||अंतरी पेटवू ज्ञानज्योत||

NORTH MAHARASHTRA UNIVERSITY, JALGAON

SCHOOL OF CHEMICAL SCIENCES

PROPOSED SYLLABUS FOR

M.Sc. - I Year

Polymer Chemistry

Industrial Chemistry

Pesticides & Agrochemicals

(W.e.f. Academic Year 2002 - 2003)

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[Polymer Chemistry, Industrial Chemistry , Pesticides & Agrochemicals]

w.e.f. - Academic Year 2002-2003

SEMESTER - I

Course No.	Course	Hours	Marks
CH-101	Inorganic Chemistry - I	60	100
CH-102	Organic Chemistry - I	60	100
CH-103	Physical Chemistry - I	60	100
CH-104	Spectroscopy - I	30	50

SEMESTER - II

Course No.	Course	Hours	Marks
CH-201	Inorganic Chemistry - II	60	100
CH-202	Organic Chemistry - II	60	100
CH-203	Physical Chemistry - II	60	100
CH-204	Spectroscopy - II	30	50

Laboratory Courses for First Year (Semester -I & II)

Course No.	Course	Hours	Marks
CH-001	Laboratory Course in Inorganic Chemistry	180	100
CH-002	Laboratory Course in Organic Chemistry	180	100
CH-003	Laboratory Course in Physical Chemistry	180	100

Minimum 50% practicals from all units should be completed in semester-I

PROPOSED SYLLABUS FOR M. Sc. I YEAR

[Polymer Chemistry, Industrial Chemistry, Pesticides & Agrochemicals]

w.e.f. Academic Year 2002-2003

SEMESTER - I

CH-101 Inorganic Chemistry-I — **60 Hrs (4 Hrs/week)**

I **Symmetry and Group Theory in Chemistry** — **12 Hrs (12 Marks)**

Symmetry elements and symmetry operations , definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices (representation for the C_{2v}, C_{3v}, C_{4h}, D_{4h} etc. groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use; spectroscopy.

II **Stereochemistry and Bonding in Main Group Compounds** — **12 Hrs (12 Marks)**

VSEPR, Walsh diagram (tri- and penta-atomic molecules), $d_{\pi}p_{\pi}$ bonds, Bent rule and energetics of hybridization, some simple reactions of covalently bonded molecules.

III **Reaction Mechanism of Transition Metal Complexes** — **20 Hrs (20 Marks)**

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidences in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the subtitution reaction. Redox reactions, electron transfer reactions, mechanism of one electron transfer reactions, outer-sphere and inner sphere type reactions

IV **Metal-Ligand Bonding** — **16 Hrs (16 Marks)**

Limitation of crystal field theory, molecular orbital theory, octahedral, tetrahedral and square planar complexes, π-bonding and molecular orbital theory.

CH-102 Organic Chemistry-I — **60 Hrs (4 Hrs/week)**

I **Nature of Bonding in Organic Molecules** — **8 Hrs (8 Marks)**

Chemical bonding, Aromacity in benzenoid and non-benzonoid compounds, alternant and non-alternant hydrocarbons, Huckel's rule, energy level of π-molecular orbitals, annulenes, anti-aromaticity, Ψ-aromaticity, homo-aromaticity, PMO approach.

Bonds weaker than covalent-addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

II **Reaction Mechanism : Structure and Reactivity** — **10 Hrs (10 Marks)**

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects.

Effect of structure on reactivity – resonance and field effects, steric effect, quantitative treatment. The Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

III **Substitution Reactions** — **24 Hrs (24 Marks)**

A. **Aliphatic Nucleophilic Substitution**

The S_N2, S_N1, mixed S_N1 and S_N2 and SET mechanisms.

The neighbouring group mechanism, neighbouring group participation by π and σ bonds, anchimeric assistance.
The S_Ni mechanism. Nucleophillic substitution at an allylic, aliphatic trigonal and a vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, phase transfer catalysis and ultrasound, ambident nucleophile, regioselectivity.

B. **Aliphatic Electrophillic Substitution**
Bimolecular mechanisms- S_E2 and S_Ei. The S_E1 mechanism, electrophillic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.

C. **Aromatic Electrophillic Substitution**
The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrates and electrophiles. Diazonium coupling, Vilsmeir reaction, Gattermann-Koch reaction.

D. **Aromatic Nucleophillic Substitution**
The S_NAr, S_N1, benzene and $S_{RN}1$ mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophile. The von Richter, Sommelet-Hauser, and Smiles rearrangements.

IV **Free Radical Reactions** 6 Hrs (6 Marks)
Types of free radical reactions, free radical substitution mechanism, mechanism at an aromatic substrate, neighbouring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity.
Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

V **Organic name reactions** 12 Hrs(12 Marks)
Aldol, Perkin, Stobbe, Dieckmann condensations, Hoffmann, Schmidt, Lossen, Curtius, Beckman & Fries rearrangements, Reimer-Tiemann, Reformatsky & Grignard reactions, Diels-Alder reactions, Claisen rearrangement; Friedel-Craft reaction, wittig reaction. Hydroboration, Oppenaur oxidation, Clemmensen, Wolf-Kishner, Meerwein-Ponndorf-Varley and Birch reductions. Favorskii reaction, Stork examine reaction, Michael addition, Mannich reactions, Barton reaction, Hofmann-Loffler-Freytag reaction, Baeyer-Villager reaction.

CH-103 Physical Chemistry-I **60 Hrs (4 Hrs/week)**

I **Mathematics for Chemists -** 15 Hrs (15 Marks)

A **Differential Calculus**
Functions, continuity and differentiability, rules for differentiation, applications of differential calculus including maxima and minima (examples related to maximally populated rotational energy levels, Bohr's radius and most probable velocity from Maxwell's distribution, etc), exact and inexact differentials with their applications to thermodynamic properties.
Integral calculus, basic rules for integration, integration by parts, partial fraction and substitution. Reduction formulae, applications of integral calculus.
Functions of several variables, partial differentiation, co-ordinate transformations (e.g. cartesian to spherical polar), curve sketching.

B **Permutation and Probability**
Permutations and combinations, probability and probability theorems, probability curves, average, root mean square and most probable errors, examples from the kinetic theory of gases etc., curve fitting (including least squares fit, etc.) with a general polynomial fit.

II Quantum Chemistry

20 Hrs (20 Marks)

A Introduction to Exact Quantum Mechanical Results

The Schrodingers equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz., particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

B Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

C Electronic Structure of Atoms

Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the p^n configuration, term separation energies for the d^n configurations, magnetic effects: spin-orbit coupling and Zeeman splitting.

D Molecular Orbital Theory

Huckel theory of conjugated systems, bond order and charge density calculations. Applications to ethylene, butadiene.

III Thermodynamics

25 Hrs (25 Marks)

A. Classical Thermodynamics

Brief resume of concepts of laws of thermodynamics, free energy, chemical potential and entropies. Partial molar properties; partial molar free energy, partial molar volume and partial molar heat content and their significances. Determinations of these quantities. Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient. Debye-Huckel theory for activity coefficient of electrolytic solutions; determination of activity and activity coefficients; ionic strength.

Application of phase rule to three component systems; second order phase transitions.

B Statistical Thermodynamics

Concept of Distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws (using Lagrange's method of undetermined multipliers).

Partition functions – translational, rotational, vibrational and electronic partition functions, calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.

Heat capacity behaviour of solids – chemical equilibria and equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal. Bose-Einstein statistics – distribution law and application to helium.

C Non Equilibrium Thermodynamics

Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

CH-104 : Spectroscopy - I **30 Hrs. (2 Hrs/week)**

I Introduction to Spectroscopy 10 Hrs (10 Marks)

Electromagnetic radiation, interaction of electromagnetic radiation with matter-absorption, emission, transmission, reflection, refraction, dispersion, polarisation and scattering.

Electronic spectra of polyatomic/diatomic molecules : Born-Oppenheimer approximation, vibrational coarse structure, Intensity of vibrational-electronic spectra, Franck Condon principle, Emision spectra, radiative and nonradiative decay, internal conversion, spectra of transition metal complexces, charge transfer spectra.

II **Microwave spectroscopy** 5 Hrs (5 Marks)

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

III **Vibrational Spectroscopy** 15 Hrs (15Marks)

A. Infrared Spectroscopy

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

B. Raman Spectroscopy

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

SEMESTER - II

CH – 201: Inorganic Chemistry-II 60 Hrs (4 hrs/week)

I **Electronic Spectra and Magnetic Properties of Transition Metal Complexes** 24 Hrs (24 Marks)

Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), calculations of Dq, B and β parameters, charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange.

II **Metal π-Complexes** 18 Hrs (18 Marks)

Metal carbonyls, structure and bonding, vibrational spectra of metal carbonyls for bonding and structural elucidation, important reactions of metal carbonyls; preparation, bonding, structure and important reactions of transition metal nitrosyl, dinitrogen and dioxygen complexes; tertiary phosphine as ligand

III **Metal Clusters** 14 Hrs (14 Marks)

Higher boranes, carboranes, metalloboranes and metallocarboranes. Metal carbonyl and halide clusters, compounds with metal-metal multiple bonds.

IV **Isopoly and Heteropoly Acids and Salts** 4 Hrs (4 Marks)

CH – 202 : Organic Chemistry-II 60 Hrs (4 hrs/week)

I **Stereochemistry** 15 Hrs (15 Marks)

Conformational analysis of cycloalkanes, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding.

Elements of symmetry, chirality, molecules with more than one chiral center, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis. Optical activity in the absence of chiral

carbon (biphenyls, allenes and spiranes), chirality due to helical shape.
Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

II **Addition Reactions** 12 Hrs.(12 Marks)

A. **Addition to Carbon-Carbon Multiple Bonds**

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

B. **Addition to Carbon-Hetero Multiple Bonds**

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Wittig reaction.
Mechanism of condensation reactions involving enolates – Aldol, Knoevenagel, Claisen, Hydrolysis of esters and amides, ammonolysis of esters.

III **Elimination Reactions** 6 Hrs (6 Marks)

The E2, E1 and E1cB mechanisms anad their spectrum. Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium.
Mechanism and orientation in pyrolytic elimination.

IV **Pericyclic Reactions** 17 Hrs (17 Marks)

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

V **Reagents in Organic Synthesis** 10 Hrs (10 Marks)

Reagent in organic synthesis : Use of the following reagents in organic synthesis and functional group transformations, complex metal hydrides, Gilmans reagent, Lithium diisopropylamide, Dicyclohexyl carbodiimide, Trimethylsilyliodide, Osmonitumtetroxide, DDQ, Seleniumdioxide, Phase transfer catalyst, Crown ethers and Merrifield resins, Willkinson's catalyst.

CH – 203 : Physical Chemistry-II **60 Hrs(4 hrs/week)**

I **Chemical Dynamics** 15 Hrs (15 Marks)

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

II **Surface Chemistry** 25 Hrs (25 Marks)

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

B **Micelles**
Surface active agents, classification of surface active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization – phase separation and mass action models, solubillization, micro emulsion, reverse micelles.

C **X-ray Diffraction**
Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.

D **Electron Diffraction**
Scattering intensity vs. scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

III **Electrochemistry** 20 Hrs (20 Marks)
Electrochemistry of solutions. Debye-Huckel – Onsager treatment and its extension, ion solvent interactions. Debye-Huckel-Jerum mode. Thermodynamics of electrified interface equations. Derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces. Guoy – Chapman, Stern, Graham – Devanathan – Mottwatts, Tobin, Bockris, Devanathan models.

Over potentials, exchange current density, derivation of Butler – Volmer equation, Tafel plot.

Quantum aspects of charge transfer at electrodes-solution interfaces, quantization of charge transfer, tunneling.

Semiconductor interfaces – theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Effect of light at semiconductor solution interface.

Electrocatalysis – influence of various parameters. Hydrogen electrode.

Bioelectrochemistry, threshold membrane phenomena, Nernst-Planck equation, Hodges – Huxley equations, core conductor models, electrocardiography.

Polarography theory, Ilkovic equation; half wave potential and its significance.

Introduction to corrosion, homogenous theory, forms of corrosion, corrosion monitoring and prevention methods.

CH-204 : Spectroscopy – II 30 Hrs. (2 Hrs/week)

I **Ultraviolet & Visible Spectroscopy** 6 Hrs (6 Marks)
Various electronic transitions (185 -800 nm). Ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dines and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds. Steric effect in biphenyls.

II **Infrared Spectroscopy** 8 Hrs (8 Marks)
Theory of IR spectroscopy, Instrumentation, Sample handling, factors affecting IR frequency,Chareacteristics vibrational frequncies of alkanes, alkenes, alkynes, aromatic compounds, alcholos, ethers, phenols and amines. Detailed study of vibrational frequncies of carbonyl compounds (ketones, aldehydes,esters,amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequncies, overtones, combination bands and fermi resonance. FTIR.

III **Nuclear Magnetic Resonance Spectroscopy** 10 Hrs (10 Marks)

Theory of NMR spectroscopy, General introduction and definition chemical shift, spin-spin interaction, shielding & deshilding mechanism. Correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic, aromatic, alcohols, phenols, carboxylic acids, amines, amides & mercapto). Simplification of complex spectra-nuclear magnetic double resonance, shift reagent , solvent effect. FT NMR , NOE .

Introduction to Carbon-13 NMR Spectroscopy.

IV **Mass Spectrometry** 6 Hrs (6 Marks)

Introduction , ion production, factors affecting fragmentation. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule.

CH-001, 002, 003 : Laboratory Course - I & II 540 Hrs (18 Hrs/week)

CH-001 - Laboratory Course in Inorganic Chemistry

Qualitative and Quantitative Analysis (Minimum 5)

(a) Less common metal ions – Tl, Mo, W, Ti, Zr, Th, V, U (two metal ions in cationic/anionic forms)

(b) Insolubles – oxides, sulphates and halides

(c) Separation and determination of two metal ions Cu-Ni, Ni-Zn, Cu-Fe etc. involving volumetric and gravimetric methods

Chromatography (Minimum 5)

Separation of cations and anions by

(a) Paper Chromatography : Separation and identification of suger present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of R_f values.

(b) Column Chromatography – Ion exchange. Separation of cations and anions.

(b) Thin- layer chromatographic separation of Ni, Mn, Co and Zn. Determination of R_f values.

Preparations (Minimum 6)

Preparation of selected inorganic compounds and their studies by I. R., electronic spectra, Mossbauer, E.S.R. and magnetic susceptibility measurements. Handling of air and moisture sensitive compounds.

(1) $VO(acac)_2$	(8) $[Co(NH_3)_6][Co(NO_2)_6]$
(2) $TiO(C_4H_8NO)_2\,2H_2O$	(9) cis-$[Co(trien)(NO_2)_2]Cl.H_2O$
(3) cis-$K[Cr(C_2O_4)_2(H_20)_2]$	(10)$Hg[Co(SCN)_4]$
(4) $Na[Cr(NH_3)_2(SCN)_4]$	(11)$[Co(Py)_2Cl_2]$
(5) $Mn(acac)_3$	(12)$[Ni(NH_3)_6]Cl_2$
(6) $K_3[Fe(C_2O_4)_3]$	(13)$Ni(dmg)_2$
(7) Prussian Blue, Turnbull's Blue.	(14)$[Cu(NH_3)_4]SO_4.H_2O$

And handling of air and moisture sensitive compounds involving vacuum lines.

1. Synthesis and thermal analysis of group II metal oxalate hydrate .J. Chem. Ed.; 1988,65,1024
2. Atomic absorption analysis of Mg & Ca.
3. Relative stability of Tin(IV) lead(IV). Preparation of ammonium hexachlorostannate $(NH_4)_2SnCl_6$, ammonium hexachloroplumbate $(NH_4)_2PbCl_6$.
4. Synthesis of metal acetylacetonate : Magnetic moment, IR, NMR. Inorg. Synth, 1957, 5 ,130 ; 1963,1, 183.
5. Bromination of $Cr(acac)_3$. J.Chem.Educ; 1986,63,90.
6. Separation of optical isomer of cis-$[Co(en)_2Cl_2]Cl$. J. Chem. Soc; 1960, 4369.
7. Determination of Cr(III) complexes.
   $[Cr(H_2O)_6]NO_3.3H_2O$, $[Cr(H_2O)_4Cl_2]Cl.2H_2O$, $[Cr(en)_3]Cl_3$., $[Cr(acac)_3]$. Inorg. Synth, 1972, 13 , 184.

8. Preparation of N,N bis(salicylaldehyde) ethelenediamine, salenH_2,Co(salen) J. Chem. Educ: 1977, 54, 443; 1973, 50, 670.
   Determination of O_2 absorption by Co(salen) . Acct.Chem. Res; 1975,8,384.
   Reaction of oxygen adduct with $CHCl_3$ (deoxygenation).
9. Reaction of Cr(III) with a multidentate ligand ; a kinetics experiment (Visible spectra Cr- EDTA complex) J.A.C.S. 1953, 75, 5670.

Spectrophotometric Determinations (Minimum 2)

1. Manganese/ Chromium/ Vanadium in steel sample
2. Iron- phenanthroline complex : Job's method of contineous variations.

Flame Photometeric Determinations (minimum 2)

1. Na & K when present together.
2. Li/Ca

CH-002 - Laboratory Course in Organic Chemistry

Qualitative Analysis

Separation, purification and identification of compounds of (minimum four) binary mixtures (two solid or one liquid and one solid) and (minimum four) ternary mixtures (three solids or two liquids & one solid or two solids & one liquid) including tlc for checking purity of separated compounds, chemical tests and spectroscopic analysis.

Organic Synthesis

The exercises should illustrate the use of organic reactions & reagents and also the purification of products by recrystallization or fractionation & chromatographic techniques.

One step synthesis (minimum five)

Acetylation : Acetylation of cholesterol and separation of cholesteryl acetate by column chromatography

Oxidation : Adipic acid by chromic acid oxidation of cyclohexanol

Grignard reaction : Synthesis of triphenylmethanol from benzoic acid

Aldol condensation : Dibenzal acetone from benzaldehyde

Sandmeyer reaction : p-Chlorotoluene from p-toluidine

Acetoacetic ester Condensation : Synthesis of ethyl-n-butylacetoacetate

Cannizzaro reaction : 4-Chlorobenzaldehyde as substrate

Friedel Crafts Reaction : β-Benzoyl propionic acid from succinic anhydride and benzene

Aromatic electrophilic substitutions : Synthesis of p-nitroaniline and p-bromoaniline

Multi step synthesis (minimum three)

Photochemical reaction

Benzophenone ⟶ Benzpinacol ⟶ Benzpinacolone

Backmann rearrangement : Benzanilide from benzene

Benzene ⟶ Benzophenone ⟶ Benzophenone oxime ⟶ Bezanilide

Benzilic acid rearrangement : Benzilic acid from benzoin

Benzoin ⟶ Benzil ⟶ Benzilic acid

Synthesis of heterocyclic compounds

Skraup synthesis : Preparation of quinoline from aniline, Fisher-Indole synthesis : Preparation of 2-phenylindole from phenylhydrazine.

Synthesis using microwaves

Alkylation of diethyl malonate with benzyl chloride.

Synthesis using phase transfer catalyst

Alkylation of diethyl malonate or ethyl acetoacetate with an alkyl halide.

Quantitative Analysis

Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method

Estimation of amines/phenols using bromate bromide solution/or acetylation method

Determination of Iodine and Saponification values of an oil sample.

Determination of DO, COD and BOD of water sample

CH-003 - Laboratory Course in Physical Chemistry

Number of hours for each experiment : 3-4 hours

A list of experiments under different headings is given below. Typical experiments are to be selected from each type. Students are required to perform at least 30 experiments.

Error Analysis and Statistical Data Analysis

Errors, types of errors, minimization of errors, error distribution curves, precision, accuracy and combination; statistical treatment for error analysis, student 't' test, null hypothesis, rejection criteria, F & Q test; linear regression analysis, curve fitting.
Calibration of volumetric apparatus, burette pipette and standard flask.

Adsorption

To study surface tension-concentration relationship for solutions (Gibbs equation).

Phase Equilibria

(i) Determination of congruent composition and temperature of a binary system (e.g., diphenylamine-benzophenone system)

(ii) Determination of glass transition temperature of a given salt (e.g., $CaCl_2$) conductometrically.

(iii) To construct the phase diagram for three component system (e.g., chloroform-acetic acid-water).

Chemical Kinetics

(i) Determination of the effect of (a) change of temperature (b) change of concentration of reactants and catalyst and (c) Ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reactions.

(ii) Determination of the velocity constant of hydrolysis of an ester/ionic reaction in micellar media.

(iii) Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics as an iodine clock reaction.

(iv) Flowing clock reactions (Ref:Experiments in Physical Chemistry by Showmaker)

(v) Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodinde ion is oxidised by persulphate ion.)

(vi) Oscillatory reaction.

Solutions

(i) Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.

(ii) Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

Electrochemistry

A. Conductometry

(i) Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.

(ii) Determination of solubility and solubility product of sparingly soluble salts (e.g., $PbSO_4$, $BaSO_4$) conductometrically.

(iii) Determination of the strength of strong and weak acids in a given mixture conductometrically.

(iv) To study the effect of solvent on the conductance of $AgNO_3$/acetic acid and to determine the degree of dissociation and quilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.

(v) Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.

B. Potentiometry/pH metry

(i) Determination of strnegths of halides in a mixture potentiometrically.
(ii) Determination of the valency of mercurous ions potentiometrically.
(iii) Determination of the strength of strong and weak acids in a given mixture using a potentiometer / pH meter.
(iv) Determination of temperature dependence of EMF of a cell
(v) Determination of the formation constant of silver-ammonia complex and stoichiometry of the complex potentiometrically.
(vi) Acid-base titration in a non-aqueous media using a pH meter.
(vii) Determination of the activity and activity coefficient of electrolytes.
(viii) Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
(ix) Determination of the dissociation constant of monobasic/dibasic acid by Albert-Serjeant method.
(x) Determination of thermodynamic constants, ΔG, ΔS and ΔH for the reaction by e.m.f. method.
(xi) $Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H$

C. Polarimetry

(i) Determination of rate constant for hydrolysis/inversion of sugar using a polarimeter.
(ii) Enzyme kinetics – inversion of sucrose

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Books Suggested

For CH- 101 & 201 (Inorganic Chemistry)

1. Advanced Inorganic Chemistry, F. A. Cotton and Wilkinson, John Wiley.
2. Inorganic Chemistry, J. E. Huhey, Harpes & Row.
3. Chemistry of the Elements, N. N. Greenwood and A. Earnshow, Pergamon
4. Inorganic Electronic Spectroscopy, A. B. P. Lever, Elsevier.
5. Magnetochemistry, R. L. Carlin, Springer Verlag.
6. Comprehensive Coordination Chemistry eds., G. Wilkinson, R. D. Gillars and J. A. McCleverty, Pergamon.
7. Chemical Applications of Group Theory, F. A. Cotton.

For CH-102 & 202 (Organic Chemistry)

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

For CH – 103 & 203 (Physical Chemistry)

1. Physical Chemistry, P. W. Atkins, ELBS.
2. Introduction to Quantum Chemistry, A. K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice hall.
4. Coulson's Valence, R. McWeeny, ELBS.

5. Chemical Kinetics, K. J. Laidler, Mcgraw-Hill.
6. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman and J. Kuriacose, McMillan.
7. Micelles, Theoretical and Applied Aspects, V. Moroi, Plenum
8. Modern Electrochemistry Vol. I and Vol. II, J. O. M. Bockris and A. K. N. Reddy, Plenum.
9. Introduction to Polymer Science, V. R. Gowarikar, N. V. Vishwanathan and J. Sridhar, Wiley Eastern.
10. The Chemistry Mathematics Book, E. Steiner, Oxford University Press.
11. Mathematics for Chemistry, Doggett and Suicliffe, Longman.
12. Mathematical Preparation for Physical Chemistry, F. Daniels, McGraw Hill.
13. Chemical Mathematics, D. M. Hirst, Longman.
14. Applied Mathematics for Physical Chemistry, J. R. Barrante, Prentice Hall.
15. Basic Mathematics for Chemists, Tebbutt, Wiley.

For CH-104 Spectroscopy - I

1. Modern Spectroscopy, J. M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F. L. Ho, Wiley Interscience.
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R. V. Parish, Ellis Harwood.
4. Physical Methods in Chemistry, R. S. Drago, Saunders College.
5. Introduction to Molecular Spectroscopy, G. M. Barrow, McGraw Hill.
6. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
7. Theory and Applications of UV Spectroscopy, H. H. Jaffe and M. Orchin, IBH-Oxford.
8. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
9. Introduction to Magnetic Resonance, A Carrington and A. D. Maclachalan, Harper & Row.

For CH-104 Spectroscopy - II

1. Practical NMR spectroscopy, M.L.Martin, J.J.Delpeuch and G.J.Martin, Heyden.
2. Spectrometric identification of organic compounds , R.M.Silverstein, G.C.Bassler and T.C. Morrill, John Willey.
3. Introduction to NMR spectroscopy, R.J.Abraham, J.Fisher and P.Loftus, Wiley.
4. Application of Spectroscopy of organic compounds, J.R.Dyer, Prentice Hall.
5. Spectroscopic method in organic chemistry, D.H.Willams, I.Fleming, Tata McGraw-Hill

CH-001, 002 & 003 : Laboratory Course-I & Laboratory Course-II

1. Vogel's Textbook of Quantitative Analysis, revised, J. Bassett, R. C. Denney, G. H. Jeffery and J. Mendhan, ELBS
2. Synthesis and Characterization of Inorganic Compounds, W. L. Jolly, Prentice Hall
3. Inorganic experiments, J.Derek Woollins, VCH
4. Microscale Inorganic Chemistry, Z.Szafran, R.M.Pike & M.M.Singh, Wiley
5. Practical Inorganic Chemistry, G.Marr & B.W.Rockett, Van Nostrand.
6. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miller, Prentice Hall
7. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.
8. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.
9. Handbook of Organic Analysis-Qualitative and Quantitative, H. Clark, Adward Arnold.
10. Vogel's Textbook of Practical Organic Chemistry, A. R. Tatchell, John Wiley
11. Practical Physical Chemistry, A. M. James and F.E. Prichard, Longman
12. Findley's Practical Physical Chemistry, B. P. Levitt, Longman
13. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill.

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