UNIVERSITY OF GOUR BANGA

(Established under West Bengal Act XXVI of 2007)

N.H.-34 (Near Rabindra Bhawan), P.O.: Mokdumpur,
Dist.: Malda, West Bengal, Pin-732 103

UG Syllabus and Question Pattern (Honours & General)
(Chemistry)

Main Feature of the Syllabus

Chemistry (Honours)

Part/ Course	Paper	Revised Paper Code	MCQ / Descriptive	Marks	Time	Total Marks	Total Time
Part- I	I	I-A	MCQ	10	20 Min	50	2.00 Hr
		I-B	Descriptive	40	1.40 Hr		
	II	II-A	MCQ	10	20 Min	50	2.00 Hr
		II-B	Descriptive	40	1.40 Hr		
	III	III-A	MCQ	10	20 Min	50	2.00 Hr
		III-B	Descriptive	40	1.40 Hr		
	IV	IV	Practical	60	4.00 Hr	60	4.00 Hr
Part- II	V	V-A	MCQ	10	20 Min	50	2.00 Hr
		V-B	Descriptive	40	1.40 Hr		
	VI	VI-A	MCQ	10	20 Min	50	2.00 Hr
		VI-B	Descriptive	40	1.40 Hr		
	VII	VII-A	MCQ	10	20 Min	50	2.00 Hr
		VII-B	Descriptive	40	1.40 Hr		
	VIII	VIII	Practical	60	4.00 Hr	60	4.00 Hr
Part-III	IX	IX-A	MCQ	15	30 Min	65	3.00 Hr
		IX-B	Descriptive	50	2.30 Hr		
	X	X-A	MCQ	15	30 Min	65	3.00 Hr
		X-B	Descriptive	50	2.30 Hr		
	XI	XI-A	MCQ	15	30 Min	65	3.00 Hr
		XI-B	Descriptive	50	2.30 Hr		
	XII	XII-A	MCQ	15	30 Min	65	3.00 Hr
		XII-B	Descriptive	50	2.30 Hr		
	XIII	XIII	Practical	60	4.00 Hr	60	4.00 Hr
	XIV	XIV	Practical	60	4.00 Hr	60	4.00 Hr

Chemistry (General)

Part/ Course	Paper	Revised Paper Code	MCQ / Descriptive	Marks	Time	Total Marks	Total Time
Part- I	I	I-A	MCQ	30	30 Min	90	3.00 Hr
		I-B	Descriptive	60	2.30 Hr		
	II	II	Practical	60	4.00 Hr	60	4.00 Hr
Part- II	III	III-A	MCQ	30	30 Min	90	3.00 Hr
		III-B	Descriptive	60	2.30 Hr		
	IV	IV	Practical	60	4.00 Hr	60	4.00 Hr
Part-III	V	V-A	MCQ	20	30 Min	60	3.00 Hr
		V-B	Descriptive	40	2.30 Hr		
	VI	VI	Practical	40	3.00 Hr	40	3.00 Hr

- Each MCQ Type Question carrying Two Marks.
- Revised Paper Code as treated Official Paper Code.

Syllabus (Draft Copy) For B.Sc. Honour In Chemistry

(Course Duration = 3 years, Part (I+I+I) with effect from the session 2015-16)

Total Marks=800

Theory = 560 Practical = 240

	Theory		*Marks*			*Practical*		*Marks*	*Total*
	Paper	***Subject***	***MCQ***	***Broad***	***Total***	***Paper***	***Subject***		
Part-I	Paper-I	Organic	10	40	50	Paper-IV	Organic	60	**210**
	Paper-II	Inorganic	10	40	50				
	Paper-III	Physical	10	40	50				
Part-II	Paper-V	Organic	10	40	50	Paper-VIII	Inorganic	60	**210**
	Paper-VI	Inorganic	10	40	50				
	Paper-VII	Physical	10	40	50				
Part-III	Paper-IX	Organic	15	50	65	Paper-XIII	Analytical	60	**380**
	Paper-X	Inorganic	15	50	65	Paper-XIV	Physical	60	
	Paper-XI	Physical	15	50	65				
	Paper-XII	Analytical and Industrial Chemistry	15	50	65				

Total: 800

PART-I

Paper-I **Organic Chemistry** **Full Marks: 50**

GROUP-A

Unit-I: Structure and Bonding **10L**

Orbital Hybridization of carbon: sp^3, sp^2 and sp hybridization, bond length, bond angles, bond energy and bond dissociation energy, distortion of bond angles –explanation by electron-pair repulsion (qualitatively). Polarization of a covalent bond: inductive effect and field effect, mesomeric (conjugative) effect, time-variable effects, hyperconjugation and steric effect. Aromaticity: Huckel's rule, aromatic, nonaromatic and antiaromatic compounds. Intermolecular forces: dipole-dipole interaction, van der Waals forces and hydrogen bonding. Dipole moment. Application of these effects in explaining relative strength of simple organic acids and bases.

Unit-II: Mechanism of Organic Reactions **10L**

Drawing electron movements with arrows, curved arrow notations, half-headed and double headed arrows, homolytic and heterolytic bond breaking. Types of reagents- electrophiles and nucleophiles. Types of organic reactions: Displacement (Substitution), Addition, Elimination and Rearrangement. Reactive intermediates: carbocations, carboanions, free radicals, carbenes, arynes and nitrene (with example). Energetics of reaction thermodynamic and kinetic considerations: thermodynamically and kinetically controlled reactions. Methods of determination of reaction mechanism (product analysis, intermediates, isotope effect, kinetic and stereochemical studies).

Unit-III: Stereochemistry **10L**

Concept of isomerism, Types of isomerism. Representation of organic molecules: Fischer, Newman, sawhorse, flying-wedge and their interconversions. Molecular symmetry: plane, centre, simple and alternating axes; symmetry operations, chiral carbon, molecular chirality, optical activity, stereogenic centre, optical rotation: specific and molecular; enantiomers, diastereomer and meso-compounds (definition and properties). Geometrical isomerism (diastereomerism) of molecules with C=C, C=N (oxime) and simple cyclic molecules. Configurational Nomenclature: D/L, R/S, erythro/threo, cis/trans, E/Z and syn/anti. Conformation: dihedral angle, angle of torsion, gauche (skew), eclipsed and staggered arrangement, conformational analysis with energy diagram of ethane, n-butane and 1, 2-ethane diol. Difference between configuration and conformation.

GROUP-B

Unit-IV: Alkanes **4L**

IUPAC nomenclature of branched and unbranched alkanes, homologous series, effect of branching and intramolecular forces on melting point and boiling points.

Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.

Unit-V: Alkenes, Dienes and Alkynes **8L**

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration, physical properties and relative stabilities of alkenes. Chemical reactions of alkenes: mechanisms involved in hydrogenation, heat of

hydrogenation and stability of alkenes, addition reactions of halogens, HX acids, H_2SO_4, hydration, halohydrin formation, hydroxylation, dimerisation, alkylation, ozonolysis, hydroboration-oxidation (synthetic use in regioselective synthesis), Markownikov's rule, peroxide effect on HBr addition, Oxymercuration-Demercuration, concept on regioselective, stereoselective and stereospecific reactions. Nomenclature and classification of dienes: Isolated, conjugated and comulated dienes. 1, 4-addition of bromine, 1, 2- vs 1, 4- addition. Nomenclature, structure and bonding in alkynes. Methods of formation, reactions: addition of hydrogen, halogen, hydrogen halides, hydration and acidity.

Unit-VI: Aromatic Hydrocarbons **10L**

Benzene: structure, explanation of stability by resonance theory. Aromaticity: Huckel's (4n+2) rule, application of Huckel's (4n+2) rule in explaining the aromatic character of cyclopropenone system, cyclopentadienyl anion, tropylium ion. Benzene derivatives: nomenclature, electrophilic substitution reaction: halogenations, nitration, sulphonation-desulphonation, Friedel-Crafts reaction, Wurtz-Fittig reaction, Gatterman-Koch reaction, reactions of side–chain (halogenations, oxidation and dehydrogenation), mechanism of electrophilic substitution reaction explanation based on stability of σ-complexes. Energy profile diagrams, activating and deactivating substituents, orientation and ortho/para ratio. Reduction and oxidation reactions of alkyl benzene; Birch reduction. Nucleophilic aromatic substitution reaction: S_NAr, S_N1, benzyne and $S_{RN}1$ mechanism, the effect of substrate structure in case of cine substitution, von Richter rearrangement, Sommelet-Hauser Rearrangement and Ullmann reaction.

Unit-VII: Polynuclear Aromatic Hydrocarbons **4L**

Naphthalene, anthracene and phenanthrene: nomenclature, aromatic stabilization, structure determination, reactions and synthesis (Haworth) of naphthalene. Reaction and synthesis of anthracene and phenanthrene (Bogert-Cook and Bardhan-Sengupta synthesis).

Unit-VIII: Alkyl and Aryl Halides **4L**

Nomenclature and classes of alkyl halides, preparation and reactions. Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides.

Part-I **Paper II** **Inorganic Chemistry** **Full Marks: 50**

Group-A

Unit–I: Atomic Structure **12 L**

Bohr's theory of atomic structure and its limitations. Application of Bohr's theory to hydrogen and hydrogen like atoms and ions, Sommerfeld's extension and quantum numbers, De Broglie's wave particle duality; Heisenberg's uncertainty principle and Schrödinger's equation (qualitative). Significance of ψ and ψ^2. Introduction to the concept of atomic orbitals; shapes, radial and angular probability diagrams of s, p and d orbitals (qualitative idea). Many electron atoms and ions: Pauli's exclusion principle, Hund's rule, exchange energy, Aufbau principle and its limitation. Term symbols of atoms and ions for atomic numbers less than 30.

Unit-II: Chemical periodicity **10 L**

Periodic table, group trends and periodic trends in physical properties. Classification of elements on the basis of electronic configuration. Modern IUPAC Periodic table. General characteristic of s, p, d and f block elements. Position of hydrogen and noble gases in the periodic table.

Effective nuclear charges, screening effects, Slater's rules, atomic radii, ionic radii (Pauling's Methods), covalent radii and vander Waals radius. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred-Rochow's scales) and factors influencing these properties. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements.

Unit-III: Acid and bases **8 L**

Arrhenius concept. Theory of solvent system. Bronsted Lowry's concept, Lewis concept of acid and bases, relative strength of acids and bases, effect of substituents and solvents. Hydracids and oxyacids, Amphoterism, Lux-flood concept, Usanovich's concept. donor/acceptor number, Gutmann's rules, HSAB principle (Hard-soft acids and bases), symbiosis, Hammett acidity function. Applications of acid base chemistry – Super acids and Super bases. pH and its calculation. Buffer solutions, salt hydrolysis, acid-base titration, acid-base indicator (theory and choice).

Group-B

Unit-IV: Chemical Bonding and Structure **18 L**

Ionic bonding: Radius ratio rules and their limitations. Packing of ions in crystals, lattice energy, Born-Lande equation and its applications, Born-Haber cycle and its applications. Solvation energy and solubility of ionic solids, Polarising power and polarisability, ionic potential, Fajan's rules. Defects in solids (elementary idea).
Covalent bonding: Lewis structures, formal charge. Valence Bond Theory and its limitations,
directional character of covalent bonds, hybridizations and shapes of simple inorganic molecules and ions, equivalent and non-equivalent hybrid orbitals, Bent's rule, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups elements), Percentage of ionic character from dipole moment and electronegativity difference.
Weak Interactions: Van der waals and London forces, ion - dipole and dipole - dipole interaction, Hydrogen bonding.

Unit-V: Study of elements and their compounds **12 L**

Comparative study of p-block elements: Group trends in electronic configuration, common oxidation states, inert pair effect, catenation and catalytic properties (if any), and their important compounds in respect of the following groups of elements:

i) Group-14 (C, Si, Ge, Sn, Pb)
ii) Group-15 (N, P, As, Sb, Bi)
iii) Group-16 (O, S, Se, Te)
iv) Group-17 (F, Cl, Br, I)
v) Group- 18 (He, Ne, Ar, Kr, Xe)
(Poly halides, pseudo halides, silicates, silicones, thionic acid, chemistry of hydrazines, hydroxylamines and azides)

Part- I **Paper – III** **Physical Chemistry** **Full Marks: 50**

Group-A

Unit-I: Gas **10L**

Fundamental assumption of kinetic theory, the kinetic gas equation, some derivations from kinetic gas equation, Maxwell molecular speed distribution (derivation not required), effect of temperature on distribution; calculation of number of molecules having energies≥ E ; derivation of most probable, root mean square and average velocities (with the introduction of related mathematical concepts). Barometric distribution law, Principle of equipartition of energy, degree of freedom, calculation of Cp and Cv, variation with temperature

Collision of gases **3L**

Collision of gas molecules, collision diameter, collision cross section, frequency of binary collisions (similar and different molecules), mean free path, effect of temperature and pressure, wall collision and rate of effusion, viscosity of gases.

Real gases **7L**

The equation of State, the concepts of an ideal gas, Andrew's and andAmagat's plots, compressibility factor, Derivation of Van der waals equation, virial equation, significance of second virialcoefficient, Boyle temperature, Dieterici equation and its features, critical state, critical parameters in terms of Van der waals constants, determination of critical constants, law of corresponding states.

Unit-II: Thermodynamics-I **7L**

Scope, definition of systems (isolated, closed, open) surrounding, boundary, different types of processes, variables (intensive and extensive), functions (state and path). Partial and total derivative, Euler's reciprocity, cyclic rule, exact and inexact differentials.

Zeroth and first law of thermodynamics. Heat and work (reversible, irreversible, isothermal, adaibatic). Internal energy, enthalphy, heat changes at constant volume and constant pressure; relation between Cp and Cv using ideal gas, calculation of work (W), quantity of heat (q), Joules experiment and its consequence,Joule - Thomson experiment and its consequences, J-T coefficient for a van der Waals gas.

Thermochemistry **3L**

Thermochemical equation, kirchoff's equations, different types of heat changes during physicochemical processes at constant P/V, Hess's law, Bond dissociation energies, Born Haber cycle for calculation of lattice energy.

GROUP-B

Unit-III: Thermodynamics-II **14L**

Second law of thermodynamics and its need, Kelvin, Planck and Clausius statements and their equivalence, Carnot cycle and refrigerator, Carnot's theorem, thermodynamic scale of temperature. Physical concept of entropy, Clausius inequality, entropy change of system and surrounding for various processes and transformations, entropy change during isothermal mixing of ideal gases, entropy and unavailable work, Gibbs function (G) and Helmholtz function (A) and their variations with T, P and V, criteria of spontaneity and equilibrium.

Thermodynamic relations, Maxwell relations, thermodynamic equation of state, Gibbs - Helmholtz equation and its consequences.

Unit-IV: Chemical equilibrium **6L**

Chemical equilibria in homogeneous and heterogeneous systems, Thermodynamic derivation of equilibrium constant, the reaction isotherm, pressure and temperature dependence of equilibrium constant,Vant's Hoff equation, Principle of Le Chattelier and Braun, Effect of pressure, temperature, concentration and Inert gas on equilibrium.

Unit-V: Liquid state and viscosity of Fluids **10L**

Properties of liquid, vapour pressure equation, surface tension, surface energy, interface, effect of temperature (EÖtvÖs) equation, critical temperature, determination of surface tension (Capillary rise, capillary depression, stalagmometer), excess pressure inside bubble and drops (basic idea of Young -

Laplace equation), cohesion, adhesion, work of cohesion and adhesion, spreading of liquid over other surface.

Definition, viscosity of gas and liquid and effect of temperature, laminer and turbulent flow, Newtonian, non-Newtonian fluid, Newton's law of viscosity, Poiseuille's Law, viscosity coefficient, effect of temperature on viscosity coefficient, measurement (Ostwald viscometer, failing sphere method).

PART-I, PRACTICAL

Paper-IV **ORGANIC CHEMISTRY** **Full Marks: 60**

Experiment-1: Qualitative Analysis of Single Solid Organic Compounds

A. Determination of Melting Point of Given Organic Sample.
B. Preliminary test: (i) Ignition test (ii) Test for Active Unsaturation ($KMnO_4$ test) (iii) pH test
C. Detection of Special Elements (N, Cl, S) by Lassaigne's test.
D. Solubility and Classification [Solvents: H_2O, Ether, 1.2 (N) HCl, 2.5 (N) NaOH, 1.5 (N) $NaHCO_3$, and conc. H_2SO_4]
E. Detection of the Following Functional Groups by Systematic Chemical Tests:
   i. Carboxylic acid group (-COOH)
   ii. Phenolic group (-OH)
   iii. Carbonyl group (>C=O)
   iv. Formyl/ aldehyde group (-CHO) [Tollen's test, Fehling's test]
   v. Primary aromatic amino group ($-NH_2$)
   vi. Aromatic nitro group ($-NO_2$)
   vii. Amido group ($-CONH_2$)
   viii. Anilido group (-CONHAr)
F. Preparation of derivatives:
   a. Benzoyl derivative [phenolic group (–OH) and Primary aromatic amino group ($-NH_2$)]
   b. Anilide or Amide or Ester derivative [Carboxylic acid group (-COOH)]
   c. Oxime or 2, 4- D. N P derivative [aldehyde and ketone]
   d. Hydrolysis products [Amido group ($-CONH_2$), Anilido group (-CONH-)]
   e. Reduction products [Aromatic nitro group ($-NO_2$)]

Experiment-2: Organic Preparation

1. *m*- dinitrobenzene from nitrobenzene
2. *p*- nitroacetanilide from acetanilide
3. benzil from benzoin
4. benzilic acid from benzil
5. preparation of methyl orange

Purification of the crude product is to be made by crystallization (water/alcohols)

PART-II

Paper-V **Organic Chemistry** **Full Marks: 50**

GROUP-A

Unit-I: Alcohols **7L**

Classification and nomenclature, method of formation by reduction of aldehydes, ketones, carboxylic acids and esters; hydrogen-bonding, acidic nature. Reaction with hydrogen halides, phosphorus trihalides, ester formation, dehydration, oxidation rection-Oppeneaur oxidation, Oxidative cleavage [$Pb(OAc)_4$ and HIO_4] of dihydric alcohols. Chemical reactions of glycerol. Rearrangement reactions: pinacol-pinacolone, semi pinacol-pinacolone, dieneone phenol rearrangements.

Unit-II: Phenols **5L**

Nomenclature, structure and bonding. Preparation of Phenols, physical properties and acidic character. Reactions: electrophilic aromatic substitution, acylation and carboxylation. Mechanism of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Houben-Hoesch reaction, Lederer-Manasse reaction. Dakin reaction, Demyanov rearrangement (Tiffeneau-Demyanov ring expansion), Reimer-Tiemann reaction, Kolbe reaction.

Unit-III: Ethers and Epoxides **3L**

Nomenclature of ethers, preparation, physical properties. Chemical reactions: cleavage and autoxidation; Ziesel's method. Synthesis of epoxides, acid and base-catalysed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

Unit-IV: Aldehydes and Ketones **10L**

Nomenclature and structure of carbonyl group. Synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones using 1,3-dithianes, synthesis ketones from nitriles and carboxylic acids, physical properties. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin, Knoevenagel and Stobbe condensations, benzilic acid rearrangement, Nef carbonylation reaction, reaction with Grignard reagents. Condensation with ammonia and its derivatives, Wittig reaction, Mannich reaction, Claisen condensation, Dieckman reaction, Darzen's glysidic ester synthesis.
Use of actals as protecting group. Oxidation of aldehydes, Baeyer-Villiger oxidation, Cannizaro reaction, Meerwein-Pondorf-Verley reduction, Clemmensen, Wolff-Kishner, Mozingo, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable carbonyl compounds, haloform reaction.
An introduction to α, β-unsaturated aldehydes and ketones, Michael reaction.

Unit-V: Carboxylic Acids and Its derivatives **5L**

Structure and nomenclature, General methods of preparation (outline) and general reactions of carboxylic acids, acid chlorides, esters, amides and acid anhydrides. Hell-Volhard-Zelinsky reaction, mechanism of decarboxylation of carboxylic acids, esterification of acids and hydrolysis of acid derivatives.

Interconversionn of acids and acid derivatives.

GROUP-B

Unit-VI: **Nucleophilic Substitution and Elimination Reactions** **10L**

Kinetics of nucleophilic substitution of alkyl halides: S_N1 and S_N2 mechanisms, effect of solvent, effect of structure. Stereochemical implications of mechanism: S_N2- inversion of Configuration, determination of

relative configuration; S_N1- racemization, S_Ni mechanis- retention of configuration, Neighbouring group participation (*anchimeric assistance*), Effect of entering groups and leaving groups.

Elimination reactions: 1,1 (α) and 1, 2 (β)-elimination, mechanism of β-elimination: E1, E1cB and E2; stereoselectivity in E2- Saytzev *vs* Hofmann Elimination; Elimination vs Substitution; Effect of Activating groups; Other 1, 2- Elimination (departure of an atom or group other than H from C^{β}); Pyrolytic *syn* elimination.

Unit-VII: Organometallic and Organosulphur Compounds **6L**

Organomagnesium compounds: the Grignard reagent: formation, structure and chemical reactions.
Organozinc compounds: formation and chemical reactions.
Organolithium compounds: formation and chemical reactions.
Organosulphur compounds: Nomenclature, structural features, methods of formation and chemical reactionsof thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine.

Unit-VIII: Important Reagents **3L**

LDA, $LiAlH_4$, B_2H_6, 9-BBN, Me_3SiCl, R_2CuLi, Wilkinson catalyst, $NaBH_4$, DIBAL-H, 1, 3-dithane, OsO_4, $KMnO_4$, SeO_2, $Pb(OAc)_4$, HIO_4 and NBS.

Unit-I: Stereochemistry **5L**

Diastereomers: *threo* and *erythro* diastereomers and their stability difference, *meso* compounds. Racemic mixture (definition), resolution: method of resolution (mainly formation of diastereomers methods). Optical purity: calculation of percentage composition of chiral compounds in a mixture (enantiomeric excess). Concept of relative and absolute configuration.

Unit-IX: Organic Compounds of Nitrogen **6L**

Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nucleophilic substitution in nitroarenes and their reductions in acidic, neutral and alkaline media, Picric acid.
Haloniterenes: reactivity, structure and nomenclature of amines, physical properties; Stereochemistry of amines. Separation of a mixture of primary, secondary and tertiary amines: the Hinsberg method. Preparation of primary amines: Hofmann, Curtius, Lossen and Schmidt reactions. Gabriel-Phthalimide synthesis.
Oximes: Geometric isomerism, determination of configurations-the Beckmann rearrangement.
Diazo compounds: diazomethanes, diazoacetic ester and their uses; Arndt-Eistert synthesis, Sandmeyer reaction, Schiemann reaction and Gomberg reaction.
Aromatic Diazonium Salts: stability, preparation, replacement, reduction and coupling reactions of diazonium salts.

Part-II **Paper-VI** **Inorganic Chemistry** **Full Marks: 50**

GROUP-A

Unit-I: Radioactivity **12 L**

Radioactive decay, half life and average life of radio elements, units of radioactivity, natural radioactive disintegration series, radioactive equilibrium, group displacement law, isotope, isotone, isobars and nuclear

isomerism. Application of isotope in medicine, agriculture, reaction mechanism (isotope as tracer), age of minerals, age of earth, radio carbon dating, nuclear particles, nuclear forces: meson exchange theory. Nuclear models (elementary idea),

nuclear stability, nuclear binding energy, nuclear reactions, magic numbers, mass defect, proton-neutron ratio, packing fraction, Artificial radioactivity, transmutation of elements, fission, fusion and spallation reaction. Nuclear energy, hazards of nuclear radiations and safety measures.

Unit-II: Molecular orbital theory. 8 L

LCAO approximation, bonding, antibonding and non -bonding orbitals, MO configurations of simple homonuclear diatomic (H_2 to He_2) and hetero nuclear diatomic molecules (NO, CO, HF and HCl), bond properties, bond order and bond strength.

Unit-III: Study of elements and their compounds 10 L

General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation oxidation states, inert pair effect (if any),Diagonal relationship, aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such as hydrides, halides, oxides, oxyacids (if any), hydracids, complex chemistry (if any) in respect of the following elements:

(i) s-block elements: Li-Na-K (Group 1), Be-Mg-Ca-Sr-Ba (Group 2).

(ii) p-block elements: B-Al-Ga-In-Tl (Group 13).

(Preparation, Structure, bonding and reactivity of B_2H_6; (SN)x with x = 2, 4; phosphazines; interhalogens. Structure of borates, borazole, boron nitride)

GROUP-B

Unit-IV: Redox potential 10 L

Standard electrode potentials, redox potentials and formal potentials, Nernst equation, redox potentials to explore the feasibility of reaction and calculation of values of equilibrium constant, redox potential as a function of pH, precipitation and complex formation, redox titrations and redox indicators, Frost and Latimer diagrams of redox potentials.

Unit-V: Lanthanides and Actinides 6 L

General features with respect to their position in the periodic table, electronic structure, oxidation states, magnetic properties and complex behaviour lanthanide contraction and its effect, separation of lanthanides through ion -exchange method; Similarities between later lanthanides and later actinides.

Unit-VI: Non-aqueous solvents 4 L

Physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid NH_3, liquid SO_2 and liquid HF.

Unit-VII: Chemistry of Elements of the First Transition series 10 L

Characteristic properties of d-block elements. Properties of the elements of the first transition series, their binary compounds and complexes. Jorgensen's proposition, Werner's theory, classification and binding modes of ligands. Nomenclature of complexes

Part-II Paper-VII Physical Chemistry Full Marks: 50

GROUP-A

Unit – I: Thermodynamics – III **6L**

Clapeyron equation, Clausius - Clapeyron equation, Trouton's rule. Open systems, activity, fugacity, activity coefficients, partial molar quantities, chemical potential, thermodynamics of mixing (ΔG_{mix}, ΔS_{mix}, ΔH_{mix}) Gibbs - Duhem equation, fugacity of gases and fugacity coefficient.

Unit – II: Phase Equilibrium **17L**

Phase, phase stability, first order phasetransition, transition temperature, phase, boundary, slope of phase boundary, vapour pressure, critical point boiling point and melting point (normal and standard). Henry's law, Nernst's distribution law, solvent extraction, phase, component degree of freedom, phase rule, derivation from thermodynamics. One component system, (Water, CO_2 and sulpher) triple point, Two component system - (i) Completely immiscible liquid pair: Steam distillation, (ii) Partially miscible liquid pair - water phenol, water - triethyl amine, nicotine - water system etc. lever rule, (iii) Completely miscible liquid pair :DuhemMargulesequation,Konowaloff'srule,devationfrom Raoult's law, azeotrope, principle of isobaric fractional distillation. (iv) Solid - solution equilibria; Simple eutectic system, systems with congruent and incongruent melting points, peritectic line.

Unit – III: Macromolecules **8L**

Introduction, types of polymers, classification of solvents, degree, extent and kinetics of polymerization, number and weight average molecular weights and their relation determination of molecular weights by osmometry and viscometry.

GROUP-B

Unit – IV: Electrolytic conduction **8L**

Conductance : Conductance and its measurement, specific conductivity, molar conductivity and equivalent conductivity, their variation with concentration for strong and weak electrolytes, Ostwald's dilution law, ionic velocities and mobilities, Kohlrausch's law of independent migration of ions, asymmetry effect, electrophoretic effect, Debye-Huckell - Onsager equation (no derivation), conductometric titration (acid - base, precipitation - and replacement reactions), temperature dependence of ion conductivity, Stoke's law, Walden's rule, Debye - Falkenhagen effect and Wien effect, application of conductance measurement, transport number, abnormal transport number, solvation of ions, measurements of transport numbers (moving boundary method)

Electromotive Force **8L**

Electrochemical cell, reversible and irreversible, EMF and electrical work, measurement of EMF, temperature co-efficient of EMF, standard cell, different type of electrodes, electrode potential, Nernst's equation, standard electrode potential, reference, electrode (hydrogen,) quinhydrone, glass, calomel), chemical and concentration cells, liquid junction potential, salt bridge, applications of potentiometric measurements.

Ionic Equilibrium **7L**

Debye-HÜckel limiting law (no derivation), solubility and solubility product, ionic product of water, PH, Henderson equation, concept of buffer solution, buffer capacity, hydrolysis, indicators (acid-base, adsorption, redox, metal ion).

Unit - V

Colligative properties of solution **8L**

Chemical potential of solute & solvent in solutions; (Relative lowering of vapour pressure, Elevation of boiling point, Depression of freezing point, osmotic pressure and their measurements) colligative properties, statement, derivation (using chemical potential), Raoult's law, Henry's law, Abnormal colligative properties, Vant Hoff's factor.

PART-II, PRACTICAL

Paper-VIII **INORGANIC QUALITATIVE** **Full Marks: 60**

Detection and analysis of mixtures containing not more than four radicals with at least one acidic radical selected from the following:

basic radicals – lead, bismuth, copper, cadmium, antimony, tin, iron, aluminium, chromium, zinc, manganese, cobalt, nickel, calcium, strontium, barium, magnesium, sodium, potassium, ammonium.

acidic radicals –chloride, bromide, iodide, sulphide, sulphite, sulphate, thiosulphate, nitrate, nitrite, thiocyanate, free boric acid, borate, fluoride, phosphate.

Insoluble Materials: Al_2O_3, Fe_2O_3, Cr_2O_3, SrSO4, $BaSO_4$, CaF_2.

Reporting of the systematic analysis of the samples for qualitative analysis should be under the following headings:

(i) Physical characteristics and solubility of the sample.

(ii) Preliminary tests for basic and acid radicals.

(iii) Systematic analysis of the sample: (a) the group present to be clearly analyzed, (b) the confirmatory tests to be reported.

(iv) Confirmatory tests for acid radicals: including spot tests, tests for acid radicals in presence of other interfering radicals to be reported.

(For all positive tests corresponding chemical reactions to be mentioned).

(v) Naming of radicals.

(vi) Probable composition with proper justification to be noted as a conclusion.

Notes: At least 08 unknown samples are to be analyzed by each student during the laboratory session.

PART-III

Paper-IX **Organic Chemistry** **Full Marks: 65**

GROUP-A

Unit – I: Pericyclic Reactions **9L**

Molecular orbital symmetry, Frontier orbital 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 disrotatory motions, 4n and 4n+2 systems. Cycloadditions: antarafacial and suprafacial additions [4+2] cycloaddition with special reference to Diels-Alder reaction, alder-ene reaction, [2+2] cycloaddition; Sigmatropic rearrangement: suprafacial and antarafacial shifts of H,

sigmatropic shifts involving carbon moieties, [3,3] sigmatropic rearrangement with reference to Cope and Claisen rearrangements.

Unit – II: Spectroscopy **12L**

UV: The electromagnetic spectrum. Range of ultraviolet (UV) region, units of wavelength. Absorption laws (Lambert's – Beer's law), molar absoptivity, types of electronic transition with reference to σ-σ^*, n-σ^*, π-π^* and n-π^* transitions; absorption maxima and absorption intensity, Structure and electronic effect, solvent effect–visible region, colour of conjugated organic compounds, complementary colour. Concept of Chromophore, auxochrome, bathochromic, hypsochromic, hyperchromic and hypochromic shifts. Woodward-Fieser empirical rules for λ_{max}- calculations of dienes and conjugated carbonyl compounds.

IR: Molecular vibrations: bending and stretching, Hooke's law, relation between bond order and position of IR bands-effect of resonance. Finger print region- its importance in identifications of organic compounds. Identification of intramolecular and intermolecular hydrogen bonding from IR study. Characteristic absorptions of various organic functional groups in IR spectra.

NMR: Principle, nuclear spin, NMR-active nuclei, equivalent and non-equivalent protons, position of signals: chemical shift, nuclear shielding and deshielding, anisotropic effect, influence of restricted rotation, solvent shifts, peak area and proton counting, splitting of signals, spin-spin coupling, coupling constants. Qualitative concept of spin relaxation; signal broadening. Interpretation of ^{1}H-NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2- tribromoethane, toluene, acetophenone etc.

Problems pertaining to structure elucidation of simple organic compounds using UV, IR and ^{1}H-NMR spectroscopic techniques.

Unit – III: Heterocyclic Compounds **8L**

Introduction, discussion on aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, mechanism of nucleophilic substitution reactions in pyridine derivatives. Comparision of basicity of pyridine, piperidine and pyrrole.

Introduction to fused five and six-membered heterocycles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fischer indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of electrophilic substitution reactions of indole, quinoline and isoquinoline.

Unit – IV: Carbohydrates **7L**

Definition, classification and nomenclature. Monosaccharides, mechanism of osazone formation, interconversion of glucose into fructose and vice-versa, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers, conversion of glucose into mannose. Formation of glycosides, ethers and esters. Determination of ring size of monosaccharides. Cyclic structure of D-(+)-glucose. Mechanism of mutarotation.

An introduction to disaccharides (maltose, sucrose, galactose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

GROUP-B

Unit – V: Amino Acids, Peptides, Proteins and Nucleic Acids **10L**

Classification, structure, stereochemistry. acid-base behavior, isoelectric point and electrophoresis of amino acids. Preparations and reactions of α-amino acids (Gabriel phthalimide and Strecker's method and reaction specially with ninhydrin). Structure and nomenclature of proteins and peptides. Classification of proteins, peptide synthesis, solid-phase peptide synthesis, peptide structure determination, end group analysis, selective hydrolysis of peptides. Structures of peptides and proteins. Level of protein structure, protein denaturation/renaturaion. (Partial hydrolysis and determination of primary structure sequence of amino acids by sequence overlapping procedure of smaller fragments). Conjugated proteins, prosthetic group (definition with example).

Nucleic acid: introduction, constituents of nucleic acids, nucleosides, nucleotides, elementary ideas of RNA and DNA.

Unit – VI: Stereochemistry **10L**

Baeyer strain theory, heats of combustion and relative stabilities of the cycloalkanes, short coming of Baeyer strain theory- explanation of why large rings difficult to synthesize. Conformational analysis of cyclohexane, mono- and di-methyl substituted cyclohexane, α-halocyclohexanone, 2-alkyl ketone effect, 3-alkyl ketone effect, decalin and 9-methyl decalin.

Topicity and prochirarity, axial chirality (allenes, biphenyls and atropmerism), planar chirality (trans-cycloalkanes). Asymmetric synthesis, Cram's rule, Felkin-Ahn model, Prelog's rule.

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

Unit – VII: Synthetic Dyes pharmaceuticals and polymers **4L**

Colour and construction (electronic concept only), Classification of dyes. Synthesis (outline) and uses of methyl orange, congo red, malachite green, phenolopthalein, alizarin and indigo. Preparation and uses of paracetamol, aspirin, s ulfadiazine, metronidazole and salbutamol; preparation and uses of polythene, polystyrene, Teflon, PVC and nylon.

Unit – VIII: Retrosynthetic Analysis **6L**

Creative chemistry, retrosynthetic analysis: synthesis backwards, disconnection approach, synthon, synthetic equivalent, functional group interconversion, Two-group disconnection are better than one, C-C disconnections, donor and acceptor synthons, two-group C-C disconnections, 1, 5 Related functional groups, 'Natural reactivity' and polarity inversion -'umpolung'.

Unit – IX: Synthetic Applications of active methylene compounds **4L**

Acidity of α-hydrogens, alkylation of diethyl malonate and ethyacetoacetate. Synthesis of ethyacetoacetate; keto-enol tautomerism of ethyl acetoacetate. Synthetic uses of diethyl malonate and ethyacetoacetate.

Part-III **Paper-X** **Inorganic Chemistry** **Full Marks: 65**

GROUP-A

Unit-I: Chemistry of coordination compounds **18 L**

Structure and bonding: VB description and its limitations. Crystal Field Theory: postulates, applications, limitations; crystal field strength, splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy in weak and strong fields; Factors affecting 10 Dq, variation of ionic radii, lattice/solvation energy, interpretation of stereochemical preference, normal and inverse spinel, weak and strong field, low and high spin, pairing energy, Jahn-Teller theorem /distortion; spectrochemical series of ligands; . Metal-ligand bonding (MO concept, elementary idea), sigma- and pi bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples).

Types of isomerism in coordination compounds : Constitutional, geometrical and optical isomerism in respect of coordination numbers 4 and 6. Determination of configuration of cis-, trans-isomers by chemical methods.

Orgel diagrams for $3d^1$-$3d^9$ ions, selection rules, d-d/charge transfer spectra, spectrochemical series, Nephelauxetic effect, trans effect, (example and applications) labile and inert complexes.

Unit-II: Magnetochemistry **12 L**

Types of magnetic behaviour, methods of determining magnetic susceptibility, spin only formula. L-S coupling, Orbital contribution to magnetic moments, quenching of magnetic moment, super-exchange, anti-ferromagnetic interaction (elementary idea with examples only), application of spin only values of magnetic moments to determine valency and stereochemistry of coordination compounds (based on VBT and CFT).

Unit-III: Metallic bonding. **6 L**

Qualitative idea of band theory, conducting, semiconducting and insulating properties with examples from main group elements. Alloys : Ionic compounds, Interstitial alloys and related compounds and substitutional alloys, Superconductivity, basic idea of nano materials (definition and applications)

GROUP-B

Unit-IV: Bioinorganic Chemistry **12 L**

Elements of life: essential major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{+2},Ca^{+2}, $Fe^{3+/2+}$, Cu^{+2}, and Zn^{+2}). Haemoglobin, myoglobin, chlorophyll, cytochromes ferredoxins and carbonic anhydrase-their structural features and functions in living system.

Toxic metal ions and their effects, lead, mercury and arsenic poisoning, organo-mercury compounds; Wilson diseases, detoxification of metal ions – chelation therapy (simple idea with some examples of chelating drugs). Pt and Au complexes as drugs (examples only), metal dependent diseases.

Unit-V: Organometallic compounds. **16 L**

Definition, Π-acid ligands, hapticity (s) of ligands, nomenclature,18-electron rule, application of 18-electron rule to carbonyl, nitrosyl, cyanide and hydrido complexes.

Preparation, structure and properties in metal carbonyls and nitrosyls, variants of CO bridging, Vibrational spectra of metal carbonyls, principle reaction types of metal carbonyls. Carbonyl metal halides, carbonyl hydrides, metal olefin , Ziese's salt (preparation, structure and bonding), and cyclopentadienyl complexes, Ferrocene (preparation, Structure, bonding and reactions). Metal-metal bonded compounds and metal culsters (simple examples).

Simple examples of fluxtional molecules, coordinative unsaturation, oxidative addition and insertion reactions, homogeneous catalysis by organometallic compounds: hydrogenation, hydroformylation and polymerization of alkenes (Ziegler Natta Catalyst).

Unit-III: Complex metric Titration **6 L**

Complexones, masking and demasking interactions, metallochrome indicators, titration of metal ions and their mixtures with EDTA, hardness of water and its determination

Part -III **Paper-XI** **Physical Chemistry** **Full Marks: 65**

GROUP-A

Unit – I: Quantum mechanics - I **15L**

Drawback of classical mechanics, stability of atom, black body radiation, photoelectric effect; Compton effect, wave particle duality, de Broglie hypothesis, Heisenberg's duality, Heisenbergs' uncertainly principle, concept of operators, different types of operators, properties and interpretation of wavefunctions (normalization, orthogonality, probability distribution) eigen function, eigen values. Commutation of operators, commutators, theorem, postulates of quantum mechanics, time - dependent, time - independantschrodinger equation, stationary state, stationary state wavefunction, applications, free particle, boundary condition.

Quantum mechanics - II **4L**

Particle in one dimensional box, wavefunction, probability of finding a particle expectation values (<x>, $<x^2>$, <px>, $<px^2>$etc), uncertainly, particle in one dimensional box, degeneracy tunneling effect.

Hydrogen atom **4L**

Hydrogen like system, schrondinger equation in polar coordinates, radial solution, radial wavefunction, real hydrogen like wave function, probability density, probability of finding of election, radial distribution function, quantum numbers, energy expression (no derivation), degeneracy, concept of orbitals (s, p, d) and shapes.

Unit – II: Chemical Kinetics- I **5L**

Introduction, reaction rate and extent of reaction, Rate law, order and molecularity, kinetics of zero first, second, fractional and pseudo- first order reactions; determination of order of reaction, temperature dependence of reaction rates, Arrhenius equation, activation energy, Elementary reaction; multi-step reactions consecutive, opposing and parallel reactions (all first order), concept of steady state and rate determining step, chain reaction; elementary idea, illustrations with H_2 - Br_2 and H_2 - O_2 reactions.

Chemical Kinetics -II **5L**

Collision theory of bimolecular reactions, unimolecular reactions, Lindemann theory, transition state theory, free energy and entropy of activation, primary kinetic salt effect relation between TST and hard sphere collision theory.

Catalysis **3L**

Definition, catalyst and inhibitor, criteria of catalysis, types of catalysis (homogeneous and heterogeneous), auto catalytic reaction, Theory of acid - bare catalysis with examples.

Enzyme Catalysis: Properties of enzymes, Michaelis-Mentene quation, Lineweaver - Burk equation turnover frequency catalytic efficiency, effect of temperature and PH.

GROUP-B

Unit – III:

Adsorption **3L**

Physical and chemisorption, adsorption, isotherms :Freundlich, Langmuir and Gibbs adsorption isotherms, surface excess, BET equation (no derivation).

Colloidal state **5L**

Definition, colloids classification, properties, ultracentrifuge, electrokineticphenomena, Zeta potential, iso-electric point, Schulze-Hardy rule, protective colloids, gold number, Perrin method for determination of Avogadro number, colloidal electrolytes, CMC values, emulsions, gels, thixotropy.

Unit – IV: Molecular geometry **8L**

Polarization, dipole moment, permittivity, Debye - Langevin equation (No derivation), clausius - Mossoti equation (No derivation), application towards explanation of structure. Spectroscopy, microwave and I.R. spectra energy expressions, selection rule applications, potential energy diagram, Franck - Condon principle, Raman spectra, rotational and vibrational Raman spectra, rule of mutual exclusion with example

Photochemistry **5L**

Thermal versus photochemical reactions, GrotthÜs - Draper Law - Lambert - Beers law, Einstein's Law of photochemical equivalence, quantum yield, actinometer, effect of absorption of light, phosphoresence, fluorescence, photochemical reactions (decomposition of HI and combination of H_2 and Br_2), photo - stationary state, Jablonsky diagram.

Unit – V: Crystalline state **6L**

Laws of crystallography, unit cell, lattice, different cystalline systems with characteristics, Bragg's equation, application towards structure of NaCl and KCl. Specific heats of solid elements, Dulong - Pelit's law, limitations, Einstein's equation, successand Limitations, Debye's T^3 law (no derivation).

Thermodynamics – III **7L**

Third Law of thermodynamics, Nernst heat theorem, Lewis - Randall statement, Planck statement. macrostates and microstates, ensemble, mathematical probability versus thermodynamic probability, Thermodynamic probability and the concept of entropy partition function and representation of the thermodynamic functions; Boltzmann distribution, nondegenerate and degenerate cases.

Part-III Paper-XII Analytical and Industrial Chemistry Full Marks: 65

GROUP-A: Analytical Chemistry

Unit-I: The treatment of Analytical Data **8L**

Accuracy, Precision, classification of Errors, minimization of errors, histogram and frequency distribution curve, mean, mode, median, standard deviation; composition of results-X^2 - - test, method of least squre ($y = mx + c$), propagation of error in computation

Computers **5L**

General introduction , different components of a computer, binary numbers and decimal numbers, conversion of decimal number to hexadecimal number and vice versa, introduction of computer languages, different operating system.

Unit –II: Gravimetric Analysis **3L**

Principal of gravimetric analysis, Co- precipitation and Post precipitation and their removal (condition for precipitation) efficiency of washing.

Unit –III: Purification Techniques

Chromatography **10L**

Introduction, Classification of Chromatography , Define the terms (adsorbtion, eluent, elution, elution time, Mobile phase Normal Phase, Revarse Phase, Stationary Phase, resolution, R_f value), Gas chromatography, Gas liquid chromatography, Column chromatography- Types, Principle, Process, Separation of mixture; Paper chromatography and thin layer chromatography.

Solvent extraction **5L**

Theory, efficiency, percentage extraction, separation factor, complexing agent in solvent extraction, selection of solvent.

Ion- exchange **4L**

Principle, quality of resins, ion exchange equilibrium, ion exchange capacity process, deionization of water.

<u>GROUP-B:</u> Industrial Chemistry

Unit-IV: Fuel **7L**

Definition and calorific value, classification of fuel

Solid fuel: High and low temperature carbonization of coal-coking of coal and recovery of coal chemicals. Objects and products of high and low temperature carbonization of coal.

Liquid fuel: Flash point, aniline point, knocking, anti-knock compounds, Octane number, cetane number, Refinery of petroleum (only Separation process), types of gasoline, natural, straight-run, reformed, polymer, Aviation and synthetic gasolines (only definition). Manufacture of synthetic gasoline from coal by Burgius process.

Gaseous fuel: Water gas, producer gas and LPG (only manufacture and uses).

Unit-V **7L**

Manufacture and uses of common glass and high glazed ceramic articles, difference between glass and porcelain.

Manufacture, composition and uses of Portland Cement, setting of cement, coloured and white cement (only composition).

Manufacture and uses of Stainless Steel and alloy steels.

Unit-VI: Polymer **8L**

Requirement of fibre forming polymer. Difference between natural and synthetic fibres. Manufacture and uses of viscose rayan. Nylon 66 and terylene.

Synthetic rubber: Difference between natural and synthetic rubber. Vulcanisation. Manufacture and uses of Buna-S. Properties and uses of Neoprene, Foam rubber and thermocoll.

Unit-VII **9L**

Insecticides: Definition, Classification according to the mode of action. Preparation and uses of D. D. T. ,B. H. C., Aldrin, Dithion and Ditho carbamate.

Paints: Constituents of paints and varnishes. Manufacture, Setting and requirements of a good paint, faiture.

Fertilizer: Definition and necessity of Fertilizers. Manufacture of Urea form carbon dioxide and urea, Manufactures of super phosphate and triple super phosphate. N. P. K.

PART-III, PRACTICAL

Paper-XIII **Analytical Chemistry** **Full Marks: 60**

A. Inorganic quantitative analysis **(30 Marks)**

1. a) Preparation of standard solution of oxalic acid and standardization of NaOH solution and KMnO4 solution
   b) Preparation and standardization of Mohr's salt solution by KMnO 4 solution.
   c) Preparation of standard K2Cr2O7 solution and standardization of Mohr's salt solution and sodium thiosulphate solution.
   d) Praparation and standardization of Na 2 EDTA solution

2. Determination of Fe(II), Fe(III), Cu(II), Cr (III), Mn (II) Ni (II), Ca(II), Mg(II), Zn(II) and Cl – in their respective compounds volumetrically through redox, precipitation and complexo metric titrations. Determination of Cr(III) in its compound through oxidation with sodium perborate.

3. Gravimetric determination of sulphate as BaSO4, chromate as BaCrO4, nickel using dimethyl glyoxime etc.
4. Analysis of binary mixture of metal ions : Fe – Ca, Ca – Mg, Zn – Mg, Fe – Cu, Fe – Cr, Cu – Cr, Cu – Ni, Cu – Ba

B. Inorganic Preparation : **(10 Marks)**

1. Praparation of chrome alum
2. Preparation of oxalato complexes of Cr (III), Fe (III) and Cu(II)
3. Preparation of $[CoHg(SCN)_4]$
4. Preparation of Reinecke salt, $(NH_4)[Cr(NH_3)_2(SCN)_4]$, H_2O

C. Viva –Voce **(10 Marks)**
D. Laboratory note book **(10 Marks)**

PART-III, PRACTICAL

Paper-XIV **Physical Chemistry** **Full Marks: 60**

A: Physical Chemistry Experiments **(40 Marks)**

1. Determination of surface tension of a given solution by drop weight method using a Stalagmometer, considering aqueous solution of NaCl, acetic acid, ethanol as systems.
2. Determination of Viscosity Coefficient of a given solution with Ostwald's viscometer considering aqueous solution of cane-sugar, glycerol, ethanol as systems.
3. Determination of PH of an unknown solution by colour matching method.
4. Study of the kinetics of acid catalyzed hydrolysis of an ester (methyl or ethyl acetate).

5. Determination of distribution co-efficient of iodine or acetic acid in water and an immiscible organic solvent ($CCl_4/CHCl_3$).
6. Adsorption isotherm study of acetic acid on charcoal.
7. Conductometric Titration of (a) Strong Acid vs. Strong Base (b) Weak Acid vs. Strong Base.
8. Validity of Lambert-Beer's Law for $KMnO_4$ or $K_2Cr_2O_7$ solution and to find out the concentration of unknown solution.

C. Viva –voce **(10 Marks)**
D. Laboratory note book **(10 Marks)**

Syllabus (Draft Copy) For Chemistry (General)

Course Structure

(Course Duration = 3 years, Part (I+I+I) with effect from the session 2015-16)

Total Marks = 400

Theory = 240 Practical = 160

	Theory		***Marks***				***Marks***		***Total***
	Paper	***Subject***	***MCQ***	***Broad***	***Total***		***Paper***		
Part-I	Paper-I	Organic, Inorganic, Physical	30	60	90		Paper-II	60	**150**
Part-II	Paper-III	Organic, Inorganic, Physical	30	60	90		Paper-IV	60	**150**
Part-III	Paper-V	Industrial and Environment Chemistry	20	40	60		Paper-VI	40	**100**

Total: 400

PART-I

Paper-I **Full Marks: 90**

[20 marks (2 questions × 10 marks) + 10 marks (5 MCQ questions × 2 marks) =30 marks]

Group-A: ORGANIC **Full Marks: 30**

Unit-I: Stereoisomerism **7L**

Elementary idea of stereoisomerism in organic Chemistry- chiral carbon, chirality, enantiomers- optical rotation, specific optical rotation, diastereomers- geometrical isomers, Configuration, Conformation of ethane, 1,2-dibromethane, ethane 1,2-diol, n-butane-representation of conformations in Newman projection formula, representation of configuration in Sawhorse projection, Flying-wedge projection, Fischer projection formula. Nomenclature of stereoisomer's (having maximum two chiral carbon-R/S and D/L – system, Z/E nomenclature of diastereomeric alkenes.

Unit-II: Structure, Reactivity of Organic Molecules and Intermediates **5L**

a) Tetravalency of carbon, shape of simple organic molecules- hybridization (SP^3, SP^2 and SP)

b) Electronic effect- Inductive effect, resonance effect, hyper conjugation-application of the effect in explaining relative acidity, basicity of simple organic compounds, stability of carbocation, carbanion and alkenes.

c) Qualitative detection of nitrogen, sulphur, halogens by lassaigne's test.

Quantitative detection of nitrogen by Kjeldahl's method.

Calculations of empirical and Molecular formula.

Unit-III: Alkanes, alkenes, alkynes; general synthesis and reactions **8L**

Alkanes-Preparation by Corey-House method, Duma's decarboxylation method, halogenation reactions and their rate of reactivity (no detail mechanism-only outline).

Alkene-Stability of alkenes, heat of hydrogenation, Preparation from alkylhalides- E_1 & E_2 reaction. Addition of HX (X=Cl, Br, I), H_2O mechanism, rearrangement-peroxide effect on HBr (no mechanism). Bromination, hydrohalogenation, hydroboration, ozonolysis, oxidation by $KMnO_4$, OsO_4 of alkene without mechanism detailed.

Alkyne-General methods of synthesis, acidity, hydration and substitution reactions

Unit-IV: Aromatic Compounds **10L**

Structure of Benzene (Keküle), aromaticity, Huckel 4n+2 rule (4n rule for antiaromaticity). Electrophilic substitution reactions-halogenation, suphonation, nitration, Friedel-Crafts reaction, ozonolysis. Directive influences in monosubsttituted benzene, eg. Toluene, phenol, halobenzene, nitrobenzene, benzaldehyde etc.

Phenols- halogenation, sulphonation, nitration, Reimer-Tiemann and Kolbe reactions

Aniline-Preparation from reduction of nitrobenzene, formation of diazonium salts and their stability. Replacement of diazonium group with H, OH, X, CN and NO_2. Diazocoupling and reduction, Sandmayer reaction.

Benzaldehyde-Preparation by Gattermann, Gattermann-Koch, Rosenmund and Stphen's method. Reaction-Perkin reaction and benzoin condensation.

Group-B: INORGANIC **Full Marks 30**

[20 marks (2 questions × 10 marks) + 10 marks (5 MCQ questions × 2 marks) =30 marks]

Unit-V: Atomic Structure: **10L**

Spectra of hydrogen atom. Bohr's model of hydrogen-like atoms and ions –its postulates, derivation of the relations for energy, velocity and radii of the electron of the different orbits, limitations of Bohr's model. Dual nature of matter, de Broglie's relationship, Heisenberg's uncertainty principle, Schrodinger wave equation, concept of atomic orbitals, shape and size of *s*, *p* and *d* orbitals, quantum numbers, Aufbau principle, Pauli's exclusion principle and Hund's rule

Unit-VI: Periodic Properties: **5L**

Modern periodic law and present form of periodic table, general characteristics of *s, p, d* and *f* block elements, periodic trends in properties of elements; atomic and ionic radii, ionization enthalpy, electron gain enthalpy, electronegativity-Pauling's scale, inert pair effect, lanthanide contraction, diagonal relationship.

Unit-VII: Chemical Bonding **8L**

Ionic bonding: Factors affecting the formation of ionic bonds, Calculation of lattice energy.

Covalent bonding: Hybridization involving *s*-, *p*- and *d*- orbitals, Valence Shell Electron Pair Repulsion theory and shape of the simple molecules and ions.

Dipole moment: Covalent molecules like CO_2, CH_4, $CHCl_3$, CCl_4, NH_3, NF_3, CO_2, SO_2, CO, BF_3, SF_6 and dichlorobenzene. Hydrogen Bonding and its effect on physical and chemical properties of simple molecules, Fajan's rule and application in area of melting point, boiling point, solubility, stability, conductivity and colour of the simple inorganic molecules.

Application of M.O. theory on H_2, He_2, He_2^+, O_2, N_2 and CO molecules.

Unit-VIII: Classification of hydrides- ionic, covalent and interstitial. **6L**

ortho- hydrogen and *para*- hydrogen ; heavy water; structure, preparation, reactions and uses of hydrogen peroxide; structure, properties and uses of borax, and diborane; preparation and uses of silicones; borazine; compounds like hydrides, oxides, oxyacids and halides of groups13-16, structure and properties of interhalogen compounds; chemical properties of noble gases; chemistry of xenon compounds

Group-C: PHYSICAL **Marks-30**

[20 marks (2 questions × 10 marks) + 10 marks (5 MCQ questions × 2 marks) =30 marks]

Unit-IX: Gaseous sate **8L**

Gas laws- Boyls law, Char's law, Avogadro's law- ideal gas equation- unit and significance of universal Gas constant, R.

Kinetic theory of gas- postulate, $PV= 1/3\ mnc^2$- deduction of gas laws from it, deduction of ideal gas equation, Graham's law, concept of average, r.m.s. velocity and most probable velocities.

Heat capacity of gases-C_p and C_v, C_p-C_v = R for ideal gas, $C_p/C_v = \gamma \geq 1 < 1.66$

Real gases-Amegat's Curves-derivation from ideal behavior- van der Waals equation for one and n mole.

Liquification of gaes-Andrew's experiment- critical parameter (P_c,V_c and T_c) and their values- reduced euation of state-law of corresponding state.

Unit-X: Thermodynamics- First law **7L**

Terminology; System, surrounding-open system, closed system-isolated system-diathermal wall, adiabatic wall, state function; Extensive and intensive properties, perfect differential, Energy, Process: isothermal, -adiabatic. Work: reversible and irreversible work, maximum work done by ideal gas due to isothermal reversible process.

First law of thermodynamics- law of conservation energy, mathematical form of 1st law-internal energy and enthalpy, $(dU/dV)_T = (dU/dP)_T = (dH/dP)_T = 0$ for ideal gas. Adiabatic relations-PV^γ = constant and other relations, isothermal and adiabatic curves.

Unit-XI: Thermochemistry **5L**

Heat of reaction, inter-relation of enthalpy change and internal energy change, heat of formation.

Laws of thermochemistry- law of Lavoisier and Laplas, Hess's law of constant heat summation. Heat of combustion, heat of neutralization, heat of dilution, thermoneutrality of salt solution.

Unit-XII: Dilute solution **7L**

Colligative Properties-lowering of vapour pressure and cause of its, Raoult's law for relative lowering of vapour pressure, Elevation of boiling point- reason, Raoult's law for elevation of boiling point,Depression of freezing point-reason, Raoult's law for depression of freezing point. Osmosis and osmotic pressure-reason,Vanhoff's laws for osmotic pressure-analogy with ideal gas equation. Relationship of these properties with molecular mass of solutes. Abnormal colligative properties-Vant Hofff's factor, *i*.

Unit-XIII: Colloid **5L**

Differnces from true solutions,Classification-Lyophilic and leophobic colloids- their differences, origin of stability. Peptisation of colloids, Coagulation-Schulze-Hardy rules, protective colloid- gold number. Dialysis and its applications, Brownian motion, Tyndal effect and its application, Elementary idea of emulsion, surfactant, micelle, colloid in everyday life.

Unit-XIV: Photochemistry **5L**

Thermal and photochemical reaction-a comparison. Laws of absorption-Lambert's law; Beer's law. Laws of photochemistry-Grothus and Draper law; Stark and Einstein's law, quantum yield, Fluorescence and phosphorescence.

Part-I (General): Practical

Paper- II **Full Marks 60**

[For Analysis 25 marks+ Organic Preparation-15 + M.P. - 5Marks+Laboratory note books-5+ Viva-Voce -10 Marks]

1. **Analysis**
   a) Detection of special elements (N, S, Cl, Br, I) in a solid organic compound by Lassaign's test
   b) Detection of the following functional groups present in solid organic compound:
   -COOH, -CO-,-CHO, -OH(phenolic),-NH_2, -NO_2

2. **Determination of Melting Point of a solid (at ambient temperature) organic compound preferably having MP less than 200^{o}C**
3. **Preparation**
   a) *meta* –Dinitribenzene from nitrobenzene.
   b) *Para*-Nitroactanilide from acetanilide
   c) *Para*-Nitroaniline from *para*-Nitroacetanilide
   d) Benzil from Benzoin.

PART-II

Paper-III **Full Marks: 30**

[20 marks (2 questions X 10 marks) + 10 marks (5 MCQ questions X2 marks) =30 marks]

Group-A: ORGANIC

Unit-I: Alcohols and Ethers **12L**

Alcohols: Classification, identification of 1^0, 2^0 and 3^0 alcohol by Victor-Meyer method, Lucas method.

General method of preparation, properties and reaction, mechanism of dehydration reaction.

Ether: General method of preparation, properties and reactions. Williamson synthesis.
Elementary idea of SN1 and SN2.

Unit-II: Aldehydes and Ketones **7L**

Nature of carbonyl group, nucleophilic addition to carbonyl group, relative reactivities of aldehydes and Ketones. Important reactions such as – nucleophilic addition reactions (such as addition of HCN, NH_3, and its derivbatives), Grignard reagent; oxidation, reduction reactions. Acidity of α-hydrogen, aldol condensation, cannizzaro reaction, Haloform reaction.

Carboxylic acids and derivatives, General methods of preparations, properties and reactions, HVZ reaction.

Unit-III: Aliphatic amines **5L**

Methods of synthesis of aliphatic amines, Heinsberg's method of amine separation, Hofmann degradation, Grabriel phthalimide synthesis, distinction of 1^0, 2^0 and 3^0 amines. Curtius reaction, Schmidt reaction.

Unit-IV: Carbohydrates: **7L**

Introduction, Classification of carbohydrates, Structure determination of glucose and fructose, osazone formation, reaction of glucose and fructose, mutarotation, cyclic structure (determination of ring size excluded), epimerization, Chain-lengthening (Kiliani-Fischer) and Chain shortening Ruff's method) in aldose. Conversion glucose to fructose and *vice versa*.

Unit-V: Chemistry of Enolate ions **5L**

Active methelen group, keto-enol tautomerism, Ethylacetoacetate- preparation, chemical properties, synthetic uses. Diethylmalonate- preparation, Chemical properties, synthetic uses.

Group-B: INORGANIC **Marks-30**

[20 marks (2 questions X 10 marks) + 10 marks (5 MCQ questions X2 marks) =30 marks]

Unit-VI: Radioactivity **5L**

α,β and γ-rays and their properties; transmutation of elements; rate of radioactive decay, decay constant, half life and average life period of radio-elements; units of radioactivity, numerical problems. Stability of atomic nucleus –effect of neutron and proton ratios, nuclear binding energy, mass defect, packing fraction, nuclear fusion and fission reactions.

Unit-VII: Co-ordination compounds **7**

Introduction to co-ordination compounds, Werner's theory; ligands, co-ordination number, chelates, IUPAC nomenclature of co-ordination compounds, perfect and imperfect complexes, isomerisim in co-ordination compounds, importance of co-ordination compounds in qualitative analysis.

Unit-VIII: Extraction and Purification of Metals **5L**

Extraction and purification of elements from natural sources: Li, Cr, Ni, Sn, Au. Electroplating, galvanizing and anodizing techniques.

Unit-IX: Acid and bases

3 L

Arrhenius, Bronsted Lowry's concept, Lewis concept of acid and bases, relative strength of acids and bases. theory of solvent system. HSAB principle (Hard-soft acids and bases) and applications.

Unit-X: Synthesis and uses of Inorganic salts **3**

Preparation and uses of some important compounds; Potassium permanganate, Potassium dichromate, Sodium nitropruside, Sodium Bismuthate. Hydrazine and Sodium Cobalti-nitrite and dimethylglyoxime.

Group-C: PHYSICAL **Marks-30**

[20 marks (2 questions X 10 marks) + 10 marks (5 MCQ questions X2 marks) =30 marks]

Unit-XI: Thermodynamics- 2nd Laws **7L**

Need of second law, popular statements of 2nd law, Carnot's cycle. Entropy-concept, Calculation entropy change during:

(i) Heating of a solid /liquid,
(ii) Isothermal expansion of ideal gas,
(iii) Phase transition.

Free energy; Helmholtz free energy and Gibbs free energy, Conditions of equilibrium and criterion for a spontaneous process. Clapeyron equation, Clausius- Clapeyron equation, Trauton's rule.

Unit-XII: Chemical Equilibria **5L**

The law of mass action, dynamic nature of equilibria, equilibrium constants (K_p & K_c), their relation. Calculation of K_p and K_c of some reversible gaseous reactions:

(i) $H_2(g) + I_2(g) = 2\,HI(g)$
(ii) $PCl_5(g) = PCl_3(g) + Cl_2(g)$;
(iii) $3H_2(g) + N_2(g) = 2\,NH_3(g)$

Le Châtelier's Principle and application

Unit-XII: Chemical Kinetics **5L**

Order and molecularity of a reaction and their comparison. Rate constant, half life of 1^{st} order, 2^{nd} order and zero order reaction. *Pseudo*-unimolecular reaction, temperature dependence of rate constant, Arrhenius equation, concept of activation energy.

Unit-XIV: Ionic Equilibria **7L**

(i) Ionization of weak electrolytes; Oswalds' dilution law, ionisation constant of weak acids and bases, ionic product of water, *pH* scale, buffer solution, buffer action and Henderson equation.

Salt hydrolysis-*pH* of salt solutions

(ii) Solubility and solubility product, common ion effect and its application in group analysis of basic radicals.

Unit-XV: Electrochemistry **8L**

(a) Electrolytic solutions, Specific conductance, equivalent conductance; variation of conductance with dilution, Kohlrasch's law. Abnormal conductance of H^+ & OH^-, Conductometric titrations.

(b) EMF- Electrochemical cell (Galvanic Cell) and electrolytic cell. Reversible and irreversible cells. Single electrode or half cell. Cell reaction, redox reaction, half cell reaction, convention of writing a cell. Electrode potential and its origin, oxidation potential and reduction potential; Nernst equation for electrode potential- Standard electrode potential- sign of electrode potential. Standard hydrogen electrode-determination of standard potential of an electrode.

Unit-XVI: Catalysis and adsorption **7L**

Definition of catalysis; positive catalyst, negative , autocatalyst and induced catalyst. Criteria of catalyst. Catalyst Promoters and catalyst poisoning.

Adsorption, absorption, types of adsorption; Physical and chemical and comparisons. Adsorption isotherm; Freundlich isotherm, its limation, Langmuir's adsorption isotherm. Application of adsorption.

Part-II (General): Practical

Paper- IV **Full Marks 60**

[Inorganic Qualitative analysis 40 marks + Laboratory note books-10+ Viva-Voce -10 Marks]

1. Systematic analysis and detection of an unknown inorganic mixture (max three radicals) from the following radicals (water/ HCl soluble samples only).

a) Acid Radical:
Cl^-, Br^-, I^-, NO_3^-, NO_2^-,S^{2-}, SO_4^{2-}, BO_3^{2-} (interfering) and PO_4^{3-} (as interfering)

b) Basic Radical
Ag, Pb, Hg, Bi, Cu, Cd, As, Sb, Sn, Fe, Al, Cr, Co, Ni, Mn, Zn, Ba, Sr, Ca, Mg, Na, K and NH_4^+

PART-III

Paper-V **Full Marks: 60**

Group- A: INDUSTRIAL **40 Marks**

[30 marks (3 questions X 10 marks) + 10 marks (5 MCQ questions x 2 marks) = 40 marks]

Unit-I: Drugs and Pharmaceuticals: **5L**

Preparation and uses of Aspirin, Paracetamol, quinine and chloroquine phosphate, Phenobarbital.

Unit-II: Food Additives **6L**

Food flavor, food colour, food preservatives, artificial sweeteners, acidulants, alkalies, edible emulsifiers and edible foaming agents. Sequesterants-uses and abuses of these substances in food beverages.

Unit-III: Polymer: **4L**

Preliminary ideas of polymer, manufacture, physical properties and uses of Nylon-66, natural-rubber, synthetic rubbers, PVC, Polyurethane.

Unit-IV: Oils and Fats-Detergents: **4L**

Distinction between oils and fats; saponification value, iodine value, hydrogenation of fats and oils. Production of toilet and washing soaps, Detergent powder.

Unit-V: Fertilizers: **3L**

Manufacture and applications of urea and superphosphate, Biofertilizers.

Unit-VI: Fuels: **4L**

Ideas of fuels, Manufacture and uses of producer gas, water gas, LPG and bio-gas.

Group-B: ANALYTICAL **20 Marks**

[14 marks (2 questions X 7 marks) + 06 marks (3 MCQ questions x 2 marks) =20 marks]

Unit-VII: Volumetric analysis: **5L**

Principle of oxidation-reduction and complexometric titrations; acid-base, redox and metal-ion indicators. Principles of estimation of mixture of $NaHCO_3$ and Na_2CO_3 by acidimetry; Iron-copper and iron-chromium by redox titration; Calcium-Magnesium by complexometric titration using EDTA.

Unit-VIII: Error analysis and Computer application **6L**

Accuracy and precision of quantitative analysis; mean, mode, median and standard deviation. General introduction of computers; different components of computer, hardware and software, input and output devices, binary numbers. Introduction of computer languages and operating system.

Unit-IX: Phase equilibrium: **5L**

Phase rule, Liquid-vapour equilibrium for two component systems, Henry's law, deviation from ideal behavior, azeotropic solution, eutectic mixture, Nernst distribution law, solvent extraction.

Part-III (General): Practical

Paper-VI **Full Marks 40**

[20 marks for Standardization and quantitative Analysis + 10 marks for project + 5 marks for Laboratory note books + 10 Marks Viva-Voce -]

1. **Quantitavie analysis**

a) Preparation of Primary Standard Solution of Oxalic Acid and Potassium dichromate.

b) Standardization of Potassium permanganate solution, hydrochloric acid solution, Caustic soda solution and Mohr's salt solution.

c) Determination of sodium carbonate and sodium bicarbonate in a mixture solution by standard hydrochloric acid solution using phenolphthalein and methyl orange indicator.

d) Estimation of hydrochloric acid, acetic acid mixture by the standard caustic soda solution.

2. **Project Work**

a) Soil testing (pH, conductivity, NPK estimation)

b) Water testing (pH, Hardness of water, BOD and COD)

c) Preparation disinfectant (Black and white Phenyl)

d) Soaps and Detergents manufacturing

e) Preparation of Cosmetic products

(The Project work should be completed in consultation with teachers and a report with a group photograph to be submitted to the examiners during practical Examination. The merit will be assessed on the basis of project report and quality of the sample if any)