UNIVERSITY OF KALYANI

REVISED SYLLABUS

FOR THREE YEARS B.Sc. DEGREE COURSE

(HONOURS AND GENERAL)

IN

CHEMISTRY

According to the New Examination Pattern
Part – I, Part- II & Part- III

WITH EFFECT FROM THE SESSION
2009 – 2010

UNIVERSITY OF KALYANI
KALYANI NADIA
COUNCIL FOR UNDER GRADUATE STUDIES
PROCEEDINGS OF THE 21ST MEETING OF THE (PREVIOUS) COUNCIL FOR UG STUDIES HELD ON 13/09/2005

Revised Structure and Distribution of Marks for Practical Based Subjects at UG Level w.e.f. Academic Session 2005-2006

BACHELOR OF SCIENCE (GENERAL)	PART-I	PART-II	PART-III
Compulsory English : One half paper : 50 Marks Modern Indian Language : One half paper : 50 Marks	50 Marks 50 Marks	– –	– –
Environmental Studies : One full paper* : 100 Marks*	100 Marks*	–	–
Elective Subjects : **Three** : Four full papers : 3x4x100 each =1200 Marks	3x1x100 =300 Marks	3x2x100 =600 Marks { Th: 3x1x100 = 300 Marks; Pr: 3x1x100 = 300 Marks }	3x1x100 =300 Marks { Th : 3x1x 60 = 180 Marks; Pr : 3x1x40 = 120 Marks }
AGGREGATE MARKS : 1400	**500 Marks**	**600 Marks**	**300 Marks**

BACHELOR OF SCIENCE (HONOURS)	PART-I	PART-II	PART-III
Compulsory English : One half paper : 50 Marks Modern Indian Language : One half paper : 50 Marks	50 Marks 50 Marks	- -	- -
Environmental Studies : One full paper* : 100 Marks*	100 Marks*	-	-
Elective subjects : **Two** : Three full papers : 2x3x100 each = 600 Marks	2x1x100 Marks =200 Marks	2x2x100 =400 Marks { Th: 2x1x100 =200 Marks; Pr: 2x1x100 =200 Marks }	- -
One Honours Subject = 800 Marks			
Theory: Seven Papers = 540 Marks Practical: Four Papers = 260 Marks	200 Marks (Th: 2 x 75 Marks) (Pr : 1 x 50 Marks)	200 Marks (Th: 2 x 75 Marks) (Pr : 1 x 50 Marks)	400 Marks (Th: 3 x 80 Marks) (Pr : 2 x 80 Marks)
For Computer Science Honours	For Computer Science Honours		
Theory : Seven Papers = 440 Marks Practical : Four Papers = 280 Marks Project : One Paper = 80 Marks	200 Marks (Th: 2 x 50 Marks) (Pr: 1 x 100 Marks)	200 Marks (Th: 2 x 50 Marks) (Pr: 1 x 100 Marks)	400 Marks (Th: 3 x 80 Marks) (Pr : 1 x 80 Marks) (Project : 1 x 80 Marks)
AGGREGATE MARKS : 1600	**600 Marks**	**600 Marks**	**400 Marks**

* ***With effect from the session 2009-2010.***

07/08/2009
Secretary, Faculty Councils (U.G.)
University of Kalyani
Kalyani, Nadia

University of Kalyani

Revised Syllabus for B.Sc. (Honours) Course in

CHEMISTRY

(w.e.f. the session 2009-2010)

According to the New Examination Pattern
Part – I, Part – II & Part – III

University of Kalyani

Revised Syllabus for Chemistry Honours Course
(w.e.f. the session 2009-2010)

Contents

Structure of 3-years B.Sc. (Honours) Degree Course

In

CHEMISTRY

UNDER

(1+1+1) Examination System

Total Marks : 800 Duration : 3 years			
Examination	Theoretical Marks	Practical Marks	Total Marks
Part – I (at the end of 1st year)	150	50	200
Part – II (at the end of 2nd year)	150	50	200
Part – III (at the end of 3rd year)	240	160	400
Total	540	260	800

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PART – I

PAPER- I : (Inorganic) Full Marks : 75

Group A : Atomic structure (extra-nuclear), periodic properties nature of chemical bond – I (37½ Marks) 45L

1. Atomic structure (extra nuclear) 12L

Bohr's atomic model and its limitations, Sommerfeld's modifications, de Broglie matter waves, Heisenberg uncertainty principle and its significance. Schrodinger wave equation, quantum numbers, ra dial and angular wave functions, probability distribution curves, shapes of orbitals (mathematical details excluded), Aufbau and Pauli exclusion principles, Hund multiplicity rule, sequence of energy levels, electronic configuration of atoms, ground state term symbols of atoms and ions.

2. Periodic properties 10L

Atomic and ionic radii, crystal radii, covalent radii, different electro negativity scales, ionization, enthalpy, electron attachment enthalpy and their periodic trends, screening effect, effective nuclear charge, Slater's rule, inert pair effect.

3. The nature of chemical bond – 1 23L

Ionic bonding : size effect, radius ratio rules and their limitations, atomic packing, hcp and ccp arrangements, voids in crystal lattice, packing ef ficiency, some ionic crystal lattices : rock salt, zinc blende, wurtzite and fluorite; layer lattice, lattice energy, Born-Lande equation, Born -Haber cycle and its applications, polarizing power, polarizibility, Fajans' rule and its applications.

Some mixed oxide structure : perovskite, ilmenite and spinels, stoichiometric crystal defect : Frenkel and Schottky defects – electrical property – concentration of Schottky defect.

Bonding in metals : free electron and band models of solids (qualitative idea), conductors, insulators and semiconductors – their band diagrams, weak chemical forces : hydrogen bonding and its importance in biological systems, vander Waals forces.

Group B : Nuclear chemistry and radio activity, chemistry of elements, acid - bases and solvents (37½ Marks) 45 L

4. Nuclear chemistry and radioactivity 10 L

Nuclear stability, nuclear binding energy, mass defect and packing fraction, nuclear forces, meson field theory, artificial radi o activity, different types of nuclear reactions, fission and fusion, nuclear energy, nuclear fuels, trans uranium elements, radio isotopes in structure determination, study of reaction mechanisms, solubility determination, radio carbon dating.

5. Chemistry of elements : **23L**

a) Comparative study : I) Al, Ga, In and Tl, i i) Si, Ge, Sn and Pb – group trends with reference to electronic configuration, size, oxidation states and in compounds such as hydrides, oxides, oxyacids, halides and complexes

b) Diagonal relationship : Li and Mg; Be and Al; B and Si.

c) Extraction, purification, uses and essential compounds of Ti, V, Cr, Ni and U.

d) Preparation, properties, bonding and stereochemistry of following except where specific aspects are mentioned
   i) electron deficiency and acceptor behaviour of boron; diboranes, borohydrides, boron ni trides, perborates and its oxidizing behaviour.
   ii) Fluoro carbons – Their effect on earth's ozone shields, freons and Teflons, silicones; structural properties of various silicates.
   iii) Hydrazine, hydroxylamine and hydrazoic acid; phosphazenes;
   iv) Peracids and per salts of sulphur and halogens and their applications.
   v) Structure, bonding and reactivity of xenon fluorides.

6. Acid – bases and solvents **12L**

Lewis concept of acids and bases, HSAB principle, PH and its calculations, buffer solution-buffer effect; neutralization curves, acid -base indicator, choice of indicator-indicator error.

Solvent properties of water and liquid ammonia -reactions in liquid ammonia, levelling and differentiating solvents.

PAPER – II **Full Marks : 75**

Group A (Organic) : Bonding features, acids and bases, reaction mechanism I & II, stereochemistry – I, Synthesis, properties (37½ Marks)
45 L

1. Bonding features in organic molecules : **7 L**

Formation of cr and n bonds, hybridization, conjugation, hyper conjugation, inductive and field effects, resonance, bond distance, bond angle, bond energy, bond polarities, bond Polaris ability, steric and angular strain, orbital pictures of representative compounds.

2. Organic acids and bases : **3 L**

Bronsted and Lewis concepts, acid-base catalysis, effect of structure and substitutes, medium on relative acid and base strength of substituted alkenes, alkynes, alcohols, phenols, enols, carbonyl compou nds, carboxylic acids, amines, HSAB principle.

3. Tauto merism : **2L**

Prototropic shifts, ring-chain tautomerism, valence tautomerism, relative stability of tautomers with reference to bond energy, hydrogen bonding, resonance energy, solvent effects.

4. Reaction mechanism – I : 7 L

Classification of reagents: electrophiles and nucleophiles, reaction intermediates : carbocations, carbanions, radicals, carbenes, nitrenes and benzynes.

Classification of reaction : substitution, addition, elimination, rearrangement;

Some methods of determining reaction mechanism : Kinetic study, study of intermediates, crossover experiment, isotope labelling, kinetic isotope effects;

Thermodynamic requirements of reaction : ΔG, ΔH, ΔS, free energy profile diagrams for one step and two step reaction.

5. Stereochemistry – I : 11 L

Representation of molecules in Fischer, Newman, Sawhorse and flying wedge notations and their inter conversions.

Elements of symmetry : simple axis, plane of symmetry, center of symmetry, alternate axis of symmetry, chirality, optical activity, specific rotation, optical purity;

Stereoisomerism : enantiomers and diastereo-isomers, dl / meso, D / L, R / S, threo / erithro, syn / anti and E / Z notations; isomerism involving two (AA and AB types), three (ABA, ABC systems) chirl centers; conformation analysis of ethane, propane, butane, propyl halide, 1, 2 – dihalo ethane, 1, 2 – glycols.

6. Reaction mechanism – II : 11 L

Nucleophilic substitution at a saturated carbon : S_N1, S_N2, S_N2^1, S_N1^1 mechanisms; neighbouring group participation; aromatic nucleophilic substitution, cine substitution; nucleophilic substitution at carbonyl carbonl (carboxylic acids and derivatives) tetrahedral mechanism; electrophilic addition to C – C multiple bonds, aromatic electrophilic substitution.

Elimination reaction : a, β and γ - eliminations; E1, E 2 and E_1cB mechanism, elimination vs substitution.

7. Synthesis, physical properties and reactions of following classes of compounds 4L

Alkanes, alkenes, alkadienes and arencs, alkyl halides, vinyl halides, allyl and benzyl halides.

<u>Group B</u> (Physical): Kinetic theory and gaseous state, chemical thermodynamics, chemical equilibrium, colligative properties, liquid state (37½ Marks) 45L

1. Kinetic theory and gaseous state : 12L

Concept of temperature and pressure, nature of distribution of velocities in one, two and three dimensions, Maxwell's distribution of speeds (no derivation) and translational kinetic energy, distribution curves, calculation of number of molecules having energies ;: E; calculation of average speed, most probable speed and root mean square speed; principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases; variation of molar heat capacity with temperature.

Collision diameter, frequency of binary collisions (similar and different molecules), mean free path, wall collision and rate of effusion; viscosity of gases. Real gases : compressibility factor, deviation from ideality, coefficient of thermal expansion and coefficient of compressibility, vander Waals and virial equation of state, critical phenomena and critical constants, reduced equation of state, significance of second virial coefficient, Boyle temperature; intermolecular forces (Keesom, Debye, London) and potentials, liquifaction of

gases.

2. Chemical thermodynamics : 16 L

Definition of thermodynamic terms : intensive and extensive variables, isolated, open and closed systems, concept of heat and work, thermodynamic processes : cyclic, reversible, irreversible, isothermal, adiabatic process, thermodynamic functions and their differentials, zeroth law of theromodynamics; fi rst law of thermodynamics, internal energy (U), Joule's experiment and its consequences, Joule-Thomson experiment and its consequences, enthalpy (H), relation between Cp and Cv, calculation of work (w), quantity of heat (q), dU and dH for expansion of ideal and van der Waals gases, gas under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion. Heat changes during various physico-chemical processes at constant pressure / constant volume, Hess law, Kirchoff's relation, concept of standard state, bond dissociation energy, Born-Haber cycle for calculation of lattice energy.

Spontaneous process, heat engine, Carnot cycle and its efficiency, statements of second law, refrigeration cycle, thermodynamic scale of tem perature, entropy as a state function, Clausius inequality, calculation of entropy changes in different processes, molecular interpretation of entropy.

Gibbs function (G) and Helmholtz function (A), criteria of thermodynamic equilibria and spontaneity, va riation of G and A with P, V and T, Thermodynamic equation of state, Clausius -Clapeyron equation, equilibrium between different phases, system of variable composition, partial molar quantities, chemical potential of a component in an ideal mixture, thermodynamic functions of mixing of ideal gases, Gibbs -Duhem equation, variation of chemical potential with T, P and mole fraction, thermodynamics of real gases – fugacity and activity determination, Nernst heat theorem, Third law of thermodynamics and concept of residual entropy.

3. Chemical equilibrium : 4L

Chemical equilibria in homogeneous and heterogeneous systems, vant Hoff reaction isotherm (deduction from chemical potential, equilibrium constant and standard Gibb's free energy change), Le chatel ier's principle (thermodynamic approach) and its application. Vant Hoff equation and its applications.

4. Colligative properties of solution 5 L

Dilute solutions, Raoult's law and Henry's law, colligative properties, thermodynamic derivation of coll igative properties of solutions and their inter relationships, abnormal colligative properties

Liquid state : 8 L

Qualitative treatment of structure of liquid state, physical properties of liquids including their method of determination vapour pressure, surface tension, surface energy, excess pressure, capillary rise method of determination of surface tension, work of cohesion and adhesion, spreading of liquid over other surface, vapour pressure over curved surface, temperature dependence of surface tension.

General features of fluid flow (stream line flow and turbulent flow, Reynold number), nature of viscous drag from stream line motion, Newton's equation, viscosity coefficient, Poiseuille equation (with derivation), temperature dependence of viscosity coefficient of liquids and comparison with that for gases, Stoke's law and terminal velocity, determination of viscosity coefficient of liquids; Refractive index, liquid crystals (elementary discussion on classification, structure and properties).

PAPER – III **(Organic Practical)** **Full Marks - 50**

Time : 6 hours

1. Qualitative analysis of single organic compound **25**

i) Detection of special elements (N, Cl, Br, I, S) by Lassigne test.
ii) Determination of m.p/b.p of the given compound
iii) Solubility test
iv) Determination of the following functional groups by systematic anal ysis : phenolic OH, aldehyde, ketone, carboxylic acid (-COOH), aromatic nitro, aromatic amine (1^0 only), amido (-$CONH_2$) anilido (-CONH Ph)
v) Preparation of at least one solid derivative of the given sample, determination of melting point of the prepared der ivative (to be submitted for evaluation)

2. Organic preparation : **15**

a) Preaparation of m-dinitrobenzene from nitrobenzene
b) Preparation of p-nitro acctanilide from acetanilide
c) Oxidation of benzoin to benzil
d) Reduction of anthraquinone to anthrone
e) Preparation of adipic acid from cyclohexanol / cyclohe xa none
f) Preparation of dibenzal acetone from benzaldehyde
g) Preparation of 2-iodo benzoic acid from anthranilic acid
h) Preparation of methyl red

3. Laboratory note book **5**

4. Viva-Voce **5**

PART – II

Paper IV : (Inorganic) **Full Marks : 75**

Group A : Transition elements and coordination compounds, nature of chemical bond II, redox potential ($37\,^1/_2$ Marks) **45 L**

1. Transition elements and coordina tion compounds : **20 L**

Characteristic properties of d-block elements, comparative study of the elements of the first transition series with reference to sizes, ionization potentials, redox potentials, magnetic behaviour, oxidation states and ab ility to form complex compounds, trends in chemical and physical properties in passing from first to second and third series.

Werner's coordination theory, classification of ligands, coordination numbers and stereochemistry, IUPAC nomenclature for coordin ation compounds, chelates, geometrical, optical and linkage isomerism, purely inorganic optically active compounds, trans effect, stability of coordination compounds : overall and step wise stability constants.

2. The nature of chemical bond – III : 15 L

Covalent bonding : directional characteristics of covalent bon d, hybridization and shapes of simple inorganic molecules and ions, valence shell electron pair repulsion (VSEPR) theory, Bent's rule and its applications, Molecular orbitals of diatomic molecules : LCAO approximation, bonding, antibonding and non - bonding orbitals, MO configurations of simple homonuclear diatomic and hetero nuclear diatomic molecules, bond properties, bond order and bond strength, polarity of covalent bonds, resonance and resonance energy.

3. Redox potentials : 10L

Standard electrode potentials, redox potentials and formal potentials, redox potential to explore the feasibility of reactions and calculations of values of equilibrium constants, Redox potential as a function of pH, precipitation and complex formation, redox ti trations and redox indicators, Frost, Latimer and Pourbaix diagrams of redox potential.

<u>Group B</u>: Lanthanides and actinides, separation through chromatographic techniques, organic reagents in chemical analysis, complexometric titrations, mono nuclear me tal carbonyls (37½ Marks) 45 L

4. Lanthanides and actinides : 12 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; super heavy elements : Oxo compounds of Np, Pu and U.

5. Separation through chromatographic techniques : 8L

Classification – basic principle, column chromatography, ion-exchange chromatography – ion exchange resins – ion – exchange capacity, principle of ion-exchange, separation and applications, ion -chromatography.

6. Organic reagents in chemical analysis : 12 L

Selective, specific and sensitive reacti ons, identification limit and concentration limit, analytical applications of dimethyl glyoxime, 8 -hydroxy quinoline, 1,10 – phenanthroline, 2,2 – bipyridyl and their substituted products in titrimetry, gravimetry, colorimetry, solvent extraction and in sp ot test analysis.

7. Complexo metric titrations 8L

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

8. Mono nuclear metal ca rbonyls 5L

Preparation, properties, reactions and bonding in $Ni(CO)_4$ and $Fe(CO)_5$; preparation, properties and uses of sodium nitroprusside.

Paper – V

Full Marks : 75

Group A (Organic) : Stereochemistry – II, reaction mechanism – III, synthesis, properties and reactions of organic compounds. Organometallic compounds ($37^1/_2$ Marks) 45L

1. Stereochemistry – II 10L

Chirotopicity and achirotopicity; pseudoasymmetry; prochirality; enantiotopic, diastereotopic and homotopic atoms and faces in organic molecules.

Axial chirality – allenes and biphenyls; R/S nomenchature of axially chiral systems.

Stereoisomerism of alicyclic compounds, Baeyer strain theory,disubstituted cyclohexane derivatives – conformational analysis.

2. Reaction mechanism – III 10L

Rearrangement reactions: actual nature of migration, migratory aptitude, Wagner-Merwein rearrangement, pinacol -pinacolone rearrangment, Wolff rearrangement, Beckman rearrangement (including fragmentation), Baeyer - Villiger type rearrangement.

Different oxidative processes based on one-electron and two electron oxidants, Cr (VI) oxidants, MnO_2 and O_sO_4 oxidations.

Different reductive processes; reduction with metal hydrides of B and Al; hydrogenations (including transfer hydrogenation), dissolving metal reduction.

3. Synthesis, physical properties and reaction of the following classes of compound : 20 L

a) Hydroxy compounds: aliphatic and aromatic (including poly hydroxy compounds)
b) Ethers and epoxides
c) Aliphatic and aromatic carbonyl compounds, aβ - unsaturated carbonyl compounds, quinines
d) Aliphatic and aromatic carboxylic acids and their derivatives, esters, amides, anhydrides
e) Aliphatic and aromatic nitrogen compounds : amines, nitroalkanes, nitroarenes, nitrophenols, amino phenols, aromatic diazonium compo unds, diazomethane, diazoacetic ester
f) Polynuclear aromatic hydrocarbons : naphthalene, phenanthrene and anthracene

4. Organometallic compounds : 5 L

Preparation and synthetic applications of Grignard reagents, organolithium compounds, organocopper reagents and organozinc reagents (Reformatskii, Simon-Smith cyclopropanation, addition of oraganozinc reagents to carbonyl compounds).

Group B (Physical) : Electrochemistry, chemical kinetics, crystalline state, adsorption and surface phenomena, colloid and macromolecules (37½ Marks) 45L

Electrochemistry 20L

Conductance : conductance and its measurement, specific conductivity, molar conductivity and equivalent conductiv ity, their variation with concentration for strong and weak electrolytes, ionic velocities and mobilities, Kohlrausch's law of independent migration of ions, conductometric titration (acid -base, precipitation and replacement reactions), ionic strength, Deb ye-Huckel limiting equation (no derivation)

Transference numbers and their experimental determination using Hittorf's and moving boundary methods, anomalous transference numbers; application of conductance measurement for determination of solubility and so lubility product, degree of ionization, ionic product of water, hydrolysis constant of salts.

Ionic equilibra : strong and weak electrolytes, dissociation equilibria of weak electrolytes, multistage equilibria, pk of acids and bases, pH, pH changes in acid-base titration (weak and strong) involving not more than two stages in aqueous medium, common ion effect, hydrolysis of salts, buffer solution, buffer capacity, mean ionic activity coefficient, dependence of activity coefficient on ionic strength, acid-base indicator, influence of ionic strength and common ion effect on solubility and solubility product.

EMF : electrolytic and galvanic cells, reversible and irreversible cells, electromotive force (E) of a cell and its measurement, Nernst equation, determ ination of E and equilibrium constant of a cell reaction, free energy, entropy and enthalpy of cell reactions, standard electrode potential, standard cell, types of clectrodes / half cells, reference electrode, determination of solubility product and ionic product of water, measurement of ionic activity coefficient of electrolytes, concentration cells with and without transference, liquid junction potential (no derivation) and its elimination, determination of pH using hydrogen electrode, quinhydr one electrode, glass electrode, potentiometric titration (acid -base, redox and precipitation), secondary cell, fuel cell.

Chemical Kinetics : 10L

Concepts of rate, order and molecularity of a reaction, differential and integrated forms of rate equation upto second order only, half -life period, experimental methods of determination of order of a reaction, comparison of methods (Guggenheims, differential, isolation method) rate -determining steps, steady – state approximation, temperature de pendence of rate constant, Arrhenius equation, energy of activation, complex reactions : opposing reaction, parallel reaction and consecutive reactions (all steps of first order), collision theory, Lindemann theory of unimolecular reaction, transition stat e theory (thermodynamic treatment)

Reaction in solution and salt effect.

Homogeneous, acid-base and enzyme catalysis.

Crystalline state : **5L**

Nature of solid state, types of bonding in solids, laws of crystallography, concept of unit cell, seven crystal systems, Bravais lattice, Miller indices, symmetry elements in crysta l, x-ray diffraction, Bragg's law, Laue method, powder method, crystal structure of NaCl and KCl, radius ratio in packing in crystals.

Adsorption and surface phenomena **5L**

Physisorption and chemisorptions of gases, adsorption isotherms, derivation of Freundlich and Langmuir isotherm, BET equation (derivation not required) and its use in surface area determination, nature of adsorbed state, adsorption and heterogeneous catalysis, surface film, concept of surface excess, Gibb's equation.

Colloids and macromolecules **5L**

Electrical double layer and colloid stability, electrokenetic phenomena, soaps and detergents, micelle formation and critical micelle concentration.

Characteristics of macromolecules (addition and condensation polymerization), degree of polymerization, concepts of number and mass -average molar mass, osmometry, viscometry, light scattering and diffusion methods in the studies of average molar mass, shapes of macromolecules.

PAPER – VI : (Inorganic practical) Full Marks : 50

Time 6 hours

A. Inorganic quantitative analysis (30 marks)

1. a) Preparation of standard solution of oxalic acid and standardization of NaOH solution and $KMnO_4$ solution
   b) Preparation and standardization of Mohr's salt solution by $KMnO_4$ solution.
   c) Preparation of standard $K_2Cr_2O_7$ 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 sulp hate as $BaSO_4$, chromate as $BaCrO_4$, 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)

i) Praparation of chrome alum
ii) Preparation of oxalato complexes of Cr (III), Fe (III) and Cu(II)
iii) Preparation of $[CoHg(SCN)_4]$
iv) Preparation of Reinecke salt, $(NH_4)[Cr(NH_3)_2(SCN)_4]$, H_2O

[Ref : Experimental Inorganic chemistry, W.G. Palmer, P. 403, Cambridge University Press (1962)]

C. Viva –voce (5 marks)

D. Laboratory note book (5 marks)

PART- III

PAPER VII : (Inorganic) Full Marks : 80

Group A: Symmetry, Magnetochemistry, Chemical bonding –III (40 Marks)

50L

1. **Symmetry elements, symmetry operations and point groups** **12L**

Symmetry as a universal theme. Different symmetry classes and symmetry operations (discussion with suitable examples). Applications of symmetry to a) Polar molecules b) chiral molecules. Symmetry properties of orbitals (basic concepts); concept of point groups, identification of molecular point groups in some simple molecules.

2. **Magnetochemistry** **12L**

Types of magnetic behaviours of substances, magnetic susceptibility and its measurement (Gouy method), diamagnetic correction, effective magnetic moment. Curie and Curie-Weiss law. Ferro-, ferri- and anti ferromagnetic behaviours, Neel temperature; sub-magnetic moments. Spin – orbit coupling, Spin – only moment for first row transition metals. Magnetic moments for rare-earth elements.

3. **The nature of chemical bond III** **26L**

Bonding in coordination compounds : Valence bond description and its limitations. Crystal Field Theory (CFT). Crystal field splitting in octahedral, tetrahedral and square planar complexes. Crystal field stabilization energy (CFSE). Factors affecting the crystal-field parameters.

Spectrochemical series, Jahn – Teller effect in octahedral complexes, colour and spectral behaviours of d^1 and d^9 systems. VB theory to explain bonding, geometry and magnetism of first – row transition metal complexes, stabilization of unusually low and high oxidation states of metals.

Group B : Organo metallic compounds; bio-inorganic chemistry; chemistry of elements (40 Marks) **50L**

4. **Chemistry of organometallic compounds** **16L**

Nature of M-C bond, classification of organometallic compounds, nomenclature, hapticity and valence electron count. Organo-lithium aluminium, magnesium, zinc and titanium compounds – their preparations, properties, reactions, bonding and applications. "Sandwitch'' bonded compound : Ferrocene – its preparation, reactions and structure.

5. **Bio-inorganic chemistry** **16L**

Metal ions in living systems – a brief review. Active transport of sodium, potassium and calcium ions through cell walls, Na^+ ion pump. Some biological ligands : Porphyrin and adenosine triphosphate (ATP). Haemoglobin, myoglobin and chlorophyll – their structural features and functions in living system.

Metal ion toxicity and its biochemical 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)

6. **Chemistry of elements** **18L**

a) Platinum metals – position in periodic table, group comparison chemistry of Pt and Pd in their +2 and + 4 oxidation states; medicinal and catalytic applications of platinum metals.
b) Oxides, halides, oxo-and halo complexes of Mo and W in their + 5 and +6 oxidation states. Tungs ten bronzes and Mo-S bonded compounds.
c) Separation of Nb from Ta; Niobates and tantalates – properties and structure of the lower halides of Nb-Ta.

PAPER VIII : (Organic) Full Marks : 80

Group A : Stereochemistry–III, reaction mechanism – IV, spectroscopy (40 Marks)

50L

1. Stereochemistry – III **10 L**

Stereoselective synthesis : addition to > C = 0 and reduction of > C = 0 (simple illustraion of Cram's and Felkin's rules) addition to C = C (electrophile induced cyclization, iodolactonization), alkylation of enolate ions, Cieplak model, aldol reactions, S_N2, NGP and E2 in cyclic systems, n – facial selectivity.

2. Reaction mechanism – IV **15 L**

Molecular orbitals of conjugated systems; HOMO and LUMO in ground and excited states.

Definition and classification of pericyclic reactions, thermal and photochemical electro cyclic reactions involving 4 and 6 n electrons (FMO approach).

Cycloaddition reactions, Diels – Alder reaction, dipolar cycloaddition reactions.

Sigmatropic shifts [1,3], [1,5] – H shifts, [3,3]- shifts with reference to Claisen and Cope rearrangements.

3. Spectroscopy in organic chemistry **25L**

UV : electronic transitions with reference to cr - cr*, n - cr*, n - n*, n - n* transitions , absorption maximum, extinction coefficient, effect of solvent, pH; bathochromic and hypsochromic shifts, Woodward rules with reference to conjugated dienes, trienes, a, β - unsaturated carbonyl compounds including cyclic systems.

IR : modes of vibrations; selection rules, Hooke's law, characteristic and diagnostic stretching frequencies O-H, N – H, C – H, C = C, C = N, C = O functions; factors affecting stretching frequencies (H -bonding, electronic factors, ring size); finger print region; diagnostic bending frequencies of benzene derivatives (o -, m and p- isomers).

^{1}H-NMR : NMR – active nuclei, principle of PMR, equivalent and non-equivalent protons, chemical shift, shielding and deshielding of protons (systems involving C = C, C = O, aromatic ring), coupling constant, simple splitting patterns (AX, ABX, AMX)

(joint application of all three spectroscopic methods in structure elucidation of simple organic molecules)

Group B: Organic synthesis, heterocyclic compounds, synthetic dyes, pharmaceuticals and polymers, molecules of nature (40 Marks) 50L

4. Organic synthesis – I 12L

Disconnection approach to bifunctional molecules (cyclic a nd acyclic); synthons, synthetic equivalents (ethyl aceto acetate, diethyl malonate, ethyl cyanoacetate), functional group inter conversions, umpolung; illogical electrophiles and nucleophiles, retro synthetic analysis and synthesis of 1,2; 1,3; 1, 4 and 1, 5 – dioxygenated compounds

5. Organic synthesis – II 12 L

Michael reaction, Robinson annulation, Perkin reaction, Stobbe reaction, Dieck man reaction, Favorskii and Demjanov rearrangement, Stork enamine reaction, Hofmann-Loffler-Freytag reaction, Prevost reaction and its modification, Birch reduction, Wittig reaction.

Utility of some reagents: n – Bu_3 SnH, boranes, trimethyl silyl chloride, sulfonium and sulfoxonium ylides, diethyl azodicarboxylate, hydrogen peroxide, N-bromosuccinimide, DDQ, m - CPBA, $HI0_4$, Pb $(OAc)_4$.

6. Heterocyclic compounds 10L

Synthesis (including retro synthetic approach) and reactivity of some n - excessive and n - deficient heterocyclic compounds; comparative reactivity of furan, thiophene and pyrrole; indole, pyridine, quinoline and isoquinoline ring systems.

7. Synthetic dyes, pharmaceuticals and polymers 6L

Preparation and use of methyl orange, congo red, malachite green, phenolphthalein.

Preparation and uses of paracetamol, aspirin, s ulfadiazine, metronidazole and salbutamol; preparation and uses of polythene, polystyrene, Teflon, PVC and nylon.

8. Molecules of nature 10L

Carbohydrates : monosaccharides, osazone formation, stepping up and stepping down of aldoses, convesion of aldoses to ketoses and vice -versa, constitution and configuration of D-glucose and D –fructose, mutarotation, anomeric effect.

Amino acids and peptides : physical properties, isoelectric point, ninhydrin reaction, petide synthesis – problems and solutions, Merrifield synthesis, structure determination of peptides, C -terminal and N-terminal determination.

PAPER IX : Physical Chemistry Full Marks : 80

Group A : Electrical and magnetic properties of matter, rotati onal spectra, vibrational spectra photochemistry, statistical thermodynamics (40 Marks) 50L

1. Electrical and magnetic properties of matter : 10L

Intermolecular forces, dipole moment, electrical polarization, Clausius -Mosotti equation (no-derivation) orientation polarization, Debye equation, measurement of dipole moment and polarisability dipole moment and molecular structure. Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, magnetic susceptibility molecular interpretation.

2. Rotational spectra : 6L

Rigid rotor model, moment of inertia, in tensity of spectral lines and determination of bond lengths of diatomic molecules, linear triatomic molecules, isotopic substitution.

3. Vibrational spectra : 12L

Classical equation of vibration (Hooke's law), linear harmonic oscillator, vibrational energies of diatomic molecules, zero -point energy, force constant and bond length. Anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, degree of freedom of polyatomic molecules, diatomic vibrating rotor, P.Q, R branches, evaluation of force constants from fundamental frequencies, application of vibrational spectra in elucidation of molecular structure from vibrational frequency.

4. Photo chemistry 17L

Potential energy curves for electro nic states, Frank-Condon principle, decay of the existed states by radiative and non -radiative paths, Jablonsky diagrams. Lumine scence phenomena : phosphorescence, flurescence, chemiluminescene and bioluminescence, Lambert – Beer law, comparison between t hermal and photo chemical reaction.

Grotthus – Draper law, Stark – Einstein law of photo chemical equivalence, quantum yield, examples of low and high quantum yield, photostationary equilibrium, photodimerisation of authracene, rate of photochemical reacti ons, actinometry, photo sensitized reactions, quenching of fluorescence and Stern - Volmer equation. Flash phololysis (brief idea only)

5. Statistical thermodynamics 5L

Limitation of chemical thermodynamics, brief resume of the concepts of distribution of energy, thermodynamic probability, Maxwell -Boltzmann distribution law, phase space, partition function and its significance, ensemble concept.

<u>Group B</u> : Quantum theory, atomic spectra and molecular structure, atomic structure and atomic spectra, c hemical bonding and molecular geometry, phase-equilibria (40 Marks) 50L

6. Quantum theory, atomic spectra and molecular structure : 20L

Bohr model and its limitation, black -body radiation, photo -electric effect and Compton effect, Zeeman effect, de Broglie equation and matter waves, diffraction of electrons. Failure of old quantum theory to explain atomic and molecular spectra.

Uncertainty principle, postulates of quantum mechanics, operators and observables, Schrodinger equation, interpretation of wave function and expectation values, quantisation of translational energy, solution of Schrodinger equation for particle in one -and three – dimensional box problems, degeneracy .

7. Atomic structure and atomic spectra **8L**

Structure of hydrogen atom, energy levels of atomic hydroge n, atomic orbitals, radial distribution function, n, l, m quantum numbers, spectral selection rules (empirical), structure of many-electron atoms, Pauli exclusion principle, total spin states and quantization of total angular momentum (J), aufbau principle , Rydberg states.

8. Chemical bonding and molecular geometry **10L**

Hydrogen molecular ion: Born-Oppenheimer approximation, variation principle, H_2^+ ion, molecular orbital (MO), non-bonding, bonding and anti bonding orbitals.

Diatomic molecular : Hydrogen molecule and molecular orbitals, s, p – overlap, structure of diatomic molecules, valence bond theory : election pair, resonance, and aromaticity. Weak chemical bonds (hydrogen bond, van der Waals and charge-transfer)

9. Phase equilibria **12L**

Phase, component, degrees of freedom, deduction of phase rule for reactive and non-reactive system, equilibrium between phases, Nernst distribution law and solvent extraction principle, phase diagram of one component system – water, carbondioxide, sulphur, 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 : Duhem Margules equation, Konowaloff's rule, deviation from Raoult's law, azeotrope, principle of isobaric fractional distillation, (iv) Solid-solution equilibria : Simple eutectic system, systems with congruent and in congruent melting points, zone refining (qualitative idea only).

Paper – X : (Practical)

Full marks – 80
Time : 2 x 6 Hours

Group A (Inorganic) **Marks: 40**

Inorganic qualitative analysis (30 marks)

Semi-micro qualitative Inorganic analysis of mixture containing not more than 4 (four) radicals from among the following by systematic tests.

Basic radicals : Pb, Cu, Bi, Cd, As, Sb, Sn, Fe, Al, Cr, Co, Ni, Mn, Zn, Ca, Sr, Ba, Mg, K, Na, NH_4^+

Acid radicals : Cl^-, Br^-, I^- , NO_2^-, NO_3^-, S^{2-}, $S_2O_3^{2-}$, SO_4^{2-}, PO_4^{3-}, ASO_4^{3-}, BO_3^{3-}, H_3BO_3.

Treatment of insoluble compounds : Al_2O_3, SnO_2, Fe_2O_3 (ignited), Cr_2O_3, $PbSO_4$, $SrSO_4$, $BaSO_4$.

Laboratory Note book 5 Marks

Viva-voce 5 Marks

Group B **Marks – 40**
Time – 6 Hours

Organic quantitative : 15 Marks
1. Quantitative estimationof aniline, glucose, phenol and acetone

Industrial analysis : 15 Marks
a) Estimation of Vitamin C in multivitamin tablet, citrous fruits
b) Estimation of nitrogen in glycine (kjeldal method)
c) Total hardness of water – estimation
d) Estimation of available chlorine in bleaching powder
e) Estimation of available oxygen in pyrolusite
f) Saponification of fats and oils

Laboratory note book 5 Marks
Viva Voce 5 Marks

Paper XI : Physical Chemistry Practical **Full Marks : 80**
Time : 2 x 6 Hours

Group A **40 Marks**
Time 6 Hours

Physical Chemistry experiments
1. Viscosity : To determine the percentage composition of a given mixture by Ostwald viscometer
2. Surface tension : To determine the percentage composition of a given mixture (e.g. aqueous solution of acetic acid) by stalagmometer
3. Adsorption : To study the adsorption of acetic acid / oxalic acid on activated charcoal and verify Freundlich adsorption isotherm
4. Distribution law :
   a) To study the distribution coefficient of iodine between water and chloroform.
   b) To study the dimerisation of benzoic acid in benzene
   c) To determine the equilibrium constant of the reaction $KI + I_2 = KI_3$ (distribution coefficient of I_2 between (CCl_4 and water to be provided)
5. Thermodynamics : To determine the enthalpy of a solution of benzoic acid in water.
6. Chemical Kinetics :
   a) To determine the specific reaction rate of the acid catalysed hydrolysis of methyl acetate / ethyl acetate at room temperature.
   b) To determine the bimolecular rate constant of the oxidation of iodide ion by hydrogen peroxide in aqueous solution at room temperature .
7. Colourimetry : To determine the pH of a given solution colourimetrically, using methyl red / bromocresol green indicator

Laboratory note book 5 Marks
Viva-voce 5 Marks

Group B **20 Marks**

Time 6 Hours (for Group B and Group C)

1. **Colorimetry :** To verity Lambert –Beer's law for $KMnO_4$ / K_2Cr_2O7 / $NiCl_2$ solution and hence to deter mine the concentration of a given solution of the substance.

2. **Polarimetry :** To study the kinetics of inversion of cane sugar

3. **Refractometry :**
   a) To determine the concentration of an unknown solution of ethanol using Abbe refractometer
   b) To determine the molar refractivities of ethanol at room temperature

4. **Conductometry :**
   a) To determine the concentration of HCl and CH_3COOH in a mixture conductometrically
   b) To determine the solubility and solubility product of a sparingly soluble electrolyte conductometrically
   c) To determine Ao of a strong electrolyte.

5. **Potentiometry :**
   a) To titrate potentiometrically the given Mohr's salt solution using $KMnO_4$ > $K_2Cr_2O_7$ as standard and hence calculate the redox potential for Fe^{+2} / Fe^{+3} system
   b) To determing the E^0 of quinhydrone electrode potentiometrically
6. P_H – metry : To determine the concentration of an unknown acid solution using P_H – meter.

Group C **10 Marks**

Computer application

1. To plot the P-V curve for a van der Waals gas
2. To plot the velocity distribution curve for Maxwell distribution of velocities.
3. To obtain the value of rate constant from analysis of observed kinetic data
4.

Laboratory note book (Gr B + Gr C) 5 Marks
Viva-voce (Group B + Group C) 5 Marks