

**NORTH MAHARASHTRA UNIVERSITY, JALGAON**  
**SCHOOL OF CHEMICAL SCIENCES**  
**(Academic Flexibility Since-2009)**



**SYLLABUS**

**for**

**MASTER OF SCIENCE in CHEMISTRY**

**M.Sc. I**

**(Semester I and II)**

**(Choice Based Credit System, 60:40 Pattern)**

**w. e. f. June 2015**

**School of Chemical Sciences**  
**North Maharashtra University, Jalgaon – 425 001**  
**M. Sc. I (Semester I and II)**  
 [Polymer Chemistry, Pesticides & Agrochemicals, Industrial Chemistry,  
 Organic Chemistry, Physical Chemistry and Analytical Chemistry]  
**Common Course Structure for the First Year (60+40 Pattern)**  
**(w.e.f. June 2015)**

**Semester I**

**Theory courses\***

<b>Course Code</b>	<b>Title</b>	<b>Marks</b>	
CH- 101	:	Inorganic Chemistry- I	100
CH- 102	:	Organic Chemistry- I	100
CH- 103	:	Physical Chemistry- I	100

**Semester II**

**Theory courses\***

<b>Course Code</b>	<b>Title</b>	<b>Marks</b>	
CH- 201	:	Inorganic Chemistry- II	100
CH- 202	:	Organic Chemistry- II	100
CH- 203	:	Physical Chemistry- II	100
CH- 204	:	Basic Concepts in Instrumentation and Analysis	100

**Laboratory Courses\*\***

<b>Course Code</b>	<b>Title</b>	<b>Marks</b>	
CH- 001	:	Lab. Course in Inorganic Chemistry	100
CH- 002	:	Lab. Course in Organic Chemistry	100
CH- 003	:	Lab. Course in Physical Chemistry	100

\* All theory courses of both First and Second Years (Semester I-IV) of all Departments in the School are of 60 hrs each including 10-12 hrs of Tutorials / Home Assignments / Class Room Discussion / Seminars / Internal Tests & Assessment.

\*\* Annual practical examination pattern.

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## CH- 101: Inorganic Chemistry- I

Total Marks- 100

[60 hrs]

- Unit- I Chemistry of Non-transition elements** [12 hrs]  
Hydrides-classification, electron deficient, precise and rich hydrides. Study of  $\text{PH}_3$ ,  $\text{SbH}_3$ ,  $\text{AsH}_3$ , selenides, Tellurides. Synthesis, properties and structures of alkali and alkaline earth metal compounds, Synthesis and reactivity of inorganic polymer of Si and P.  
Metal Clusters: Boranes: Classification, synthesis, structure and topology ( $\text{B}_2\text{H}_6$  to  $\text{B}_{10}\text{H}_{14}$ )  
Carboranes: Classification, Synthesis and structure  
Metalloboranes and metallocarboranes.
- Unit- II Molecular Orbital Theory and its application.** [12 hrs]  
Linear triatomic molecules –  $\text{BeH}_2$ ,  $\text{CO}_2$ . Trigonal planar molecule  $\text{BF}_3$ , Tetrahedral molecule –  $\text{CH}_4$ , Trigonal pyramidal molecule  $\text{NH}_3$ , Angular Triatomic molecules  $\text{H}_2\text{O}$ ,  $\text{NO}_2$ .  
Symmetry elements and operations, Symmetry planes, reflections, inversion centre, proper / improper axes of rotation, equivalent symmetry elements and atoms, symmetry elements and optical isomerism, symmetry point groups of some molecules  $\text{H}_2\text{O}$ ,  $\text{NH}_3$ ,  $\text{C}_2\text{H}_2\text{Cl}_2$ , (cis& trans) ,  $\text{BF}_3$ ,  $\text{PCl}_5$ ,  $\text{H}_2\text{O}_2$  (trans),  $\text{XeF}_4$ ,  $\text{H}_3\text{BO}_3$ ,  $\text{CO}_2$ ,  $\text{POCl}_3$ ,  $\text{C}_2\text{H}_2$  ,  $\text{NO}_3^-$
- Unit- III Organometallic compounds of transition metals.** [12 hrs]  
The 18 electron rule, Molecule orbital theory and 18 electron rule, Counting electrons in complexes. Alkyl & aryl complexes, Alkene complexes. Metal  $\pi$  complexes- Metal carbonyl and metal nitrosyls.
- Unit- IV The Ionic solids.** [12 hrs]  
Classification of ionic structures, radius ratio rules, calculation of some limiting radius ratio values, close packing, Structures of ionic solids. A cautionary word on radius ratios. Lattice energy. The

Born - Haber cycle, Applications of lattice energetics.

Resonance : resonance energy. Concept of formal charge, criteria for resonating structures. Hydrogen bonding concept and structure of water, alcohols, phenols, types, properties

**Unit- V      Bio-inorganic Chemistry      [12 hrs]**

Metalloproteins and metalloenzymes, amino acids in metal binding sites. Selective transport and storage of iron (siderophores, iron transport proteins in higher organisms, release of iron transferrin , ferritin, the cellular Fe store), electron transfer (General considerations, Electron transfer cytochrome, FeS clusters, copper transfer centers), ionophores.

**References**

- 1) Inorganic Chemistry Principles of Structures and Reactivity, 4<sup>th</sup> edition; James E. Huheey, Ellen A. Keiter, Richard L. Keiter.
- 2) Concise Inorganic Chemistry, 5<sup>th</sup> edition J. D. Lee.
- 3) Inorganic chemistry, 3<sup>rd</sup> edition Alan G. Sharpe.
- 4) Chemical Applications of Group Theory, F.A. Cotton.
- 5) Inorganic Chemistry, Fourth Edition; Shriver & Atkins Intern.student edition.
- 6) Principles of Inorganic Chemistry; Late B.R. Puri, L.R. Sharma & K.C. Kalia.
- 7) Electrons and Chemical bonding By H.B. Gray.
- 8) Modern Aspects of Inorganic Chemistry, By H. J. Emeleus and A.G. Sharpe; Universal Book Stall, New Delhi – 2
- 9) Advanced Inorganic Chemistry; Dr. S.K. Agarwala, Dr. Keemtilal, PragatiPrakashan, Meerut.
- 10) Theoretical Principles of Inorganic Chemistry, G.S. Manku , Tata McGraw-Hill Ed
- 11) Concepts and Models of Inorganic Chemistry, 2<sup>nd</sup> edition, B. Douglas, D.H. Mc. Daniel, J.J. Alexander.
- 12) General & Inorg. Chem. (Part one), R. Sarkar, New Central Book Agency ; Kolkata.
- 13) Group Theory and its Chemical applications, P.K. Bhattacharya, Himalaya Publishing House.
- 14) Advance Inorganic Chemistry , Cotton & Wilkinson.
- 15) Concept and Applications of Group Theory, Dr. Kishor Arora, Anmol Publication Pvt. Ltd., New Delhi.
- 16) Modern Inorganic Chemistry by William L. Jolly, 2<sup>nd</sup> edition, Tata McGraw Hill Co.

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## CH-102: Organic Chemistry - I

**Total Marks: 100**

**[60 hrs]**

### **Unit-I**

**[12 hrs]**

**A).IUPAC nomenclature of organic compounds: [02 hrs]**

**B). Aromaticity: [02 hrs]**

Huckel's rule and Concept of Aromaticity, non-aromaticity and antiaromaticity, Annulenes and Heteroannulenes, Fullerenes (C<sub>60</sub>).

**C). Reactive intermediates: [8 hrs]**

Formation and stability of Carbocations, Carbanions, Free Radicals, Carbenes, Nitrenes, and Arynes.

Carbanions – Ionization of carbon –hydrogen bond and protopy, base and acid catalyzed halogenations of ketones, keto-enol equilibria, structure and rate in enolization, concerted and carbanion mechanism for tautomerism.

### **Unit-II**

**[12 hrs]**

**A) Stereochemistry: [4 hrs]**

Recognition of symmetry elements and chiral structures, R-S nomenclature, diastereo isomerism in acyclic and cyclic-systems, E-Z isomerism, conformational analysis of simple cyclic (Chair and Boat Cyclohexanes and acyclic systems, Interconversion of Fischer, Newman and Sawhorse Projections.

**B) Nucleophilic Substitutions at Saturated Carbon [8 hrs]**

The Reaction Mechanism: Reactivity at a saturated carbon atom, Available pathways, The SN<sup>1</sup> Mechanism, SN<sup>2</sup> Mechanism. Stereochemistry of Nucleophilic Substitution: The SN<sup>1</sup> reaction and SN<sup>2</sup> reaction. The Variables in Nucleophilic Substitution: The Leaving Group, The Nucleophile, The site of substitution, solvent effects, solvolysis, SN<sup>1</sup> versus SN<sup>2</sup> reaction. The Scope of Nucleophilic Substitution: Halide as the Nucleophile, Competing Reactions, Oxygen and Sulfur as the Nucleophiles, Nitrogen and Phosphorus as the Nucleophile, Neighboring Group Participation, Phase transfer catalyst and crown ethers in nucleophilic substitutions.

### **Unit-III**

**[12 hrs]**

**Aromatic Electrophilic Substitution:** Mechanism and Orientation in Electrophilic Aromatic Substitution: An Addition-Elimination Mechanism, Ortho, Meta and Para Orientation, Relative

Rates of Substitution, The Rate Orientation Relation, Orientation in Multiply Substituted Aromatics, A pi-complex intermediate. Quantitative Correlations of Substituents Effects. Electrophilic Aromatic Substitution Reactions– Heteroatoms as the Electrophiles, Carbon as the Electrophile. Nucleophilic Aromatic Substitutions, The elimination-addition mechanism-benzyne. The aryl cation mechanism-diazonium salts, Nucleophilic Substitution via Thallium Derivatives.

#### **Unit-IV**

**[12 hrs]**

**Elimination Reactions-Alkenes and Alkynes:** The Reaction Mechanism: The E1, E2 & E1cB mechanism, mechanistic variables. Elimination versus Substitution: Basicity versus Nucleophilicity, Substrate Structure, Solvent, Temperature. The Direction of Elimination: Formation of the More-Substituted Alkene, Formation of the Less-Substituted Alkene. Stereochemistry: Anti Elimination, Syn elimination, Stereoelectronic Factors. Formation of Alkenes: Dehydrohalogenation, Dehalogenation, Dehydration, Hofmann Elimination, Pyrolytic Elimination, Catalytic Dehydrogenation. Formation of Alkynes.

#### **Unit-V**

**[12 hrs]**

**Addition Reactions: Electrophilic Additions to Unsaturated Carbon :** The Mechanism of Electrophilic Addition: The AdE2 Mechanism, Structural Effects and Reactivity. Direction and Stereochemistry of Addition: Markovnikov Orientation. Stereochemistry of Addition. Additions to alkenes and alkynes: Halogenation, Hydrohalogenation, Hydration, Hydroboration, Epoxidation-Hydroxylation, Carbene Addition, Hydrogenation, Ozonolysis, Addition of alkenes and alkanes, Alkenes and Alkynes as petrochemical raw material. Transition Metal Organometallics: Alkene-Transition Metal Organometallics, Homogeneous Catalysis, Industrial Application of Catalysis, Transition Metals in Biological Systems. Wilkinson catalyst, Ziegler-Natta catalyst.

#### **References:**

1. Organic Chemistry by Stanley H. Pine.
2. Stereochemistry: Conformations and Mechanism by P. S. Kalsi.
3. Advance Organic Chemistry: Reactions, Mechanisms and Structure by Jerry March.
4. Organic Chemistry by Clayden, Greeves, Warren and Wothers.

5. Organic Chemistry by Morrison and Boyd.
6. Stereochemistry of organic compound: D. Nasipuri
7. Stereochemistry of Carbon Compounds by E. L. Eliel.
8. Guidebook to mechanisms in organic chemistry: Peter Sykes
9. Advanced organic chemistry by F. A. Carey and R. J. Sundberg
10. Organic chemistry vol. I and II by I. L. Finar

## CH-103: Physical Chemistry I

**Total Marks- 100**

**[60 hrs]**

### **Unit I: Atomic Structure and Wave-Mechanics**

**[12 hrs]**

The classical wave equation, The time independent classical wave equation, The Schrödinger wave equation, Translational energy, Quantization of energy, The free particle, Particles in a box, Tunnel effect, Atomic spectra, Bohr orbits and ionization energies, Schrödinger equation for hydrogen atom, The radial equation (no derivation), The quantum numbers and Radial wave functions.

### **Unit II: Kinetics-Molecular Theory of Gases**

**[12 hrs]**

PVT relations for an ideal gas, non-ideal behaviour of gases, Equation of state, Compressibility factor, Virial equation, van der Waals equation, excluded volume and molecular diameter, Maxwell-Boltzmann law for distribution of molecular velocities, Derivation of expressions for average, root mean square and most probable velocities, Experimental verification of distribution law, Molecular collision in gases, collision diameter and collision number in a gas, Kinetic theory of viscosity and diffusion.

### **Unit III: Thermodynamics**

**[12 hrs]**

Introduction to three laws of thermodynamics, Entropy and equilibrium, Free energy functions, Maxwell relations, Thermodynamic equation of state, Interpretation of Gibb's function, Phase equilibrium, Derivation of phase rule, PT diagrams for pure components like CO<sub>2</sub>, H<sub>2</sub>O, SiO<sub>2</sub>. The Clapeyron-Clausius equation, Chemical potential and Chemical equilibrium.

Ideal mixtures, Partial molar quantities (Volume/free energy), Henry's and Rault's laws, Gibbs-Duhem relation, Liquid-Vapour free energies, Vapour pressures and solution properties, Non-ideal solutions and excess properties, Activity and activity coefficients and their determination from Freezing point depression and vapour-pressure measurements.

Third law entropies- Calculations of standard entropies from C<sub>p</sub> data, Exceptions to third law.

### **Unit IV: Nuclear Chemistry**

**[12 hrs]**

Radioactive decay and equilibrium, Nuclear reactions, Q-value, Cross-sections, Types of reactions, Nuclear models, Chemical effects of molecular transformations, Fission and Fusion reactions, Fission products and Fission yields, Radioactive techniques, tracer technique, Neutron activation analysis (NAA), Nuclear detectors (Geiger Muller counter, Ionization and



Proportional).

### **Unit V: Kinetics of Reactions**

**[12 hrs]**

Types of reactions and their kinetics: Opposing reactions, Consecutive reactions, Parallel reactions, Chemical relaxation, Reactions in flow system, Chain reactions, Formation of hydrogen bromide, Temperature dependence of reaction rates, Catalysis by enzymes, Michaelis-Menten equation and mechanism.

Collision theory of bimolecular reactions, Transition state theory, Potential energy surfaces-examples of (D + H<sub>2</sub>) and (H + H<sub>2</sub>) reactions, Activated complex theory of reaction rate, The entropy of activation, Kinetic and thermodynamic control of a chemical reaction.

#### **Books Recommended:**

1. Physical Chemistry, P. W. Atkins, ELBS, 1998
2. Physical Chemistry, G. M. Barrow, International student edition, 2003.
3. Physical Chemistry, G. W. Castellan, AddisonWesley.
4. Physical Chemistry, W. J. moore, Orient Longman, 1998.
5. Thermodynamics for Chemist, S. Glasstone, D. Van Nostrand, 1965.
6. Essentials of Nuclear Chemistry, H. J. Arnikar, New Age Publication Ltd., 1995.
7. Nuclear and Radiochemistry, Friedlander, Kennedy and Miller, John-Wiley, 1981.
8. Introduction to Nuclear Physics and Chemistry, B. G. Harvey, Prentice Hall, 1963.
9. Sourcebook of Atomic Energy, S. Glasstone, van Nostrand, 1967.
10. Chemical Kinetics, K. J. Laidler, McGraw Hill, 1985.
11. Kinetics and Mechanism, Frost and Pearson.

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## CH- 201: Inorganic Chemistry- II

Total Marks-100

[60 hrs]

- Unit I. Electronic spectra of transition metal complexes** [12 hrs]  
Energy levels in an atom, coupling of orbital angular momenta, coupling of spin angular momenta, spin orbit coupling. Determining the ground state terms – Hund's rule, Hole formulation, Derivation of the terms for a  $d^2$  configuration, calculation of the number of microstates, Electronic spectra of transition metal complexes – Laporte 'orbital' selection rule, spin selection rule, splitting of electronic energy levels and spectroscopic states. Spectra of  $d^1$  &  $d^9$  ions,  $d^2$  &  $d^8$  ions,  $d^5$  ions. Spectrochemical and Nephelauxetic series, charge transfer and luminescence spectra, calculations of  $Dq$ ,  $B$  and  $\beta$  parameters.
- Unit II. Magnetic properties of complexes** [12 hrs]  
Paramagnetism, 1<sup>st</sup> and 2<sup>nd</sup> order Zeeman effect. Quenching of orbital angular momentum by ligand fields. Magnetic properties of A, E & T ground terms in complexes, Spin free - spin paired equilibria.
- Unit III. Reaction mechanism in transition metal complexes.** [12 hrs]  
Ligand substitution reaction, The classification of mechanism, The substitution of square planar complexes, the nucleophilicity of entering group, the shape of activated complexes,  $k_1$  pathway, Substitution in Octahedral complexes, Rate law and their interpretation, The activation of octahedral complexes, Base hydrolysis, Stereochemistry, Isomerization reactions
- Unit IV. Catalysis** [12 hrs]  
Catalysis, Description of catalyst, Properties of catalyst, Homogeneous catalyst, Catalytic steps, Hydrogenation of alkenes, Hydroformylation, Monsanto acetic acid synthesis, Wacker oxidation of alkenes, Alkene polymerization, Heterogeneous catalysis, Nature of heterogeneous catalyst. Examples of heterogeneous catalysts (hydrogenation, oxidation)
- Unit V. The Structure and Reactivity of molecules/ Environmental aspects** [12 hrs]  
VSEPR Theory, structures of molecules containing lone pair of electrons. Sulphur tetrafluoride, Bromine trifluoride, Dichloroiodate (I) anion, Pentafluorotellurate (IV) anion, Tetrachloroiodate (III) anion, Nitrogen dioxide, nitrite ion and nitryl ion, phosphorus trihalides, carbonyl fluoride, summary of VSEPR Rules, Photochemical reaction, Atmospheric Chemistry.

## References

- 1) Inorganic Chemistry Principles of Structures and Reactivity, 4<sup>th</sup> edition; James E. Huheey, Ellen A. Keiter, Richard L. Keiter.
- 2) Concise Inorganic Chemistry, 5<sup>th</sup> edition J. D. Lee.
- 3) Inorganic chemistry, 3<sup>rd</sup> edition Alan G. Sharpe.
- 4) Chemical Applications of Group Theory, F.A. Cotton.
- 5) Inorganic Chemistry, Fourth Edition; Shriver & Atkins Intern.student edition.
- 6) Principles of Inorganic Chemistry; Late B.R. Puri, L.R. Sharma & K.C. Kalia.
- 7) Electrons and Chemical bonding By H.B. Gray.
  
- 8) Modern Aspects of Inorganic Chemistry, By H. J. Emeleus and A.G. Sharpe; Universal Book Stall, New Delhi – 2
  
- 9) Advanced Inorganic Chemistry; Dr. S.K. Agarwala, Dr. Keemtilal, PragatiPrakashan, Meerut.
  
- 10) Theoretical Principles of Inorganic Chemistry, G.S. Manku , Tata McGraw-Hill Ed
  
- 11) Concepts and Models of Inorganic Chemistry, 2<sup>nd</sup> edition, B. Douglas, D.H. Mc. Daniel, J.J. Alexander.
  
- 12) General & Inorg. Chem. (Part one), R. Sarkar, New Central Book Agency ; Kolkata.
  
- 13) Group Theory and its Chemical applications, P.K. Bhattacharya, Himalaya Publishing House.
  
- 14) Advance Inorganic Chemistry , Cotton & Wilkinson.
  
- 15) Concept and Applications of Group Theory, Dr. Kishor Arora, Anmol Publication Pvt. Ltd., New Delhi.
  
- 16) Modern Inorganic Chemistry by William L. Jolly, 2<sup>nd</sup> edition, Tata McGraw Hill Co.

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## CH-202: Organic Chemistry - II

**Total Marks-100**

**[60 hrs]**

**Unit-I:**

**[12 hrs]**

**Selective Name Reactions:**

Aldol, Perkin, Stobbe, Dieckmann Condensation. Reimer-Tiemann, Reformatsky and Grignard reactions. Diels-Alder reaction, Robinson Annulation. Michael, Mannich, Stork-enamine, Sharpless Asymmetric Epoxidation, Ene, Barton, Hofmann-Löffler Freytag, Shapiro reaction. Chichibabin Reaction, Cannizzaro reaction, Baylis-Hilman reaction, Darzens reaction, Benzoin condensation, Knoevenagel reaction.

**Unit-II:**

**[12 hrs]**

**Rearrangements:** Wagner-Meerwein, Pinacol, Wolff, Arndt-Eistert synthesis, Hofmann, Curtius, Schmidt, Lossen, Beckmann, Baeyer-Villiger, Migration from Boron, Favorskii, Benzilic acid, Stevens, Wittig, Claisen and Cope.

**Unit-III:**

**[12 hrs]**

**Reagents in Organic Synthesis:**

Complex Metal hydrides, DIBAL-H, Gilman's reagent, Lithium dimethyl cuprate, LDA, DCC, 1,3-propane-dithiane, Trimethyl-silyl iodide, Tri-n-butyl-tin-hydride, Woodward and Prevost hydroxylation, DDQ, SeO<sub>2</sub>, PTC, Crown ethers, Merrifield resins, Peterson's synthesis, Baker's yeast. chromic acid, sodium dichromate, potassium dichromate, Jones reagent, Collins reagent, Birch reduction, periodic acid, lead-tetra acetate, Wolf-Kishner reduction, Clemmensen reduction, Mozingo reduction, Meerwein-Ponndorf-Verley reduction, Oppenauer oxidation, Wittig reagent.

**Unit-IV:**

**[12 hrs]**

**A) U.V spectroscopy: [3 hrs]**

Woodward-Fisher rules for conjugated dienes and carbonyl compounds, applications of UV.

**B) IR Spectroscopy: [3 hrs]**

Characteristics vibrational frequencies of alkanes, alkenes, aromatic compounds, alcohols, phenols, aldehydes, ketones, carboxylic acids, esters, amides, anhydrides, lactones and lactams. Effect of hydrogen bonding and solvent effect on vibrational frequencies

**C) NMR Spectroscopy: [6 hrs]**

Chemical shift, factors influencing chemical shift, shielding-deshielding, spin-spin coupling (n+1) rule, Pascals triangle, factors affecting on coupling constant.

**Unit-IV:****[12 hrs]****A) CMR Spectroscopy: [3 hrs]**

Introduction, off resonance, un-decoupled and proton decoupled.

**B) Raman Spectroscopy: [3 hrs]**

Introduction, pure rotational raman spectra , vibrational raman spectra.

**C) ESR Spectroscopy: [3 hrs]**

Introduction, rules for providing hyperfine lines.

**D) Mass Spectrometry: [3 hrs]**

Introduction, various methods of ionization, detectors in mass spectrometry

**References:**

1. Organic Chemistry by Stanley H. Pine.
2. Stereochemistry: Conformations and Mechanism by P. S. Kalsi.
3. Advance Organic Chemistry: Reactions, Mechanisms and Structure by Jerry March.
4. Organic Chemistry by Clayden, Greeves, Warren & Wothers.
5. Organic Chemistry by Morrison and Boyd.
6. Modern Methods of Organic Synthesis by W. Carruthers, Iain Coldham.
7. Spectroscopy of Organic compounds by P. S. Kalsi
8. Spectroscopic Identification of Organic compounds by R.M.Silverstein, G.C.Bassler and T. C. Morrill.
9. Stereochemistry of Carbon Compounds by E. L. Eliel.
10. Stereochemistry of Organic compounds by D. Nasipuri.
11. Pavia spectroscopy of Organic compounds – Pavia
12. Fundamentals of molecular spectroscopy – C. N. Banwell, and E. M. McCash

## CH-203: Physical Chemistry -II

**Total Marks-100**

**[60 hrs]**

### **Unit II: Photochemistry**

**[12 hrs]**

Electronic transitions: Frank-Condon principle, selection rules, photodissociation, Predissociation, photoreduction, photooxidation, photodimerization, photochemistry in atmosphere and Green house effect.

Life time of electronically excited state, electronic transition and intensity of absorption bands, Construction of Jablonski diagram, Photophysical pathways of excited molecular systems, Fluorescence and phosphorescence, Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, Fluorescence quenching.

### **Unit III: Electrochemistry**

**[12 hrs]**

Electrochemical cells with and without transference, Determination of activity coefficient of an electrolyte by emf method, Acid and alkaline storage batteries.

Electrochemistry of solutions: Debye-Hückel and Onsager treatment for activity coefficients and equivalent conductance of an electrolyte, Ion-pair formation and Bjerrum model, Experimental verification of Debye-Hückel model, Structure of electrified interfaces, Guoy-Chapman and Stern models.

### **Unit IV: Colloids and Macromolecules**

**[12 hrs]**

Small particles/Large molecules, Mass range and Average mass, Surface tension, capillarity, Surface tension of solutions, surfactants and micelles, Critical micelle concentration, structure of surface films, Colloidal sols-particle size distribution, Methods of determination of molecular weights, Osmometry, Solution viscosity, methods based open diffusion coefficient and light scattering.

Mechanism of polymerization, Degree of polymerization, Kinetics of free radical and Condensation polymerization.

### **Unit V Microwave Spectroscopy**

**[12 hrs]**

Rotation of molecule, Rotational spectra of Diatomic molecule, polyatomic molecule, Technique and Instrumentation, Calculation of moment of inertia of simple molecules, Doppler shift, Stark effect and calculation of dipole moment. Microwave heating.

## Unit V Infra-Red Spectroscopy

[12 hrs]

Vibrating Diatomic Molecule, Simple Harmonic Oscillator, Anharmonic Oscillator, Diatomic Vibrating Rotator, Breakdown of Born-Oppenheimer Approximation, Vibration of Polyatomic Molecules, Skeletal vibrations, and finger printing, Group frequencies, Calculations of bond length and force constant of simple molecules.

### Books for References:

1. Physical Chemistry, P. W. Atkins, Oxford University Press, 2002
2. Physical Chemistry, G. M. Barrow, Tata-McGraw Hill, 2003.
3. Physical Chemistry, G. K. Vemulapalli, Prantice-Hall of India, 1997.
4. Physical Chemistry, W. J. Moore, Prantice-Hall of India, 1984.
5. Modern Electrochemistry, Vol I and II, J. O. M. Bockris and A. K. N. Reddi, Plenum, 1998.
6. Polymer Chemistry, F. W. Billmeyer Jr., John-Wiley and sons 1971.
7. Polymer Chemistry of Macromolecules, D. D. Deshpande, Vishal Publications, 1984.
8. Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. MacCash, fourth Edition, McGraw Hill.
9. Magnetic Susceptibility- L. N. Mulay.
10. Molecular Structure and Molecular Spectra by G. Herzberg, Van Nostrand.
11. Molecular Spectroscopy by G. M. Barrow.

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## CH-204: Basic Concepts in Instrumentation and Analysis

**Total Marks-100** [60 hrs]

**Unit 1. Statistical Analysis:** [12 hrs]

Error, Precision, Average and Mean deviation, Q-test, Student T test, Varian ratio

**Unit 2. Basic Analytical Terms:** [12 hrs]

Volumetric and Gravimetric analysis, Titration, Types of titration viz. acid-base, redox, iodometric, iodimetric and complexometric titrations, Types of indicators, Selection of indicator, Aquametry (Karl-Fisher titration)

**Unit 3. A) Chromatographic Analysis: Principle, brief Theory and Applications of** [12 hrs]

Column Chromatography, HPLC, TLC, HPTLC, GC, GCMS, LCMS, Electrophoresis

**B) Spectroscopy: Principles, Instrumentation and Applications of**

UV- Visible Spectroscopy, IR Spectroscopy, Atomic (absorption and emission)

Spectroscopy, NMR ( $^1\text{H}$  and  $^{13}\text{C}$ ) Spectrometry, Mass Spectrometry.

**Unit 4. A) Principles, brief Theory and Applications of** [12 hrs]

X- Ray Fluorescence, X- Ray Diffraction and Neutron Diffraction Spectrometry

**B) Thermal Analysis: Principle, Theory and Applications of**

Differential Thermal Analysis, Thermogravimetric Analysis, Differential Scanning Calorimetry

**Unit 5. A) Principles, Techniques and Applications of** [12 hrs]

Conductometry, pH and Potentiometry, Polarography, Fluorometry, Flame photometry, Turbidimetry.

**B) Morphological Analysis: Principle, brief Theory and Applications of**

Scanning Electron Microscopy, Transmission Electron Microscopy, Atomic Force Microscopy

### References:

1. Instrumental Methods of Analysis- Willard Merrit and Settle.
2. Instrumental Methods and Chemical Analysis- G. R. Chattwal and S. Anand
3. Essential of Nuclear Chemistry- H. J. Arnikar.
4. Vogel's Textbook of Practical Organic Chemistry – Furniss B. S., Hannaford A. J., Smith P. W. G. and Tatchell A. R., 5th edn., Pearson education Ltd., New Delhi, 2004.
5. A Txtbook on Experiments and Calculations in Engineering Chemistry- Dara S. S., S. Chand & Company Ltd., New Delhi, 2003.
6. Advanced Practical Organic Chemistry- Vishnoi N. K., Vikas Publishing House Private Ltd., New Delhi, 2005.
7. Laboratory Manual of Organic Chemistry- Bansal R. K., New Age International 7 Publishers, New Delhi, 2009.
8. Application of Absorption Spectroscopy of Organic Compounds- J. R. Dyer –



Prentice Hall

9. Spectroscopic Methods in Organic Chemistry – D .H. Williams ad I  
FlemmingMcgraw Hill, 4th Ed., (1989)

10. Organic Spectroscopy- P. S. Kalsi

11. Instrumental Methods of Analysis – Chattawal and Anand

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**CH-001: Laboratory Course in Inorganic Chemistry.**

**[Total Marks-100]**

**1. Analysis of ore (Any one)**

- i) Pyrolusite ore - Estimation of silica gravimetrically and Manganese volumetrically.
- ii) Chromite ore – Estimation of Iron gravimetrically and Chromium volumetrically

**2. Analysis of Alloy**

Solder alloy – Estimation of Tin gravimetrically and Lead volumetrically

**3. Instrumental method of Analysis**

A) Photometric Analysis - To study complex formation between Fe (III) and salicylic acid and find the formula and stability constant of the complex.

B) Simultaneous determination of  $\text{Cr}^{+2}$  and  $\text{Cu}^{+2}$

C) To determine the strength of given mixture of carbonate and bicarbonate in the given mixture by pH metric method

D) Potentiometric determination of stability constant.

E) To determine the amount of copper present in given solution by iodometric method potentiometrically.

**4. Preparation and purity determination (Any two)**

i) Potassium trioxalato chromate (III). ii) Tris (acetylacetonato) Iron (III). iii) Bis (ethylene diamine) copper (II) sulphate.

**5. Drug Analysis:** Determination of iron from given drug sample.

**6. Characterization of soil and water.**

**7. Column Chromatography:** Ion exchange capacity of resine by Co and Ni.

**8. Table work**

- i. Data Analysis, error analysis, least squares method,. Plot of Born Maeyer to determine 1:1 type molecule (internuclear separation). Characterization of metal ligand bonding using IR spectroscopy.
- ii. Visualizing frontier MO's

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## CH-002: Laboratory Course in Organic Chemistry

[Total Marks-100]

### 1. Techniques: (At least Two Practical of Each Technique)

Crystallization, Sublimation, Distillation, Steam Distillation, Vacuum Distillation, Column Chromatography, Thin Layer Chromatography.

### 2. Preparation of Derivatives: (Each Derivative of two Compounds)

Oxime, 2, 4-DNP, Acetyl, Benzoyl, Semicarbazone, Anilide, Amide, Aryloxyacetic acid.

### 3. Preparations: Single Stage (Any 12)

- i) Cyclohexanone to Adipic acid
- ii) Benzophenone to Benzhydryl alcohol
- iii) Anthracene to Anthraquinone
- iv) Chlorobenzene to 2,4-Dinitrochlorobenzene
- v) 2,4-Dinitrochlorobenzene to 2,4-Dinitrophenol
- vi) Acetoacetic ester to 1-Phenyl-3-methyl-5 pyrazolone
- vii) Benzaldehyde to Cinnamic acid
- viii) 4-Chlorobenzaldehyde to 4-Chlorobenzoic acid + 4-Chlorobenzyl alcohol
- ix) Benzene to  $\beta$ -Benzoyl propionic acid
- x) Benzaldehyde to Dibenzylidene acetone
- xi) p-Aminobenzoic acid to p-Chlorobenzoic acid
- xii) N,N-Dimethylaniline to 4-Formyl-N, N-dimethyl aniline
- xiii) Benzophenone to Benzpinacol
- xiv) p-Nitrotoluene to p-Nitrobenzoic acid
- xv) Anisole to 2,4-Dinitroanisole
- xvi) Phthalic anhydride to phthalimide
- xvii) Phthalimide to Anthranilic acid
- xviii) Acetanilide to p-Bromoacetanilide
- xix) p-Bromoacetanilide to p-Bromoaniline
- xx) m-Dinitrobenzene to m-Nitroaniline

### 4. Use of Computer - Chem Draw-Sketch, ISI – Draw: (Max. 24 Hours for each batch)

Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name.

**5. Interpretation of UV, FT-IR & <sup>1</sup>H-NMR spectrum of above synthesized compounds.**  
(10 Compounds)

References:

Vogel's, Practical Organic chemistry.

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### CH-003: Laboratory Course in Physical Chemistry

[Total Marks-100]

Students are expected to perform atleast 15 experiments of 3-4 hours duration each.

Experiments are based on Potentiometry, Calorimetry, Phase rule, Conductometry, Kinetics, Nuclear chemistry, Colorometry (spectrophotometry), Refractive index, Adsorption, Densimetry and Viscosity.

1. Determination of molecular weight of high polymer by viscometry.
2. Determination of sparingly soluble salts solubility in water by conductometrically.
3. Determination of hydrolysis constant of sodium acetate conductometrically (or  $\text{NH}_4\text{Cl}$ ).
4. To determine the equivalent conductance of weak electrolyte at infinite dilution using Kohlrausch law.
5. To test the validity of Beer-Lambert's law and hence the unknown concentration in a solution.
6. To determine dissociation constant of an indicator (phenolphthalein) colorimetrically.
7. Determination of molecular radius of molecule (organic liquids) using refractometer.
8. Determination of partial molar volume of ethanol and of water in aqueous solutions at room temperature.
9. Study of the kinetics of zero order reaction.
10. Study of the kinetics between  $\text{K}_2\text{S}_2\text{O}_8$  and  $\text{KI}$  using differential method.
11. To determine the integral heat of solution of a salt using Dewar's Flask as calorimeter.
12. Determination of heat of transition./OR Determination of transition temperature of sodium sulphatedecahydrate by thermometric method.
13. To investigate the adsorption of oxalic acid from aqueous solution by activated charcoal and examine the validity of Freundlich and Langmuir's adsorption isotherms.
14. Construction of phase diagram for three component system.
15. Determination of pH values of various mixtures of sodium acetate and acetic acid in aqueous solutions and hence dissociation constant of an acid.
16. Study of redox potential of  $\text{Fe}^{2+} - \text{Fe}^{3+}$  system potentiometrically.

17. Study of dissociation constant of monobasic acid potentiometrically (or dibasic acid).
18. Determination of molecular weight of organic compounds using Freezing-point technique.

**Reference Books:**

1. Findlays Practical Chemistry, Revised by J. A. Kitcher.
2. Text Book of Quantitative Inorganic Analysis, by A. I. Vogel.
3. Experimental Physical Chemistry, by R. C. Das and Behera.
4. Advanced Practical Physical Chemistry, by J. B. Yadav, Goel Publishing.
5. Experimental Physical Chemistry, by F. Daniels and J. Williams.
6. Advanced Physical Chemistry Experiments, by Shoemaker and Gerland.
7. Instrumental Methods of Analysis, by Willard, Merrit Dean and Settle

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