

(d) Hexammine Cobalt (III) chloride.

(e) Potassium tris oxalato ferrate (III).

4. Volumetric estimation of Cu^{2+} and Ca^{2+}.

ANALYTICAL CHEMISTRY PRACTICAL

THIRD YEAR

Unit : AC – Lab. I

Quantitative analysis of simple mixtures of copper and iron, chromium and manganese. Analysis of dolomite, brass and stainless steel (quantitative) complexometric titration of calcium, magnesium, zinc and manganese.

Solvent extraction : Separation and Estimation of Cations.

ORGANIC CHEMISTRY (Honours)

1st Year 1st Semester

Unit: OC – 101 **22L**

A. Structure and Bonding:

Hybridisation, bond energy, bond length, bond angle and shapes of organic molecules, localized and delocalized chemical bonds, M.O. concept of bonding, hydrogen bond, electron donor acceptor complexes, van der Waals interaction.

B. Factors Influencing Properties of Organic Molecules:

Concept of electronegativity, dipole moment, polarization and polarizability, inductive and field effect, electromeric effect, resonance and hyperconjugation, steric inhibition of resonance.

C. Strength of Organic Acids and Bases

Unit: OC – 102 **22L**

Reactions of Organic Molecules:

Reagent type (electrophiles, nucleophiles and free radicals), reaction type (homolytic, heterolytic cleavage of covalent bonds, substitution, addition, elimination, rearrangement, oxidation and reduction). Energetics of reactions, transition state, Hammond's postulate; Kinetics of reactions (unimolecular, bimolecular, first order and second order), kinetically controlled reactions and thermodynamically controlled reactions, steric effect on the reactivity of organic molecules.

M.O. Picture of Organic Molecules:

M.O. picture of ethylene, acetylene, 1,3-butadiene, 1,3,5-hexatriene, formaldehyde, allene, carbene, allyl and benzyl cations, radicals and anions.

1st Year 2nd Semester

Unit: OC – 103 **22L**

Stereochemistry - Unit-I

Stereoisomerism**:**Enantiomerism and Diastereomerism, Stereogenic centres, symmetry properties of molecules, Racemisation and Resolution, optical purity and enantiomeric excess, configuration and conformation-relationship and differences, configurational notations (D, L; R,S; *cis*, *trans*; *E, Z),* representation of conformations (Fischer, Newman, sawhorse, flying-wedge), conformations of ethane, propane, n-butane and 2-methylbutane with energy diagram, steric and stereoelectronic factors and conformational analysis in relation to substitution, elimination and addition reactions in acyclic systems. Elementary idea of stereoselective and stereospecific reactions.

Unit: OC – 104 **22L**

Preparations and reactions of alkanes, alkenes, polyalkenes, alkynes and alkyl halides; detailed treatment of S_N1, S_N2, S_Ni, S_N1', S_N2', S_Ni', S_RN1, E1, E2 and E1cB processes; the $S_N1 - S_N2$ mechanistic spectrum, E1-E2-E1cB spectrum with emphasis on methods of investigation of reaction mechanism, α-elimination, *syn*-elimination.

2nd Year 1st Semester

Unit: OC – 201 **30L**

Chemistry of Aromatic Compounds:

Structure of benzene and aromaticity, Benzenoid and nonbenzenoid aromatics, antiaromaticity and homoaromaticity, Aromatic substitution reactions with emphasis on mechanistic aspects, orienting effect of substituents. Higher homologues of benzene, halogen compounds (nuclear and side chain), sulphonic acids, nitro compounds, amines, reactions involving arynes.

Unit: OC – 202 **30L**

Chemistry of Aliphatic Compounds:

A. Mono and polyhydric alcohol – Preparations and Reactions, Aromatic alcohols.

B. Ethers and Epoxides – Methods of preparation, ether cleavage, epoxide ring opening.

C. Aldehydes and Ketones – Preparations and Reactions.

D. Carboxylic acids (mono- and polycarboxylic) and their derivatives, oils, fats and waxes; Mechanism of esterification and ester hydrolysis.

E. Idea of carbanions and their stability, synthetic uses of active methylene compounds.

2nd Year 2nd Semester

Unit: OC – 203 **30L**

Chemistry of Aromatic Compounds:

Diazo compounds and their reactions, Dyes, Phenols, Aldehydes and ketones, Quinones, Mono and polycarboxylic acids, Naphthalene, Anthracene and Phenanthrene – Synthesis and Reactions.

Unit: OC – 204 **30L**

Chemistry of Aliphatic Compounds:

A. *Chemistry of Aliphatic Nitrogen Compounds*:
Nitro compounds, Amino compounds, Quaternary ammonium salts, Nitrogen ylids, Aliphatic diazo compounds, Nitriles, Isonitriles, Isocyanates, Urethanes and urea. Amino acids and peptides.

B. *Chemistry of Organic Sulphur and Phosphorus Compounds*:
Mercaptans and dithiols, sulphides, sulphoxides, sulphones, sulphonic acids, sulphonamides, sulphur and phosphorus ylids (elementary idea)

C. Preparation and uses of organometallic compounds of magnesium, zinc, lithium, cadmium and copper.

D. Synthetic uses of diborane, trimethylsilyl chloride, trimethylsilyl iodide, trimethylsilyl cyanide, triphenylphosphine, tri-n-butyltin hydride, selenium dioxide, manganese dioxide, DDQ; preparation of the above boron, silicon and tin reagents.

3rd Year 1st Semester

Unit: OC – 301 **30L**

Stereochemistry - Unit-II

A. Idea of conformational analysis related to cyclopropane, cyclobutane, cyclopentane, cyclohexane and cycloheptane, treatment of mono- and disubstituted cyclohexanes.

B. Topicity and prostereoisomerism, axial chirality (allenes, spiranes, biphenyls and atropisomerism), planar chirality (*trans*-cycloalkenes).

C. Asymmetric synthesis, Cram's rule, Felkin-Ahn model, Prelog's rule

D. Diastereoselectivity and its application in enantioselective synthesis, Sharpless epoxidation, homogeneous hydrogenation and hydroformylation.

E. Steric assistance and steric hindrance.

Unit: OC – 302 **30L**

Spectroscopy:

Ultraviolet (UV) absorption spectroscopy – Absorption laws (Beer – Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated dienes, polyenes and enones, Woodward – Fieser rules.

Infrared (IR) absorption spectroscopy – Molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic molecules.

Nuclear Magnetic Resonance (NMR) spectroscopy – Proton magnetic resonance (^{1}H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, local diamagnetic effect, anisotropic effect and induced ring current, interpretation of ^{1}H NMR spectra of simple organic molecules such as ethyl bromide, acetaldehyde, ethyl acetate, acetone, ethyl methyl ketone, methyl acetate, ethyl propionate, methyl propionate, toluene and acetophenone.

Unit: OC – 303 **30L**

A. **Chemistry of Reactive Intermediates:** Free radicals, carbenes, nitrenes and nonclassical carbonium ions.

B. **Synthetic methods:** McMurry reaction, Mitsunobu reaction, Julia olefination, Shapiro reaction, Swern oxidation, Baylis-Hillman reaction.

C. Criteria of concertedness of organic reactions, stereoelectronic requirements as applied to molecular rearrangements and neighbouring group participation. Some typical molecular rearrangements [Wagner-Meerwein, pinacol-pinacolone, benzil-benzilic acid, Hofmann, Curtius, Schmidt, Lossen, Dienone- Phenol, Fries, Wolff, Neber, Beckmann, Favorskii, Bayer-Villiger, Wittig, Stevens and Claisen rearrangements].

3rd Year 2nd Semester

Unit: OC – 304 **30L**

A. Ring forming reactions, kinetic and thermodynamic aspects, Baldwin rule.

B. Pericyclic Reactions: Preliminary idea of electrocyclic, cycloaddition and sigmatropic reactions, FMO approach.

C. Disconnection approach and its application for synthesis of simple biologically active molecules.

Unit: OC – 305 **30L**

Chemistry of Heterocyclic Compounds:

Furan, Pyrrole, Thiophene and Pyridine – M.O. picture, synthesis and reactions; Indole, Quinoline and Isoquinoline – synthesis and reactions.

Unit: OC – 306 **30L**

A. **Carbohydrates:** Introduction, occurrence, classification, structures of glucose and fructose: Haworth projection formulae, configuration of monosaccharides, determination of ring size and anomeric effect, conformational analysis of monosaccharides. Reactions of glucose and fructose: Osazone formation, mutarotation, epimerization, chain lengthening and chain shortening in aldoses. Hudson's lactone rule, interconversion of aldoses and ketoses. Importance of ribose and 2-deoxyribose. Introduction to simple disaccharides (Sucrose, lactose and maltose).

B. **Nucleic acids:** Constitutents of nucleic acids. Ribonucleosides and ribonucleotides, the double helix structure of DNA.

C. **Polymers:** Addition polymerization, Ziegler-Natta catalyst, condensation polymerization – polyesters, polyamides, phenol-formaldehyde resin, natural and synthetic rubber.

Organic Chemistry Practical

2nd Year Chemistry Honours

Unit: OC – Lab - I

1. Distillation of carbon tetrachloride : Determination of its boiling point.

2. *Synthesis of Organic Compounds* :

   a) Acetylation (Preparation of Acetanilide)
   b) Bromination (Preparation of *p*-Bromoacetanilide)
   c) Nitration (Preparation of *p*-Nitroacetanilide and *m*-Dinitrobenzene).
   d) Diazotization and coupling (Preparation of Methyl orange)
   e) Replacement of diazonium group by halogen (Preparation of o-Iodobenzoic acid).
   f) Imide formation (Preparation of Phthalimide)

   Monitoring of any one of the above reactions by thin layer chromatography. Purification of the products of the above reactions by decolorisation and/or crystallization and determination of melting points of the pure materials.

3. Determination of mixed melting points (Urea + Cinnamic acid)

4. Estimation of Organic Compounds:

   a) Glucose; b) Phenol or Aniline;
   c) Neutralisation equivalent of acids.

3rd Year Chemistry Honours

Unit: OC - Lab - II

1. *Qualitative Analysis*:

   Identification of an organic compound through study of its physical properties, detection of special element(s) and functional group(s) present in it and preparation of suitable derivative(s).

2. Preparation of organic compounds and their purification by steam distillation (conversion of phenol to *o*– and *p*- nitrophenols).

3. Separation of the constitutents of a binary mixture by column chromatography.

[Expts of Sl. Nos. 2 and 3 will be treated as sessional]

PHYSICAL CHEMISTRY(Honours)

1st Year 1st Semester

Unit:PC–101 ***22L***

A. **Physico-Chemical Quantities** :
Units (emphasis on SI units), dimensions and dimensional analysis of Physical quantities.

B. **Gaseous State : Kinetic Theory of Gases**

Gas laws and postulates of Kinetic theory, expression for gas pressure, average kinetic energy of translation, Boltzmann constant and absolute scale of temperature, root mean square speed and temperature. Barometric distribution law, Avogadro constant.

Maxwell distribution law of molecular speed (no derivation), molecular speed and energy distribution as a function of mean square speeds of molecules, Maxwell-Boltzmann distribution, principle of equipartition of energy, molecular basis of heat capacity. Mean free path and collision frequencies, viscosity of gases.

Unit:PC- 102 **22L**

A. **Real Gases** :
Deviation from ideality, van der Waals equation of state, other equations of state, Boyle temperature, Critical constants, Law of Corresponding States, coefficient of thermal expansion & compressibility, intermolecular forces and liquefaction of gases.

B. **Liquid State** :
Qualitative treatment of the structure of the liquid state, physical properties of liquids including their methods of determination - Vapour pressure, Surface tension, Viscosity, Refractive index. Liquid crystals (elementary discussion on classification, structure and properties), preliminary idea regarding water structure.

1st Year 2nd Semester

Unit : PC – 103 ***22L***

Chemical Thermodynamics : Zeroth Law & First Law

Definition of thermodynamic terms, intensive and extensive variables, isolated, closed and open systems, thermodynamic processes, cyclic processes, reversible and irreversible processes, thermodynamic functions and their differentials, Zeroth law of thermodynamics, concept of heat and work.

First law of thermodynamics and Internal energy (U), Enthalpy (H), relation between C_p and C_v. Calculation of W, Q, ΔU & ΔH for expansion of ideal and Van der Walls gases under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion, Joule's law, Joule-Thompson coefficient and inversion temperature.

Unit : PC – 104 ***22L***

A. Chemical Thermodynamics : Thermochemistry

Application of first law of thermodynamics, standard state, standard enthalpy of formation, Hess's law of constant heat summation. Enthalpy of solution, enthalpy of dilution (including enthalpy of infinite dilution) enthalpy of neutralization, enthalpy of ionization and of formation of ions, Bond dissociation energy (calculation from thermo-chemical data). Born-Haber cycle for calculation of lattice energy, Kirchoff's equation, relation between ΔH and ΔU of a reaction.

B. Solids :

The nature of solid state, law of constancy of angles, concept of unit cell, seven crystal systems, Bravais lattices, law of rational indices, Miller indices, symmetry elements in crystals.

X-Ray diffraction, Bragg's law, Laue's method, power method, crystal structure of NaCl and KCl, radius ratios and packing in crystals.

2nd Year 1st Semester

Unit : PC –201 ***30L***

Chemical Thermodynamics :

Second Law, Third Law, Spontaneity and Equilibrium.

Spontaneous processes, Heat engine, Carnot cycle and its efficiency.

Statements of Second law, refrigeration cycle, thermodynamic scale of temperature. Entropy as a state function, calculation of entropy changes in different processes, molecular interpretation of entropy.

Nernst heat theorem , third law of thermodynamics.

Gibbs function (G) and Helmholtz function (A), criteria for thermodynamic equilibrium and spontaneity, vatriation of G and A with P, V and T. Thermodynamic equation of state.
Clausius-Clapeyron equation, equilibrium between different phases, Chemical equilibria in homogeneous and heterogeneous systems, expression of equilibrium constants, pressure, temperature and concentration dependence of equilibrium constants (K_c, K_p and K_x) Le Chatelier's principle.

Unit : PC – 202 ***30L***

Chemical Kinetics

Concept of rate and differential rate of reaction. Rate laws and rate equations, order of a reaction and molecularity, differential and integrated forms of rate equation (upto second order only), experimental methods for determination of order of reaction, comparison of methods (Guggenhime's method, differential method , isolation method).

Elementary and complex reactions, rate determining step, steady state approximation and derivation of rate laws of complex reactions; opposing, parallel, consecutive and chain reactions, temperature dependence of reaction rates and energy of activation, catalysed reactions.

Theories of reaction rates, collision theory, transition state theory (elementary idea), theory of unimolecular reactions.

Reactions in solution, homogeneous catalysis, acid-base catalysis, Salt effect and solvent effect (qualitative aspects). Enzyme catalysis, elementary idea about inhibition.

Oscillatory reaction.

2nd Year 2nd Semester

Unit : PC 203 ***30L***

A. **Colligative Properties** : (Studies from chemical potential consideration).

Dilute solution, Raoult's ;aw and Henry's law, relative lowering of vapour pressure, elevation of boiling point, depression of freezing point, Osmosis, Osmotic pressure and its determination, relation between colligative properties and molecular mass. Van't Hoff factor, abnormal molar mass.

B. **Phase Equilibria** :

Phase, component, degree of freedom, phase rule for non-reactive and reactive systems, equilibrium between phases, cooling curves and phase diagrams, phase diagrams for one and two component systems (involving eutectics), congruent and incongruent melting points, solid solutions.

Liquid-liquid mixture, fractional distillation of binary miscible liquids, azeotropes, Lever rule, lower and upper critical solution temperature, steam distillation, Nernst distribution law.

Phase equilibria in 3 component systems, Higher order phase transition. Phase equilibria in 3 component systems, Higher order phase transition. Phase equilibria in 3 component systems, Higher order phase transition.

Unit : PC –204 ***30L***

Electrochemistry : Ionics (Ionic equilibrium and conductance)

Strong and weak electrolytes, dissociation equilibria of weak electrolytes, multistage equilibria.

Conductance and its measurements, molar conductivity, Kohlraush law of independent migration of ions, variation of molar conductivity with concentrations of weak and strong electrolytes. Arrhenius and Debye-Huckel Theories, mean activity coefficient, ionic strength, dependence of activity coefficient on ionic strength, conductometric titrations, determination of solubility product and dissociation constant by conductance measurements.

Transference number and their experimental determination, anomalous transference numbers, ionic velocities and mobilities, Stoke's law, proton jump mechanism, Stokes – Einstein equation.

3rd Year 1st Semester

Unit : PC 301 ***30L***

Electrochemistry : Electrodics

Electrolytic and galvanic cells, reversible and irreversible cells, electromotive forces of a cell and its measurement, Nernst equation, determination of E^0 and equilibrium constant of a cell reaction free energy, entropy and enthalpy of cell reactions.

Electrochemical potential, inner, outer and surface potential, standard electrode potential, types of electrodes (including reference electrode) and half cells, determination of solubility product and ionic product of water, measurement of mean ionic activity coefficient of electrolytes, determination of E^0 of M^{z+}/M systems, activity coefficients of HX, MX etc.

Concentration cells with and without transference, liquid junction potential, pH determination using Hydrogen electrode, quinhydrone electrode, glass electrode, redox electrode, potentiometric (acid-base redox and precipitation) titration, determination of pk_a and pk_b of acids, bases and of ampholytes by emf methods, electrochemical power sources; primary, secondary and fuel cells.

Polarization and overvoltage phenomena, Activation polarization; basics of activation controlled reactions, Tafel Equation. Electrochemical processes, theories of H_2 overvoltage, corrosion and inhibition of corrosion (preliminary idea), electroplating.

Unit : PC - 302 ***30L***

A. **Adsorption and Surface Phenomena** :

Physisorption and chemisorption, adsorption isotherms, quantitative aspects of Freundlich and Langmuir adsorption isotherms. B.E.T. equation and its use in surface area determination, adsorption and heterogeneous catalysis.

Colloids, electrical double layer and colloid stability, electrokinetic phenomena, elementary ideas about soaps and detergents, micelles and emulsions.

Pressure inside a droplet, vapour pressure of curved surfaces and Kelvin's equation, concept of surface excess, Gibbs equation insoluble monolayer and surface pressure.

Liquid- liquid interface-immiscibility, contact angle and surface spreading.

B. **Macromolecules**

Characteristics of macromolecules, degree of polymerization, concept of number and weight average molecular mass, osmometry, viscometry, light scattering and diffusion methods in the studies of average molecular weights and shapes of macromolecules.

Unit : PC – 303 ***30L***

Basic Quantum Chemistry

Black body radiation, failure of classical mechanics and ultraviolet catastrophe, Plank's distribution law, photoelectric effect and Compton effect, diffraction of electrons, de Broglic equation and matter wave, principle of complimentarity.

Uncertainty principle, operators and observables, Schrodinger equation, interpretation of the wave function, stationary and nonstationary states.

Quantisation of translational motion : Solution of Schrodinger equation for one, two and three dimensional box problem, degenerate states, Tunneling through potential barrier.

Quantisation of vibrational motion : The linear harmonic oscillator, vibrational wave function and vibrational energy levels (no rigorous derivation), vibrational selection rule.

Hydrogen Atom : Wave function and energy levels of hydrogen-like atoms (no rigorous derivation), a Phase equilibria in 3 component systems, Higher order phase transition.tomic orbitals, radial distribution function, n, l, m, s quantum numbers.

3rd Year 2nd Semester

Unit : PC – 304 ***30L***

Statistical Thermodynamics:

Limitations of classical thermodynamics, brief resumes of the concepts of distribution of energy and velocity, thermodynamic probability, ensembles, Maxwell Boltzmann distribution law, Statistical interpretation of thermodynamic laws and parameters, Partition function and its physical significance, relationship between thermodynamic functions and partition functions, application in case of ideal monatomic gases, diatomic gases (translational, rotational, vibrational) Specific heat of solids-Dulong Petit's law, Einstein's law and Debye's law (Rigorous deduction not needed).

Unit : PC – 305

30L

A. **Photochemistry** :

Grotthus-Draper law, Lambert-Beer's law, Stark-Einstein law of photochemical equivalence, quantum yield, photostationary equilibrium, photodimeristion of anthracene, rate of photochemical reactions, actinometry. Luminescence, phosphorescence, fluorescence, chemiluminescence phenomena, photosensitized reations, quenching of fluorescence, Stern-Volmer equation.

Flash photolysis technique, comparision between thermal and photochemical reactions.

Frank Condon principle, photochemical reaction such as HI decomposition, HCl reaction.

B. **Electrical and Magnetic properties of matter** :

Intermolecular forces and dipole moments, basic idea of electrostatics, electrostatics of dielectric media, Clausius – Mossotti equation.

Lorentz-Lorentz equation. Dipole moments and molecular polarisabilities and their measurements. Diamagnetism and paramagnetism, magnetic susceptibility and its measurement.

Unit:PC – 306 ***30L***

Atomic and Molecular Spectra

Electromagnetic radiation, interaction of electromagnetic radiation with atoms and molecules and quantisation of different forms of energies (translational, rotational, vibrational and electronic).

Condition of resonance and energy of absorption for various types of spectra.

Origin of atomic spectra, spectra of hydrogen atoms, many-electron atoms, total Phase equilibria in 3 component systems, Higher order phase transition.spin and total angular momentum (J), Terms and Symbols, spectral selection rules.

Rotational Spectra : rigid rotor model, energy and eigenfunction, parity of wave function, molecular symmetry, moment of inertia, intensity of spectral lines, determination of bond lengths of diatomic molecules.

Vibrational Spectra : Harmonic oscillator model, zero-point energy, energy levels and wave functions, diatomic vibrating rotor, anharmonicity, Morse potential, dissociation energies, overtones and hot bands; PQR branches, force constant from fundamental frequencies, application of vibration spectra in elucidation of molecular structure.

Physical Chemistry Practical

3rd Year Chemistry Honours

Unit : PC – Lab. I

1. Surface Tension by Capillary rise method
2. Viscosity Coefficient by Ostwald Viscometer.
3. Rate constant of a 1st order reaction.
4. Specific Rotation by Polarimetry.
5. Absorption maximum and extinction coefficient by colorimetry.
6. Adsorption from solution on a solid surface.
7. Potentiometric trtration of mixture of acids.
8. Conductometric titration of mixture of acids.
9. Dissociation constant of an acid from conductance and potentiometric measurements.
10. Distribution coefficient of benzoic acid.
11. Equilibrium constant of a homogeneous chemical equilibrium.
12. Phase diagram of a liquid ternary system.
13. Critical solution temperature of a partially miscible liquid mixture.
14. Molecular weight by ebullioscopic / cryospoic method.
15. Determination of CMC.