

# TUMKUR UNIVERSITY

## Faculty of Science and Technology M. Sc. Chemistry - Course Structure (CBCS Scheme) I Semester

Sl. No.	Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of Exam	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT-1.1	Concepts of Inorganic Chemistry	4	4	3 Hrs	20	80	100
2	CPT-1.2	Organic Reaction Mechanisms and Stereochemistry	4	4	3 Hrs	20	80	100
3	CPT-1.3	Thermodynamics, Quantum Chemistry and spectroscopy	4	4	3 Hrs	20	80	100
4	SPT-1.4.A	Organic Synthesis	4	4	3 Hrs	20	80	100
	SPT-1.4.B	Separation techniques and Spectroscopy-1	4	4	3 Hrs	20	80	100
5	CPP-1.5 (1.1)	Practical Inorganic Chemistry - I	4	2	4 Hrs	10	40	50
6	CPP-1.6 (1.2)	Practical Organic Chemistry - I	4	2	4 Hrs	10	40	50
7	CPP-1.7 (1.3)	Practical Physical Chemistry - I	4	2	4 Hrs	10	40	50
8	SPP – 1.8 (1.4.A)	Practical Organic Chemistry	4	2	4 Hrs	10	40	50
	SPP – 1.8 (1.4.B)	Practical separation Methods and spectroscopy	4	2	4 Hrs	10	40	50
Total			32	24				600

CPT: Core paper theory  
OET: Open Elective theory

CPP: Core paper practical  
OEP: Open Elective practical

SPT: Special paper theory

SPP: Special paper practical

## II Semester

S. No.	Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of Exam	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT- 2.1	Group Theory, Coordination Chemistry & Spectroscopy	4	4	3 Hrs	20	80	100
2	CPT- 2.2	Reaction Mechanism, Photochemistry and Spectroscopy	4	4	3 Hrs	20	80	100
3	SPT- 2.3.A	Statistical Mechanics, Electrochemistry and Advanced quantum chemistry	4	4	3 Hrs	20	80	100
	SPT- 2.3.B	Surface, Nuclear Chemistry and Non-Equilibrium Thermodynamics	4	4	3 Hrs	20	80	100
4	OET – 2.4	Fundamentals of Chemical Analysis & Chromatography	4	4	3 Hrs	20	80	100
5	CPP-2.5 (2.1)	Practical Inorganic Chemistry - 2	4	2	4 Hrs	10	40	50
6	CPP-2.6 (2.2)	Practical Organic Chemistry - 2	4	2	4 Hrs	10	40	50
7	SPP-2.7.A (2.3.A)	Practical Physical Chemistry	4	2	4 Hrs	10	40	50
	SPP-2.7.B (2.3.B)	Practical Physical Chemistry	4	2	4 Hrs	10	40	50
8	OEP 2.8 (2.4)	Quantitative analysis and Separation Techniques	4	2	4 Hrs	10	40	50
Total			32	24				600

CPT: Core paper theory  
OET: Open Elective Theory

CPP: Core paper practical  
OEP: Open Elective practical

SPT: Special paper theory

SPP: Special paper practical

### III Semester

Sl. No.	Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of Exam	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT- 3.1	Reactions, Rearrangements and Heterocyclic chemistry	4	4	3 Hrs	20	80	100
2	CPT- 3.2	Chemical Kinetics, Photochemistry and Surface Phenomena	4	4	3 Hrs	20	80	100
3	SPT- 3.3.A	Organometallic Chemistry & Catalysis	4	4	3 Hrs	20	80	100
	SPT- 3.3.B	Industrial and Materials Chemistry	4	4	3 Hrs	20	80	100
4	OET – 3.4	Environmental Chemistry	4	4	3 Hrs	20	80	100
5	CPP-3.5 (3.1)	Practical Organic Chemistry - 3	4	2	4 Hrs	10	40	50
6	CPP-3.6 (3.2)	Practical Physical Chemistry - 3	4	2	4 Hrs	10	40	50
7	SPP-3.7.A (3.3.A)	Practical Inorganic Chemistry	4	2	4 Hrs	10	40	50
	SPP-3.7.B (3.3.B)	Practical Inorganic Chemistry	4	2	4 Hrs	10	40	50
8	OEP-3.8 (OET-3.4)	Practical Environmental Chemistry	4	2	4 Hrs	10	40	50
Total			32	24				600

CPT: Core paper theory  
OET: Open Elective Theory

CPP: Core paper practical  
OEP: Open Elective practical

SPT: Special paper theory

SPP: Special paper practical

## IV Semester

Sl. No.	Paper	Title of the paper	Instruction Hours per Week	No. of Credits	Duration of Exam	Marks		
						Internal Assessment	Semester End Exam	Total Marks
1	CPT- 4.1	Bioinorganic Chemistry and Reaction mechanisms	4	4	3 Hrs	20	80	100
2	CPT- 4.2	Macromolecules and Solid State chemistry	4	4	3 Hrs	20	80	100
3	SPT- 4.3.A	Chemistry of Natural Products	4	4	3 Hrs	20	80	100
	SPT -4.3.B	Medicinal chemistry	4	4	3 Hrs	20	80	100
4	CPD-4.4	Core Paper Dissertation	4	4		20	80	100
5	CPP-4.5 (4.1)	Practical Inorganic Chemistry - 4	4	2	4 Hrs	10	40	50
6	CPP-4.6 (4.2)	Practical Physical Chemistry - 4	4	2	4 Hrs	10	40	50
7	SPP- 4.7 (4.3.A)	Practical Organic Chemistry –	4	2	4 Hrs	10	40	50
	SPP- 4.7(4.3.B)	Practical Organic Chemistry -	4	2	4 Hrs	10	40	50
8	Project 4.8	Core Paper Dissertation Practical	4	2	-	10	40	50
Total			32	24				600

CPT: Core paper theory      CPP: Core paper practical      SPT: Special paper theory      SPP: Special paper practical  
 OET: Open Elective Theory    OEP: Open Elective practical    CPD: Core Paper Dissertation      CPDP: Core Paper Dissertation Practical

- Open Elective to be offered by other departments within the faculty
- Open Elective offered by chemistry department for others

### Basis for Internal Assessment Marks Allotment for theory

1<sup>st</sup> Test for 10 marks

2<sup>nd</sup> Test for 10 marks: Average of two tests

**Seminar**

**Extra activities**

**Total**

: 10

: 05

: 05

**: 20 Marks**

### Internal Assessment Marks for practicals: 10

**THEORY QUESTION PAPER PATTERN**  
**M.Sc. Chemistry (CBCS Scheme)**

**Note: Answer Question no. 1 and any FOUR of the remaining. Max. Marks = 80**

**1. Answer the following questions** **8 X 2 = 16**

- (a)
- (b)
- (c)
- (d)
- (e)
- (f)
- (g)
- (h)

**2. Write short notes on any FOUR of the following** **4 X 4 = 16**

- (a)
- (b)
- (c)
- (d)
- (e)

**3.** **8+4+4=16**

- (a)
- (b)
- (c)

**4.** **8+4+4=16**

- (a)
- (b)
- (c)

**5.** **8+4+4=16**

- (a)
- (b)
- (c)

**6.** **8+4+4=16**

- (a)
- (b)
- (c)

**\*Note: Equal weightage to be given to each unit while preparing question paper.**

## PRACTICAL QUESTION PAPER PATTERN

**Max. Marks = 40**

1. Experiment and Spotting	30
2. Practical record	05
3. Viva-voce	05
<b>Total</b>	<b>40 Marks</b>

**Chairman  
BOS in Chemistry**

## CONCEPTS OF INORGANIC CHEMISTRY

## UNIT- I

(16 h)

**Chemical bonding:**

**Ionic bond:** Review of Lattice energy, Born-Haber cycle and uses of Born-Haber type calculations; Born-Landé equation, Kapustinskii equation; Ionic radii, factors affecting the Ionic radii, radius ratio effects, polarizability and partial covalent character in inorganic solids, structures of simple inorganic solids ( $AB_2$  and  $A_2B$ ). Hydration energy and solubility of ionic compounds, Zintl salts, isoelectronic relationship in solids.

**Covalent bond:** Hybridisation: Salient features, Bent rules and energetics of hybridization; types of hybridisation. VSEPR theory: Assumptions, shapes of  $AB_n(lp)_x$  ( $n = 1-7$ ;  $X = 1-4$ ) type molecules. Structure and shape of molecules/ions containing only sigma bonds:  $AB_n$ ,  $n = 2-6$ ,  $AB_4^-$ ,  $AB_4^+$ ,  $AB_6^-$ ,  $AB_4^{2-}$ ,  $AB_4^{3-}$  and polyhalide ions. Structure and shape of molecules/ions containing only sigma as well as pi bonds:  $MO_2$ ,  $MO_3$ ,  $AO_n^x$  ( $n = 1-4$ ,  $x = 1-4$ ). Short coming of the VSEPR model, electronegativity and partial ionic character. Bonds- Multicenter, Synergic and Agostic bonding.

**Molecular orbital theory:** LCAO and MO diagrams of heteronuclear diatomic ( $CO$ ,  $NO$ ,  $HF$ ,  $ICl$ ,  $CN$  and  $CN^-$  species,  $NO$ ,  $NO^+$ ,  $NO_2^+$ ,  $NO^-$  species,) and triatomic molecules ( $CO_2$  and  $NO_2^-$ ).

Weak secondary interactions in covalent compounds.

## UNIT- II

(16 h)

**Chemistry of Non-transition Elements:** General discussion on the properties of the non-transition elements. Synthesis, properties and structure of halides oxides and Oxyacids of Boron, Carbon, Nitrogen, Phosphorous and Sulphur and Halogens.

Synthesis, properties and structure of inorganic chains, rings and cages: Boranes, Carboranes, Borazines, Carbides, Silicates, Silicones, Phosphazenes, Sulphur-Nitrogen compounds.

Synthesis, properties and structure of Interhalogen compounds, Pseudohalogens and noble gas compounds especially of xenon.

## UNIT- III

(16 h)

Halogens in positive oxidation states, Chemistry of Astatine.

**Lanthanide series:** Review on electronic structure, oxidation states, spectral and magnetic properties, lanthanide contraction, abundance and extraction. Lanthanides as shift reagents.

**Separation of lanthanides:** Solvent extraction and ion-exchange. Chemical properties of compounds of lanthanides in II, III, and IV oxidation states.

**Actinides:** Review on Electronic structure and position in the periodic table, oxidation states, occurrence and synthesis of the elements. Spectral and magnetic properties of compounds of actinides in comparison with those of lanthanides and d-block elements. Trans actinides Chemistry of Trans -uranium elements.

**Theories of acid base concepts-** Lux -Flood and Usanovich concepts, solvent system and leveling effect. HSAB concept: Basis of HSAB concept, acid-base strength, hardness and softness, symbiosis, applications of HSAB concept;

Acid-base concept in non-aqueous media, reactions in  $\text{BrF}_3$ ,  $\text{N}_2\text{O}_4$ , anhydrous  $\text{H}_2\text{SO}_4$ ,  $\text{CH}_3\text{COOH}$ . Solutions of metals in liquid ammonia, hydrated electron

**Isopoly and heteropoly acids** of W, Mo and V, preparations, properties, structure and applications.

Stereoisomerism- Chirality, optical activity- CD, ORD, Cotton effect, absolute configuration of metal complexes, magnetic circular dichroism.

### SUGGESTED BOOKS

1. Basic Inorganic Chemistry- F. A. Cotton, G. Wilkinson and P. L. Gaus; John Wiley and sons. Inc, 6<sup>th</sup> edition (1999).
2. Advanced Inorganic Chemistry, 6th edition; F. A. Cotton and G. Wilkinson.
3. Inorganic Chemistry IV edition; J. E. Huheey, E. A. Keiter and R. L. Keiter, Addison; Wesley (1993).
4. Inorganic Chemistry, II edition, D. F. Shriver, P. W. Atkins and C. H. Langford, ELBS; Oxford University Press, 1994.
5. Chemistry of elements; N. N. Greenwood and A. E. Earnshaw, Butterworth Heinemann (1997).
6. Concise Inorganic Chemistry, 5th edition; J. D. Lee (1996).
7. Inorganic Chemistry, 3rd Edition; Gary. L. Miessler and Donald . A. Tarr (2007).



## UNIT – I

(16 h)

**Structure and reactivity:** Introduction to Acids and Bases, Structural effects on acidity and basicity of organic molecules, hydrogen bonding, resonance, inductive and field effects, hyper conjugation effects, steric effect, Bredt's rule. Aromaticity: Concept of aromaticity, Huckel's rule, Polygon rule, annulenes, heteroannulenes and polycyclic systems.

**Reaction Intermediates:** Generation, structure, stability, reactivity and detection of classical and non-classical carbocations, carbanions, free radicals, carbenes, nitrenes and nitrogen, phosphorous and sulfur ylides. Singlet and triplet state oxygen-generation and reactions with organic molecules.

## UNIT – II

(16 h)

**Methods of Determining Reaction Mechanism:** Kinetic and non-kinetic methods,

**Kinetic method:** Mechanistic implications from rate laws, the transition state theory, ambiguities in interpreting kinetic data, solvent effect, ionic effect, isotopic effect, substituent effect, steric effect, linear free energy relationships – Hammett equation and Taft treatment.

**Non-kinetic methods:** Energy profile diagram, identification of products, testing possible intermediates, trapping of intermediates, cross over experiments, isotopic labeling, stereochemical evidences.

**Bonding in organic systems:** Theories of bonding-molecular orbital approaches. Huckel - systems: ethylene, allyl, cyclopropyl,  $\pi$  molecular orbital theory and its application to simple butadienyl, cyclopentadienyl, pentadienyl, hexatrienyl, cyclohexatrienyl, heptatrienyl, -energy, and M.O. coefficients of the  $\pi$ -cycloheptatrienyl systems. Calculation of the total systems.

## UNIT – III

(16 h)

**Aromatic electrophilic substitution reactions:** Mechanism of nitration, halogenation, sulphonation, Friedel-Crafts alkylation and acylation, Mannich reaction, chloromethylation, Vilsmeier Haack reaction, Diazonium coupling, Gattermann-Koch reaction, Mercuration reaction. Aromatic nucleophilic substitution reactions:  $S_N1$ ,  $S_N2$  and benzyne mechanism, Bucherer reaction, von Richter reaction.

**Mechanism of Addition reactions:** Addition to C-C multiple bonds involving electrophiles, nucleophiles and free radicals. Addition of hydrogen halides, oxymercuration and demercuration, applications, Epoxidation of alkenes. Hydroboration and its application.

**Additions to carbonyl compounds (Aldehyde and Ketones):** Addition of water, alcohol, bisulphate, HCN, Grignard reagent and amino compounds.

**Elimination reactions:** Mechanism and stereochemistry of eliminations -  $E1$ ,  $E2$ ,  $E1cB$ . cis elimination, Hofmann and Saytzeff eliminations, competition between elimination and substitution, decarboxylation reactions. Chugaev reaction.

**Stereochemistry:** Molecular representations: Wedge, Fischer, Newman and Saw-horse formulae, their description and interconversions.

Molecular Symmetry & Chirality: Symmetry operations and symmetry elements ( $C_n$  &  $S_n$ ). Criteria for Chirality. Desymmetrization.

Axial, planar and helical chirality: Axially chiral allenes, spiranes, alkylidene cycloalkanes, chiral biaryls, atropisomerism, planar chiral ansa compounds and trans- cyclooctene, helically chiral compounds and their configurational nomenclature

Relative and absolute configuration: Determination of configuration by chemical correlation methods.

Racemisation and resolution techniques: Racemisation, resolutions by direct crystallization, diastereoisomer salt formation chiral chromatography and asymmetric transformation.

Determination of configuration in E, Z-isomers: Spectral and Chemical methods of configuration determination of E,Z isomers. Determination of configuration in aldoximes and ketoximes.

### SUGGESTED BOOKS

1. E.L.Eliel and S.H. Wilen, Stereochemistry of Organic Compounds, Jhon Willey and Sons, New York. 1994.
2. Introduction to stereo chemistry- K.Mislow.
3. Stereo chemistry and mechanism through solved problems – P.S. Kalsi.
4. D. Nasipuri, Stereo chemistry of Organic Compounds, 2nd edition, Wiley Eastern Limited, New Delhi, 1987.
5. H.Pine, Hendrickson, Cram and Hammond, Organic Chemistry, Mac Grow hill, New York, 1987.
6. Organic Chemistry – Morrison & Boyd.
7. I.L. Finar, Organic Chemistry, ELBS Longmann, Vol. I & II, 1984.
8. Basic principles of Organic Chemistry – Robert & Casereo.
9. N.S. Issacs, Reactive intermediates in Organic Chemistry, John Willey abd Sons, New York. 1974.
10. R.K. Bansal, Organic Reaction Mechanism, Wiley Eastern Limited, New Delhi, 1993.
11. E.S. Gould, Mechanism Mechanism and Structure in Organic Chemistry, Halt, Rinhart and Winston, New York, 964.
12. A guide book to mechanism in Organic Chemistry – Petersykes.
13. F.A Carey and Sundberg, Advanced Organic Chemistry – Part A & B, 3rd edition, Plenum Press, New York, 1990.
14. S.K. Ghosh, Advanced General Organic Chemistry, Book and Alleied (P) Ltd, 1998.
15. Organic Chemistry-P.Y.Bruice (Pearson Education Pvt. Ltd.,New Delhi),2002.

### CPT 1.3

## Thermodynamics, Quantum Chemistry and Spectroscopy

### UNIT – I

(16 h)

**Concepts of entropy and free energy:** Entropy as measure of randomness and unavailable energy. Entropy changes in reversible and irreversible process and during various processes. Variation of entropy with T and P. Helmholtz and Gibbs free energies. Thermodynamic criteria of equilibrium and spontaneity. Variation of free energy with temperature and pressure. Maxwell's relations, Von't Hoff's reaction isotherm and isochore, Gibbs-Helmholtz equation. Determination of free energy changes. Nernst heat theorem and third law of thermodynamics-calculation of absolute entropies and residual entropy.

**Partial molar Properties:** Physical significance, Partial molar volume and partial molar free energy (chemical potential). Determination of partial molar quantities by intercept method and slope methods. Physical significance of chemical potential. Variation of chemical potential with temperature and pressure. Formulation of the Gibbs Duhem equation. Derivation of Duhem-Margules equation.

### UNIT – II

(16 h)

**Fugacity:** Relation between fugacity and pressure, determination of fugacity of gases. Variation of fugacity with temperature and pressure. Activity and activity coefficients. Variation of activity with temperature and pressure. Determination of activity coefficients by electrical methods.

**Thermodynamics of dilute solutions:** Raoult's law, Henry's law. Ideal and non-ideal solutions. Discussion and thermodynamic derivation of the laws of osmotic pressure, cryoscopy and ebullioscopy. Determination of molecular weights. Thermodynamic treatment using the concept of chemical potentials.

**Phase Rule Studies:** Thermodynamic derivation of phase rule; application of phase rule to the two component systems: simple eutectic type, compound formation with congruent melting point and incongruent melting points, systems involving the formation of a continuous series of solid solutions. Application of phase rule to three component systems: Systems of three liquids and systems of two salts and a liquid.

### UNIT – III

(16 h)

**Quantum Chemistry:** A brief review of wave-particle duality and Heisenberg Uncertainty principle. Concept of operators (operator-operand): algebra of operators, commutative and non-commutative operators, linear operator, Laplacian operator, Hamiltonian operator. Eigen value, eigen function, well behaved function, Hermitian operator and its characteristics. Schrodinger wave equation for particles. Wave function: significance of  $\psi^2$  and  $\psi \psi^*$ . Postulates of quantum mechanics. Application of Schrodinger equation to a particle trapped in a potential field (one dimension and three dimensions). Concept of Degeneracy. Wave equation for H atom: separation and solution of R,  $\theta$  and  $\phi$  equations (Rigorous treatment not required), radial and angular distributions, quantum numbers. Application of Schrodinger equation to rigid and harmonic oscillator.

**Microwave spectroscopy:** Classification of the molecules based on rotation-Linear, symmetric, spherical and asymmetric top molecules. Criteria for a molecule to be microwave active. Pure rotation Spectra of diatomic molecule: Rigid rotor model- energy equation and energy levels, rotational quantum number and the selection rule. Effect of isotopic substitution on rotation spectra. Non rigid rotor model: energy equation and energy levels, rotational quantum number and the selection rule. Determination of moment of inertia and bond length of diatomic molecules using rotational spectra. Rotational spectra of polyatomic molecules: Moment of inertia expression for linear polyatomic molecules.

**Vibrational spectroscopy:** Vibration of diatomic molecules: Hooke's law, energy curves for simple harmonic oscillator. Vibration spectra of harmonic oscillator : energy equation and energy levels, rotational quantum number and the selection rule. Effects of anharmonic oscillation: energy equation and energy levels, rotational quantum number and the selection rule. The diatomic vibrating rotor: Born-Oppenheimer approximation, energy equation and energy levels, rotational quantum number and the selection rule. Vibration rotation spectra of carbon monoxide. Expressions for fundamental and overtone frequencies.

**Vibration of polyatomic molecules-** The number of degrees of freedom of vibration and their symmetry – overtones and combination frequencies – Influence of rotation on the spectra. Parallel and perpendicular vibrations ( $\text{CO}_2$  and  $\text{H}_2\text{O}$ ).

#### SUGGESTED BOOKS

1. Thermodynamics for chemists by S. Glasstone. Affiliated East-West press, New Delhi, (1965)
2. Chemical Thermodynamics by I. M. Koltz, W.A Benzamin Inc. NewYork, Amsterdam, (1964).
3. Basic Physical Chemistry by W.J. Moore, Prentice Hall of India Pvt. Ltd., New Delhi (1986).
4. Text book of Physical Chemistry by Samuel Glasstone, MacMillan Indian Lts., (II edition), (1974).
5. Quantum Chemistry - A. K. Chandra, Second Edition, Tata McGraw Hill Publishing Co. Ltd., (1983).
6. Quantum Chemistry – Eyring, Walter and Kimball, John Wiley and Sons, Inc., New York.
7. Quantum Chemistry – I.N. Levine, Pearson Education, New Delhi, (2000).
8. Theoretical Chemistry – S. Glasstone, East West Press, New Delhi, (1973).
9. Quantum Chemistry- R.J.Prasad, New Age International Publishers (1996).
10. Valence Theory – Tedder, Murel and Kettle.
11. Quantum Chemistry- D.A. McQuarrie.
12. Theoretical Inorganic Chemistry – Day and Selbin.
13. Elements of Physical Chemistry – Lewis and Glasstone.
14. Physical Chemistry by P.W. Atkins, ELBS, 4<sup>th</sup> Edition, Oxford University Press (1990).

**SPT-1.4.A**  
**Organic Synthesis**

**UNIT – I**

**(16 h)**

**Reactions and Synthesis:** Types of carbon to carbon bond forming reactions, Carbon skeletal complexity, stereoselectivity. Principles and methodology of alkylation, acylation, formylation, benzylation, carbethoxylation, arylation, vinylation, methylenylation, O-alkylation versus C-alkylation. Methods of Carbon - Sulfur, Carbon - Nitrogen and Nitrogen - Nitrogen bond formations.

**Protecting groups:** Principle, Protection of Amide, Hydroxyl, Thiol, Amino, Carboxylic, Carbonyl, Phosphate and Terminal alkyne groups. Illustration of protection and deprotection in synthesis.

**UNIT – II**

**(16 h)**

**Synthetic Design:** Carbon skeleton frame work, Classification of carbon-carbon single bond and double bond forming reaction and their use in carbon skeleton ring formation. Ring closure and ring opening, Ring expansion and ring contraction reactions, use of Thorpe condensation, Carbene insertion reaction, Friedel-Crafts reaction.

**Planning of organic synthesis:** Selection of starting materials, Reagents and key intermediates during the synthesis. Functional group interconversion (FGI), Functional group addition (FGA), Target molecule (TM), Umpolung synthesis, Difference between conversion and synthesis.

**UNIT – III**

**(16 h)**

**Disconnection Approach:** General introduction to disconnection approach. Basic principles and technologies used in disconnection approach. Synthons and synthetic equivalents, one group C<sub>X</sub> and two group C<sub>X</sub> disconnections, 3-hydroxy-3-methylbutan-2-one, 2-methylbut-3-en-2-ol, (E)-pent-3-en-2-one. Cyclobutanone, 2-aminopropanoic acid, ethyl 4-amino-3-phenylbutanoate, ethyl 2,5-dimethylfuran-3-carboxylate, 4-(dimethylamino)butan-2-one, diethyl 3-methylcyclopent-3-ene-1,1-dicarboxylate, 5-((ethylperoxy)methyl)-2-phenyl-4H-pyran-4-one, imidazolidine-2,4-dione, 3,5-diphenylcyclopentane-1,2,4-trione, pyrimidine-2,4,6(1H,3H,5H)-trione, 2,3-dihydronaphthalene-1,4-dione, 4-(dichloromethyl)-4-methylcyclohexa-2,5-dienone, 2-oxocyclohexanecarbonitrile, ethyl 3-oxo-2-(3-oxobutanamido)butanoate, 1H-pyrrole-2-carbaldehyde, 3,4,8,8a-tetrahydronaphthalene-1,6(2H,7H)-dione, 5,6-dihydro-1H-indene-2,7(4H,7aH)-dione.

**Retrosynthetic analysis:** Retrosynthesis of Benzofurans, p-methoxy acetophenone, saccharine,  $\alpha$ -bisabolene, nuciferal, penicillin-V. Analysis of alcohols, carbonyl compounds cyclic and acyclic alkanes, benzocaine, p-nitroacetophenone, acetonecyanohydrin, Synthesis of Cubane and Iswarane.

**UNIT – IV**

**(16 h)**

**Strategic Applications of Named Reactions in Organic Synthesis:** Michael condensation, Claisen Ester condensation, Dels-Alder reaction, Cannizzaro reaction, Hydroboration reactions, Gabriel synthesis, Japp-Klingermann reaction, Kolbe-Schmitt reaction, Bachwald-Hartwig cross coupling reaction, Heck reaction, Suzuki coupling and Sonogashira coupling reactions.

## SUGESTED BOOKS

1. Modern Organic Reactions- H.O.House.
2. Organic Synthesis- R.E.Ireland (Prentice Hall India), 1969.
3. Art in Organic Synthesis- Anand, Bindra & Ranganath-(Wiley New Delhi), 1970.
4. Organic Synthesis a Disconnection Approach- Stuart
5. Advanced Organic Chemistry-IV-Ed. Part A &B-F.J.Carrey & R.J.Sundberg(Kluwer) 2001.
6. Modern Methods of Organic Synthesis-N.Carruthers (Cambridge University), 1996.

## SPT-1.4.B

### Separation technique and Spectroscopy-1

#### UNIT-I

(16 h)

##### Techniques of Chromatography

Introduction, Classification of chromatographic techniques, differential migration rates, partition ratio, retention time, relation between partition ratio and retention time, capacity factor, selectivity factor. Efficiency of separation- resolution, diffusion, plate theory and rate theory.

**Thin-layer chromatography (TLC):** definitions, mechanism, efficiency of TLC plates, methodology-selection of stationary phase, and mobile phase, preparation of plates, spotting, development, identification and detection, reproducibility of RF values, comparison of TLC with high performance thin-layer chromatography, Paper chromatography, and column chromatography. Qualitative and quantitative analysis.

**GC:** Principle, instrumentation, detectors- TCD, FID, ECD. Derivatization techniques. GC analysis of hydrocarbons in a mixture, GC assay of methyl testosterone in tablets, atropine in eye drops.

**HPLC:** Principle, instrumentation, detectors- UV detectors, Photodiode array detector, fluorescence detector. Applications: Methods of quantitation for GC and HPLC: HPLC assay of paracetamol and aspirin in tablets.

#### UNIT-II

(16 h)

**UV-VIS Spectroscopy (Outer shell electronic spectroscopy):** Quantitative aspects of absorption –Beer's law. Terminology associated with absorption measurements. Limitations of the law: Real, Chemical, instrumental and personal. Theory of molecular absorption. Vibration-rotation fine structure of electronic spectra. Types of absorption bands:  $n \rightarrow \pi^*$ ,  $\pi \rightarrow \pi^*$ ,  $n \rightarrow \sigma^*$ ,  $\sigma \rightarrow \sigma^*$ , C-T and ligand field. Empirical rules (Woodward's Fieser) for predicting the wave length of maximum absorption: Olefins, conjugated dienes, cyclic trienes and polyenes  $-\alpha$ ,  $\beta$ -unsaturated aldehydes and ketones, benzene and substituted benzene rings.

Applications: Qualitative and quantitative analysis of binary mixtures, measurement of dissociation constants of acids and bases, determination of molecular weight, photometric titrations, Determination of stoichiometry and stability of the complexes and kinetic studies.

#### UNIT-III

(16 h)

##### IR spectroscopy:

**Organic IR spectroscopy:** Recapitulation, Characteristic vibration frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines.

Detailed study of vibrational frequencies of carbonyl compounds Ketones, aldehydes, esters, amides, acids, anhydride, Lactose, lactams and conjugated carbonyl compounds. Factors affecting group frequencies: overtones, combination bands and Fermi-resonance. FTIR and sampling technique.

**Inorganic IR spectroscopy:** Structural information from vibrational spectra: Group frequencies, Characteristic band stretching frequencies, Mode of vibrations of linear and non-linear molecules, deformation, frequencies of carbonyl metal complexes, pattern of

group frequencies, mode of bonding of ambidentate ligands, Cyanides, Ethylenediamine and Diketone complexes.

#### UNIT-IV

(16 h)

**<sup>1</sup>H NMR spectroscopy:** Magnetic properties of nuclei, Principles of NMR Instrumentation, CW and pulsed FT instrumentation, equivalent and non equivalent protons, enantiotopic and diastereotopic protons, Chemical shifts, factors affecting the chemical shifts, electronegativity and anisotropy, shielding and deshielding effects, Signal integration, Spin-spin coupling: vicinal, germinal and long range, Coupling constants and factors affecting coupling constants.

Applications of <sup>1</sup>H NMR spectroscopy: E, Z isomers, conformation of cyclohexane and decalins, keto-enol tautomerism, hydrogen bonding, proton exchange processes (alcohols, amines and carboxylic acids), C-N rotation.

#### SUGGESTED BOOKS

1. Fundamental Analytical Chemistry, D.A. Skoog, D.M. West, Hollar and Crouch 8<sup>th</sup> edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G. D. Christian, 5<sup>th</sup> ed., 2001 John Wiley and Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6<sup>th</sup> edition, 1993 presence Hall, Inc. New Delhi.
4. Vogel's Text book of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D Barners and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint. 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing, Callifornia, 1990.
6. Spectroscopic identification of Organic Compounds, R. M. Silverstern, G. C. Bassler and T. C. Morrill.
7. Introduction to NMR spectroscopy, R. J. Abraham, J. Fisher and P. Loftus.
8. Application of spectroscopy of organic compounds – J. R. Dyer.
9. Spectroscopy of organic compounds, P. S. Kalsi.
10. Organic Spectroscopy, William Kamp.
11. Organic Chemistry, R. T. Morrison and R. N. Boyd.
12. Practical NMR spectroscopy, M. L. Martin, J. J. Delpenck and G. J. Martin.
13. Spectroscopic methods in organic Chemistry, D. H. William, I. Flemming
14. Fundamentals of Molecular spectroscopy – C.N.Banwel



**CPP 1.5 (1.1)**  
**Practical Inorganic Chemistry - 1**

(64 h)

**1. Analysis of Ores:**

1. Hematite
  1. Insoluble (gravimetrically)
  2. Iron titrimetrically using cerium (IV) solution.
2. Dolomite.
  1. Insoluble (gravimetrically)
  2. Calcium and magnesium using EDTA
3. Pyrolusite.
  1. Insoluble (gravimetrically)
  2. Manganese dioxide titrimetrically using permanganate.

**2. Micro – volumetric estimation of calcium using EDTA.**

**3. Analysis of alloys:**

- a) Solder – lead and tin using EDTA
- b) Copper – nickel alloy
  - (i) Copper volumetrically using  $\text{KIO}_3$
  - (ii) Nickel gravimetrically using DMG.

**4. Quantitative analysis of mixtures:**

- a) Chloride and iodide
  - (i) Iodide volumetrically using  $\text{KIO}_3$
  - (ii) Total halide gravimetrically.
- (b) Calcium and lead – using EDTA

**5. Spectrophotometric determination of :**

- a) Iron using thiocyanate / 1, 10 – phenanthroline
- b) Chromium using diphenyl carbazide.
- c) nickel Using dimethylglyoxime
- d) Titanium using hydrogen peroxide.

**6. Circular paper chromatography – separation of : (Demonstration)**

- a) Iron and nickel,
- b) Copper and nickel.

**SUGGESTED BOOKS**

1. A text book of Quantitative Inorganic Analysis – A.I. Vogel. III edition.
2. Vogel's text book of Quantitative Chemical Analysis – J. Basset, R.C. Denney.
3. G.H. Jeffery and J. Mendham. Spectrophotometric determination of elements.

**CPP-1.6 (1.2)**  
**Practical Organic Chemistry-1**

**(64 h)**

Organic Preparations: Preparations involving oxidation, reduction, dehydration, decarboxylation, halogenation, nitration, sulfonation, diazotization, cyclization, condensation, addition reactions.

Emphasis has to be given for collecting the literature, setting up of experiment, purification and characterization of the final product based on physical data, mechanism involved in the reaction, calculation of theoretical yield, practical yield and percentage yield.

1. Preparation of p-bromoaniline from acetanilide.
2. Preparation of p-nitroacetanilide from acetanilide.
3. Preparation of n-butyl bromide from n-butanol.
4. Preparation of o-iodobenzoic acid from anthranilic acid.
5. Preparation of aniline from nitrobenzene.
6. Preparation of osazone derivative.
7. Preparation of penta – O – acetyl – D – glucose from glucose.
8. Preparation of 3 – methyl – 1 – phenyl – pyrazolone.
9. Preparation of cis and trans cinnamic acids.
10. Preparation of phenoxy acetic acid.
11. Preparation of hippuric acid from glycine.
12. Preparation of m-nitrobenzoic acid from methyl benzoate.
13. Preparation of aspirin.
14. Oxidation of toluene by  $\text{KMnO}_4$
15. Preparation of adipic acid from cyclohexanol.

**SUGGESTED BOOKS**

1. A Text book of Practical Organic chemistry – A.I. Vogel Vol. I
2. Practical Organic chemistry – Mann & Saunders.
3. Manual of Organic chemistry – Dey and Seetharaman.
4. An introduction to practical organic chemistry – Robert, Vingrover etc.
5. J.N Guthru and R. Kapoor, Advance experimental chemistry. S. Chand company, 1991.
6. R. K. Bansal, Laboratory Manual of Organic chemistry, New PGE international (P) Ltd. London, 3rd edition, 1996.
7. N. K. Visno, Practical Organic Chemistry, New PGE International (P) Ltd. London, 3rd edition, 1996.

## CPP 1.7 (1.3)

### Practical Physical Chemistry – 1

(64 h)

1. Study of phase diagram of a three component liquid-liquid-liquid systems.
2. Study of phase diagram of a three component solid-solid-liquid systems.
3. Determination of molecular weight of a compound using Beckmann's cryoscopic method using benzene or / and water as solvent.
4. Determine the degree of association and association constant of benzoic acid in benzene/toluene.
5. Determine the activity coefficient of an electrolyte by freezing point depression method.
6. To determine the eutectic point of a two component system (Eg: Naphthalene-m-dinitrobenzene, Naphthalene-biphenyl system, naphthalene - phenanthrene and benzophenone-diphenyl amine).
7. Determine the transition temperature of Glauber's salt ( $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ ) by solubility method.
8. To determine the partial molal volumes of sodium chloride in aqueous solutions.
9. To determine the partial molal volumes of potassium chloride in aqueous solutions.
10. To determine the relative viscosity coefficient of dilute solutions of sodium chloride at different concentrations
11. To determine the degree of ionization of sodium chloride at different concentrations of its aqueous solutions from the depression of freezing point temperatures
12. Determine the partial molar volume of methanol in dilute aqueous solutions.
13. Determine the partial molar volume of ethanol in dilute aqueous solutions.
14. Determination of molecular weight of non-volatile and nonelectrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.
15. Determination of heat of neutralization of strong acid by strong base by using a calorimeter.
16. Determination of heat of neutralization of weak acid by strong base by using a calorimeter.
17. Determination of heat of solution of a salt base by using a calorimeter.

### SUGGESTED BOOKS

1. Practical Physical chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels et al.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico – Chemical experiments – J. Rose.
7. Practical Physical Chemistry. - S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994)
11. Experimental physical chemistry, R. C. Das and B. Behera, Tata McGraw-Hill Publishing Company Limited, 1983.
12. Experimental Physical Chemistry, V. D. Athawale and Parul Mathur, New Age International (p) Limited, Publishers, New Delhi, 2001.

**SPP- 1.8 (1.4.A)**  
**Practical Organic Chemistry**

**(64 h)**

Emphasis has to be given in designing the procedure based and the literature available, setting up of experiment, purification and characterization of the final product based on physical data, mechanism involved in the reaction, calculation of theoretical yield, practical yield and percentage yield.

**Multi Step Organic Synthesis**

1. Preparation of Ethyl resorcinol from Resorcinol,
2. Preparation of 3-Bromo-4-methyl benzaldehyde from p-Toludine,
3. Preparation of  $\epsilon$ -Caprolactam from cyclohexanone,
4. Preparation of p-Amionobenzoic acid from p-Nitrotoludine,
5. Preparation of s-Tribromobenzene from aniline,
6. Preparation of o-hydroxy acetophenone from phenol,
7. Preparation of Benzanilide from Benzophenone,
8. Preparation of Benzylic acid from Benzoin,
9. Preparation of Benzopinacolone from Benzophenone,
10. Preparation of p-Chlorotoluine from p-Toludine,
11. Preparation of 2,5-Dihydroxy acetophenone from Hydroquinone.

**SUGGESTED BOOKS**

1. An introduction to practical organic chemistry- Robert, Vingrove etc
2. Semimicro qualitative analysis by Cheronis, Entrikin and Hodnet.
3. R. K. Bansal. Laboratory Manual of Organic Chemistry, New PAG International (P) Ltd. London, 3rd edition, 1966
4. N. K. Visno, Practical Organic chemistry, New PAGE International (P) (P) Ltd. London, 3rd edition, 1966
5. Quantitative Analysis By A I Vogel
6. Practical organic Chemistry, Mann and Saunders

## SPP- 1.8 (1.4.B)

### Practical Separation Methods and Spectroscopy

(64 h)

Identification and separation of organic compounds by using TLC, paper chromatography and column chromatography

Theoretical Identification of organic molecules by using UV, IR,  $^1\text{H}$  &  $^{13}\text{C}$  NMR Spectral Data

#### SUGGESTED BOOKS

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M West, Holler and Crouch 8<sup>th</sup> edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A Day and A.L. Underwood, 6<sup>th</sup> edition, 1993prentice Hall, Inc. New Delhi.
4. Vogel's Text book of Quantitative Chemical Analysis, J. Mendham, R.C Denney, J.D Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint.2003 Pearson education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principals, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing California, 1990.

**CPT –2.1**  
**Group Theory & Coordination Chemistry**

**UNIT – I**

**(16 h)**

**Symmetry and Group theory:** Symmetry elements and symmetry operations, point groups. Definition of groups, subgroups, cyclic groups, conjugate relationships, classes, simple theorems in group theory. Schönflies notations, representations of groups by matrices, reducible and irreducible representations, characters of representations, Great Orthogonality Theorem (without proof) and its applications, properties of IRs, character tables for  $C_s$ ,  $C_i$ ,  $C_2$ ,  $C_{2v}$ ,  $C_{2h}$ ,  $D_{3h}$  and  $C_{3v}$  groups (to be worked out explicitly). Mulliken symbols for irreducible representations

**Applications of group theory:** Symmetry and dipole moments, symmetry and optical activity.

**UNIT – II**

**(16 h)**

**Preparation of coordination compounds:** Introduction, preparative methods- simple addition reactions, substitution reactions, oxidation-reduction reactions, thermal dissociation reactions, reactions of coordinated ligands, trans effect, theories of trans-effect, application of trans-effect in the synthesis of complexes. Other methods. Geometries of metal complexes of higher coordination numbers (2-12).

**Stability of coordination compounds:** Introduction, trends in stepwise stability constants, factors influencing the stability of metal complexes with reference to the nature of metal ion and ligands, the Irving-William series, chelate effect. Determination of stability constants: Theoretical aspects of determination of stability constants of metal complexes by spectrophotometric, pH metric and polarographic methods.

**Crystal field theory:** Salient features of CFT, d-orbital splitting in octahedral, tetrahedral, square planar and tetragonal complexes, Jahn-Teller distortions, measurement of  $10 Dq$  and factors affecting it. Experimental evidences for covalence and adjusted CFT.

**UNIT – III**

**(16 h)**

**Molecular Orbital Theory:** MOT applied to octahedral, tetrahedral and square planar complexes with sigma bonding ligands. MOT applied to octahedral complexes with pi-bonding ligands of both pi-acceptor and pi-donor type. M.O. energy level diagrams of complexes of above geometries. Jahn-Teller effect.

**Electronic absorption spectra of transition metal complexes:** Introduction, selection rules, electronic-dipole transitions, magnetic-dipole transitions, Effects of spin-orbit coupling; Term symbols for  $d^n$  ions. Orgel and Tanabe-Sugano Energy level correlation diagrams. Charge-transfer (CT) transitions.

**Magnetic properties of transition metal complexes:** Introduction, magnetic susceptibility and its measurements, spin cross over systems, ferromagnetism and antiferromagnetism.

**Electron Spin Resonance Spectroscopy:** Basic principles- intensity-width-position and multiple structure. General rules for the interpretation of the spectra. Zero field splitting and Kramer's degeneracy rule. Factors affecting the magnitude of 'g' value. Double resonance-ENDOR and ELDOR. Applications-study of free radicals-structure determination- biological study-coordination compound and analytical applications.

**Mossbauer spectroscopy:** Theoretical basis. Interpretation of Mossbauer spectra- isomer shift- Quadrupole splitting and magnetic hyperfine structure, time and temperature effects. Instrumentation. Applications-structure deduction- $I_2Br_2Cl_4$ ,  $Fe_3(CO)_{12}$

**NQR Spectroscopy:** Energies of the Quadrupole transitions, effect of magnetic field on the spectra, relationship between electric field gradient and molecular structure. Applications- interpretation of  $e^2Qq$  data. Structural information from NQR spectra.

### SUGGESTED BOOKS

1. Symmetry in Chemistry – H. Jaffe and M. Orchin, John Wiles, New York (1965).
2. Symmetry in Molecules- J.M.Hollas, Chapman and Hall Ltd., London (1972).
3. Chemical Applications of Group Theory- F.A. Cotton, Wiley Eastern Ltd., 2nd edition, New Delhi (1971).
4. Group theory and Symmetry in Chemistry- G. Raj, A. Bhagi and V. Jain, Krishna Prakashan Media (P) Ltd., Meerut (1998).
5. The Determination of Molecular Structure – P.J. Wheatley, Oxford University Press, Oxford (1969).
6. Advanced inorganic chemistry, (5<sup>th</sup> edition)- F.A. Cotton and G. Wilkinson: John Wiley and sons 1988.
7. Inorganic chemistry (3<sup>rd</sup> edition)-J.E. Huheey: Harper and Row, N.Y. 1983
8. Modern aspects of Inorganic chemistry (4<sup>th</sup> edition)-H.J., Emeleus and A.G. Sharpe: UBS 1989.
9. Coordination chemistry-S.F.A. Kettle, (1969)-Thomas Nelson and Sons Ltd., London.
10. Physical Inorganic Chemistry-A Coordination Chemistry Approach- S.F.A. Kettle, Spektrum, Oxford, 1996.
11. Symmetry and spectroscopy of molecules, K. Veera Reddy, New-Age International, 2009.
12. Group theory and its chemical applications, P. K. Bhattacharya, Himalaya Publishers, Students Edition.
13. Spectroscopy by B P Stranghan and S Walker, John Wiley and Sons, Inc., New York, Vol. I and 2 , 1976
14. Organic spectroscopy by Willaa Kemp, ELBS Society, MacMillan, 1987.
15. Application of absorption spectroscopy of organic compounds by JohnR. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi.1974.
16. Organic spectroscopy by V.R. Dhani, Tata McGraw-Hill Publishing company Ltd., New Delhi, 1995.
17. Spectrometric identification of organic compounds, 4<sup>th</sup> edition, Robert M, Silverstein, G. Clayton Bassler and Terence C. Morrill, John Wiley and Sons Inc., New York, Vol.1, 1981.
18. Analytical Chemistry Principles, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing, California, 1990.

19. Instrumental method of analysis, Hobart H, Willard, Lynne L, Merritt, Jr., John A. dean and Frank A Settle, Jr., 6<sup>th</sup> edition, CBS Publishers and Distributors, Delhi, 1986.
20. Physical methods for chemists by R.S. Drago, Sanders College publishing, New York.
21. Quantitative Analysis, R. A Day and A./L Underwood, 6<sup>th</sup> edition, prentice Hall, Inc., 1999.
22. Principles of instrumental Analysis, D.A.Skoog, F.J Holler and T.A. Nieman, 5<sup>th</sup> edition, Thomson Asis Pvt. Ltd. Singapore, 1998.



## CPT – 2.2

### Reaction Mechanism, Photochemistry and Spectroscopy

#### UNIT – I

(16 h)

**Oxidation:** Oxidation with chromium and manganese reagents ( $\text{CrO}_3$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$ , PCC, PDC, Sarret reagent,  $\text{MnO}_2$ ,  $\text{KMnO}_4$ ) ozone, peroxides and peracids, periodic acid,  $\text{OsO}_4$ ,  $\text{SeO}_2$ , NBS, Oppenauer oxidation, Dess-Martin reagent.

**Reduction:** Catalytic hydrogenation (homogeneous and heterogeneous) – Metals catalysts and reduction of functional groups, catalytic hydrogen transfer reactions. Wilkinson catalyst,  $\text{LiAlH}_4$ ,  $\text{NaBH}_4$ , Dissolving metal reductions (Birch reduction). Leukart reaction (reductive amination), diborane as reducing agent, Meerwein-Ponndorf-Verley reduction, Wolff-Kishner reduction, Clemensen reduction.

**Special reducing agents:**  $\text{LiBH}_4$ , DIBAL-H, Sodium cyanoborohydride,  $\text{NaBH}_4\text{-CeCl}_3$ , Lindlar's catalyst, Rosenmund reduction

#### UNIT – II

(16 h)

**Reagents and reactions in organic synthesis:** Use of following reagents in organic synthesis and functional group transformations: Lithium diisopropylamide (LDA), Gilman reagent, dicyclohexyl carbodimide (DCC), dichlorodicyanoquinone (DDQ), Silane reagent, trialkylsilyl halides, trimethylsilyl cyanide, trimethyl silane, phase transfer catalyst, crown ethers, cyclodextrins, Ziegler-Natta catalyst, diazomethane, Woodward and Prevost hydroxylation, Stark enamine reaction, phosphorous ylides - Wittig and related reactions, sulphur ylides – reactions with aldehydes and ketones, 1,3-dithiane anions - Umpolung reaction, Peterson reaction. Palladium reagents: Suzuki coupling, Heck reaction, Negishi reaction

#### UNIT – III

(16 h)

**Photochemistry and concerted reactions:** Introduction, light absorption and electronic transitions, Jablonski diagram, intersystem crossing, energy transfer, sensitizers, quenchers

Photochemistry of olefins, conjugated dienes, aromatic compounds, ketones, enones, photooxidations, photoreductions Norrish type I and II reactions, Paterno-Buchi reaction, Barton reaction, Di-pi-methane rearrangements

**Pericyclic reactions:** Electrocyclic reactions: Stereochemistry, Symmetry and Woodward-Hofmann rules for electro cyclic reactions, FMO theory of electrocyclic reactions, correlation diagram for cyclobutadiene and cyclohexadiene systems.

**Cycloaddition reactions:** [2+2] [3+2] and [4+2] cycloadditions, analysis by FMO and correlation diagram method. Sigmatropic reactions: Classification, stereochemistry and mechanisms.

**NMR spectroscopy-II**

**<sup>13</sup>C NMR:** Resolution and multiplicity of <sup>13</sup>C NMR, <sup>1</sup>H-decoupling, noise decoupling, broad band decoupling; Deuterium, fluorine and phosphorus coupling; NOE signal enhancement, off-resonance, proton decoupling, Structural applications of CMR. DEPT; Introduction to 2D-NMR: COSY, NOESY, DEPT, INPET, APT, INADEQUATE.

**Solid state NMR spectroscopy:** First order and non first order spectra e.g., AX, AX<sub>2</sub>, AX<sub>3</sub>, A<sub>2</sub>X<sub>3</sub>, AMX and AB, ABC. Simplification of complex spectra: increased field strength, deuterium exchange, Lanthanide shift reagents and double resonance techniques. Discrimination of enantiomers by use of chiral NMR solvents (CSAs), chiral lanthanide shift reagents and Mosher's acid. Nuclear Overhauser enhancement (NOE)

Introduction to solid state NMR: Magic angle spinning (MAS). Applications of solid state NMR.

**Mass spectrometry**

Origin of mass spectrum, principles of EI mass spectrometer. Types of fragments: odd electron and even electron containing neutral and charged species (even electron rule), Nitrogen rule, isotopic peaks, determination of molecular formula, metastable ion peaks. High resolution mass spectrometry. Salient features of fragmentation pattern of organic compounds including β-cleavage, McLafferty rearrangement, retro Diels – Alder fragmentation and ortho effect. Principle of EI, CI, Fast Atom Bombardment (FAB), Secondary Ion Mass Spectrometry (SIMS), Electrospray (ESI) ionization and Matrix Assisted Laser Desorption Ionization (MALDI) methods.

**SUGGESTED BOOKS**

1. H. Pine, Hendickson, Cram and Hammond, Organic Chemistry, Mac Grow Hill, New York, 1987.
2. Organic Chemistry-Morrison & Boyd
3. I. Finar, Organic Chemistry, ELBS Longmann, Vol I &II, 1984.
4. J. March, Advanced Organic Chemistry, Willey Interscience, 1994.
5. E.S. Gould, Mechanism and Structure in Organic Chemistry, Halt, Rinhart &Winston, Nee York, 1964.
6. F. A. Carey and Sundberg, Advanced Organic Chemistry-Part A and B, 3rd edition, Plenum Press, New York, 1990.
7. Comprehensive Organic Synthesis- B. M. Trost and I. Fleming series, Pergamon Press, New York, 1991.
8. A Guide book to mechanism in Organic Chemistry- Peterskye
9. S. K. Ghosh, Advanced General Organic Chemistry, Book and Alleied (P) Ltd., 1998.
10. Photochemistry-Calvert & Pitts, Willey, New York, (1966).
11. Advances in Photochemistry- Rahatgi Mukherjee.
12. Principles and applications of Photochemistry – RP Wayne, Elsevier, New York, (1970).
13. Photochemistry, Paul Suppan, RSC, London, (1944).
14. Dupey and Chapmann Molecular reactions and Photochemistry, Prencitic Hall-International, Tokyo, 1972.

15. J. Michael Hollas , Fourth Edition, Modern Spectroscopy, Wiley, 2004.
16. J. E. Sansonetti and W. C. Martin, Handbook of Basic Atomic Spectroscopic Data, 2007.
17. Martin Kaupp, Michael Bhl, Vladimir G. Malkin, Calculation of NMR and EPR Parameters-Theory and Applications, 2004.
18. Pavia, Lampman, Kriz. Introduction to Spectroscopy. 2001.

## SPT 2.3 A

### Statistical Mechanics, Electrochemistry and Advanced Quantum Chemistry

#### UNIT – I

(16 h)

**Statistical mechanics:** Introduction, thermodynamic probability, relation between entropy and thermodynamic probability, principle of equipartition of energy, Maxwell-Boltzmann distribution equation, partition function and its significance. Derivation of translational, rotational, vibrational and electronic partition functions for a molecule. Evaluation of internal energy, enthalpy, Helmholtz and Gibbs free energies, equilibrium constant, partition functions of atoms and diatomic molecules. Evaluation of molecular entropies, entropy of monatomic gas (Sackur-Tetrode equation).

**Distribution equations** – Bose-Einstein and Fermi-Dirac distribution equations.

**Heat capacity of solids:** Einstein and Debye heat capacity equations, Debye-characteristic temperature and its significance.

#### UNIT – II

(16 h)

**Poisson–Boltzmann equation;** ion–cloud and chemical potential change; Electrical double layer and its thermodynamics.

**Electrical double layer:** A brief survey of Helmholtz - Perrin, Gouy - Chapman and Stern electrical double layer, EMF cells Liquid Junction Potential and its determination. Debye-Huckel theory of strong electrolytes, Debye Huckel – Onsager equation, Debye - Huckel limiting equation for activity coefficients, modifications and verifications. Diffusion - Fick's law of diffusion - Effect of ionic association on conductance-electro kinetic phenomena - membrane potential.

**Electrodicts:** The basic electrodic equation: Butler–Volmer equation; overpotential; polarizable and nonpolarizable interfaces.

#### UNIT – III

(16 h)

**Electrochemical power sources** - theoretical background on the basis of thermodynamic and kinetic considerations.

**Primary cells** - various types, especially magnesium and aluminium based cells - magnesium reserve batteries.

**Properties of Electrochemical energy storers:** Measure of battery performance, Charging and discharging of a battery, Storage Density, Energy Density. Classical Batteries : (i) Lead Acid (ii) Nickel-Cadmium, (iii) Zinc manganese dioxide. Modern Batteries : (i) Zinc-Air (ii) Nickel-Metal Hydride, (iii) Lithium Battery.

**Fuel cells** - classification - chemistry of fuel cells - detailed description of hydrogen/oxygen fuel cells, alkaline fuel cell, Phosphoric and fuel cell, methanol - molten carbonate solid polymer electrolyte and applications of fuel cells

**Solar energy conversion devices** - photovoltaic cells - photoelectrochemical cells - semiconductor electrolyte junctions, photocatalytic modes for fuel conversion process - photobiochemical options.

**Corrosion and prevention:** Thermodynamics and the stability of metals, Potential -pH (or Pourbaix) Diagrams; uses and abuses, Corrosion current and corrosion potential - Evans diagrams. Measurement of corrosion rate: i) Weight Loss method, (ii) Electrochemical Method. Inhibiting Corrosion: Cathodic and Anodic Protection. (i) Inhibition by addition of substrates to the electrolyte environment, (ii) by charging the corroding method from

external source, anodic Protection, Organic inhibitors, Passivation :Structure of Passivation films, Mechanism of Passivation.

## UNIT – IV

(16 h)

### Advanced Quantum Chemistry

**Approximate methods** – Necessity of approximate methods, Perturbation method: first order and second order corrections for wave functions and energies, application to He – atom (first order correction only) – calculation of first ionization potential and binding energy. Variation theorem-statement and proof. Application of variation theorem to a particle in one dimensional box, H and He – atoms.

**Chemical Bonding in diatomics:** Covalent bond-Valence bond and molecular orbital approaches with comparison. Secular equations and secular determinants. Molecular orbital theory applied to homonuclear and heteronuclear diatomic molecules. Introduction to Huckel molecular orbital theory of conjugated systems and its applications.

### SUGGESTED BOOKS

1. Statistical thermodynamics by B.C. Mecllland, Chapman and Hall, London (1973).
2. Elementary Statistical thermodynamics by N. D. Smith, plenum Press, NY (1982).
3. Elements of classical and statistical thermodynamics by L.K Nash, Addison-Westley (1970).
4. Statistical thermodynamics by I. M. Klotz.
5. Introduction to Statistical thermodynamics by M. Dole, Prentice-Hull, (1962).  
Elements of Physical Chemistry – Lewis and Glass tone.
6. Physical Chemistry by P.W. Atkins, ELBS, 4<sup>th</sup> Edition, Oxford University Press (1990).
7. Introduction to electrochemistry by S. Glasstone.
8. Modern Electrochemistry Vol I and II by J.O.M. Bockr's and A.K.N. Reddy, Plenum Press, New York (1970).
9. Chemical and Electrochemical energy systems – R.NarayanandB. Vishwanathan, Universities Press (India) (1998).
10. Electrochemistry – Principles and applications by E.G. Potter.
11. Electrochemistry by Reiger, Prince Hall (1987).
12. C. A. Vincent Modern Batteries, Edward Arnold, 1984.
13. R. Narayanan and B. Viswanathan, Chemical and Electrochemical energy systems, Orient Longmans, 1997.
14. A. S. J. Appleby and F. K. Foulkes, Fuel cell Hand Book, Von Nostrand Reinhold, 1989.
15. D. Linden, Hand book of batteries and Fuel cells, McGraw Hill Book Company, 1984.
16. T. Ohta, Solar Hydrogen energy systems, Pergamon Press, 1979.
17. M. Gratzel, Energy Resources through photochemistry and catalysis, Academic Press, 1983.
18. T. Ohta, Energy Technology, Sources, Systems and Frontiers conversions, Pergamon, 1994.
19. Fundamentals of molecular spectroscopy by C.N Banwell and E.M. Mc Cash-4<sup>th</sup> edition, Tata Mc. Graw Hill, New Delhi, 1998.
20. Introduction to molecular spectroscopy by G. M. Barrow, Mc Graw Hill, New York (International student edition) (1972).
21. Theoretical chemistry by S. Glasstone, affiliated East-West press Pvt. Ltd., New Delhi, (1973).

22. Spectroscopy Vol I and II by B. P. Straughan and S. Walker, John Wiley and Sons Inc, New York. (1976).
23. Vibrational spectroscopy, Theory and Applications, by D. N. Sathyanarayana, New Age International Publications, New Delhi, (1996).
24. Instrumental methods of analysis by H.H Willard, L.L. Merritt and J.A Dean, 7<sup>th</sup> edition, (1988).
25. Physical methods inorganic chemistry by R.S Drago, Affiliated East-West Press Pvt. Ltd. (student edition) (1978).
26. Principles of instrumental Analysis by D A. Skoog, F J. Holler and T.A. Nieman. Fifth edition, Saunders college Publishing, Philadelphia.
27. Spectroscopy of organic compounds, P. S. Kalsi, new age international publishers, New Delhi.
28. Quantum Chemistry - A. K. Chandra, Second Edition, Tata McGraw Hill Publishing Co. Ltd., (1983).
29. Quantum Chemistry – Eyring, Walter and Kimball, John Wiley and Sons, Inc., New York.
30. Quantum Chemistry – I.N. Levine, Pearson Education, New Delhi, (2000).
31. Theoretical Chemistry – S. Glasstone, East West Press, New Delhi, (1973).
32. Quantum Chemistry- R.J.Prasad, New Age International Publishers (1996).
33. Valence Theory – Tedder, Murel and Kettle.
34. Quantum Chemistry- D.A. McQuarrie.

## SPT 2.3.B

### Surface, Nuclear Chemistry and Non-Equilibrium Thermodynamics

#### UNIT – I

(16 h)

**Macromolecules:** Number and average molecular mass, molecular mass determination: Osmometry, Viscometry, sedimentation, diffusion and light scattering method. Chemical adsorption, application of adsorption, factors affecting adsorption, Langmuir theory, BET theory, heat and entropy of adsorption. Surface film on liquids; Electrokinetic phenomena. types of adsorption isotherm. micelle formation, mass action model and phase separation model, shape and structure of micelles, CMC, factors affecting CMC effect of added electrolyte on the surface excess of ionic surfactants. Modern techniques for investigating surfaces-Low energy electron diffraction(LEED), PES, Scanning tunneling and atomic force microscopy (STM and AFM).

#### UNIT – II

(16 h)

**Electrode Interfaces:** Quantum aspects of charge transfer at electrode-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.

**Electro catalysis:** Comparison of electro catalytic activity, importance of oxygen reduction and hydrogen evolution reactions, and their mechanism,

**Bio-electrochemistry:** Threshold membrane phenomena, Nernst Plank equation, Hodges Huxley equations, core conductor models, electrocardiography.

#### UNIT – III

(16 h)

**Nuclear Chemistry:** Radioactive decay and equilibrium, Nuclear reactions; Q-value, cross sections, types of reactions, chemical effects of nuclear transformations, fission and fusion, fission products and fission yields. Radioactive techniques, tracer technique, neutron activation analysis, counting techniques such as G.M. ionization and proportional counter.

#### UNIT – IV

(16 h)

**Non-equilibrium thermodynamics:** Phenomenological laws and Onsager's reciprocal relations, Linear phenomenological relations, Conjugate flows, Entropy production, Specific examples of entropy production, Interanal energy, Prigogine's principles of minimum entropy production, Entropy production in coupled phenomena, Seebeck effect, Peltier effect, Second Kelvin relation, First Kelvin relation.

#### SUGGESTED BOOKS

1. Y. Moroi, Micelles : Theoretical and Applied Aspects, Plenum Press, New York (1992).
2. E.M. Mc Cash, Surface Chemistry, Oxford University Press, Oxford (2001).
3. P.A. Eglestaff, An Introduction to Liquid Statell Academic Press.
4. J.A.Pryde, The Liquid Statell
5. A.F.M.Barton, —The Dynamics of Liquid Statell, Longman.
6. Introduction to Radiation Chemistry: J. W. T. Spinks and R. J. Woods
7. Radiochemistry: A. N. Nesmeyanov (Mir Publications)
8. G. Hughes- Radiation Chemistry- Oxford University Press, London
9. A. D. Baker and C. R. Brundle, Eds, Electron Spectroscopy, Vol. 1 - 4 Academic Press, 1978.

10. H. Ibach, *Electron Energy Loss Spectroscopy*, Springer Verlag, 1992.
11. D. Briggs and M. P. Seah, Editors, *Practical Surface Analysis*, 2nd ed. vols 1 & 2, Auger and X-ray photoelectron spectroscopy, John Wiley & Sons, 1990.
12. *Principles of Physical Chemistry*, Puri, Sharma and Pathania, S-C Chand and Co, New Delhi



## OET-2.4

### Fundamentals of Chemical Analysis & Chromatography

#### UNIT – I

(16 h)

**Statistical Treatment of Analytical Data and Sampling:** Limitations of analytical methods. Classification of errors – systematic errors – sources, effects and their reduction. Random errors – sources and distribution. Accuracy and precision. Measures of central tendency and variability. Reliability of results – confidence interval.

**Comparison of results** – Student's t-test, comparing the two means and standard deviations-F test, t-test and paired t-test. Rejection of a result – Q-test. Number of replicate determinations. Control charts. Correlation and regression- correlation coefficient, linear regression, errors in slope and intercept, error in the estimate of concentration. Detection limits.

**Sampling and sample handling** – representative sample, sample storage, sample pretreatment and sample preparation. Hazards in sampling.

Quality in analytical laboratories – quality control and quality assurance, accreditation system

#### UNIT – II

(16 h)

**Acid base titrations:** Principles of titrimetric analysis, titration curves for strong acid-strong base, weak acid-strong base and weak base-strong acid titrations, poly protic acids, poly equivalent bases, determining the equivalence point – theory of acid base indicators, colour change range of indicator, selection of proper indicator.

**Applications of acid-base titrations:** Determination of nitrogen, sulphur, ammonium salts, nitrates and nitrites, carbonates and bicarbonates, and organic functional groups like carboxylic acid, sulphonic acid, amine, ester, hydroxyl, carbonyl groups, air pollutants like SO<sub>2</sub>.

**Acid-base titrations in non-aqueous solvents:** Role of solvent in Acid-base titrations, solvent systems, differentiating ability of a solvent, some selected solvents, titrants and standards, titration curves, effect of water, determining the equivalence point, typical applications-determination of carboxylic acids, phenols and amines.

#### UNIT – III

(16 h)

**Precipitation titrations:** Titration curves, feasibility of precipitation titrations, factors affecting shape – titrant and analyte concentration, completeness of the reaction, titrants and standards, indicators for precipitation titrations involving silver nitrate the Volhard, the Mohr and Fajan's methods, typical applications.

**Complexometric titrations:** Complex formation reactions, stability of complexes, stepwise formation constants, chelating agents, EDTA – acidic properties, complexes with metal ions, equilibrium calculations involving EDTA, conditional formation constants, derivation of EDTA titration curves –effect of other complexing agents, factors affecting the shape of titration curves- completeness of reaction, indicators for EDTA titrations- theory of common indicators.

#### UNIT – IV

(16 h)

**Solvent extraction:** definition, types, principle and efficiency of extraction, sequence of extraction process, factor affecting extraction-pH, oxidation state, modifiers, synergistic, masking and salting out agent, techniques- batch and continuous extraction, application.

**Fundamentals of chromatography:** general description, definition, terms and parameter used in chromatography, classification of chromatographic methods, criteria for selection of stationary phase, and mobile phase, nature of adsorbents, factor influencing the adsorbent, nature and type of mobile phases and stationary phases.

Theories- plate theory, rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency-plate theory and rate theory approach, Van Deemter's equation, and its modern version, optimization column performance, interrelationships- capacity factor, selectivity factor, column resolution, distribution constant and applications of conventional column chromatography, advantages and limitations.

### **SUGGESTED BOOKS**

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M West, Holler and Crouch 8<sup>th</sup> edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A Day and A.L. Underwood, 6<sup>th</sup> edition, 1993prentice Hall, Inc. New Delhi.
4. Vogel's Text book of Quantitative Chemical Analysis, J. Mendham, R.C Denney, J.D Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint.2003 Pearson education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principals, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing California, 1990.

**CPP 2.5 (2.1)**  
**Practical Inorganic Chemistry-2**

**(64 h)**

Semimicro qualitative analysis of mixtures containing TWO anions and TWO cations and ONE of the following less common cations.

W, Mo, Ce, Th, Ti, Zr, V, U and Li.

**SUGGESTED BOOKS**

1. Vogel's Qualitative Inorganic Analysis- Svelha.
2. Macro and semimicro inorganic qualitative analysis – A.I Vogel.
3. Semimicro Qualitative Analysis –F.J. Welcher and R. B. Halin.
4. Semimicro Qualitative Analysis – Ramanujam.

**CPP-2.6 (2.2)**  
**Practical Organic Chemistry – 2**

**PART-I**

**(64 h)**

Qualitative analysis: Separation of binary mixtures, identification of functional group and preparation of suitable derivatives (10 DIFFERENT MIXTURES).

**PART-II**

Spectroscopic interpretations of organic molecules using UV, IR, <sup>1</sup>H-NMR, <sup>13</sup>C NMR and mass spectral analysis.

**SUGGESTED BOOKS**

- 1) A text book of practical organic chemistry – AI Vogel Vol I
- 2) Practical organic chemistry –Mann &Saunders
- 3) Manual of organic chemistry – Dey and Seetharaman
- 4) An introduction to practical organic chemistry – Robert, Vingrove etc.
- 5) Semimicro qualitative organic analysis by Cheronis, Entrikin and holdnet
- 6) J.N. Guthru & R. Kapoor, Advanced experimental chemistry, S. Chand Company, new Delhi, 1991.
- 7) N. K. Visno, Practical organic chemistry, New PGE International (P) Ltd. London, 3rd edition, 1996.
- 8) Organic spectroscopy by- W Kemp
- 9) Spectroscopy of Organic Compounds - Silverstein
- 10) Spectroscopy of Organic Compounds – P S Kalsi
- 11) Introduction to Spectroscopy by Pavia

**SPP 2.7.A (2.3.A)**  
**Practical Physical Chemistry**

**(64 h)**

- 1) Determination of the equivalent conductance of a weak acid at different concentrations and verification of Ostwald's dilution law.
- 2) Determination of equivalent conductance of a strong electrolyte at different concentrations and examine the validity of the Onsager's theory as limiting law at high dilutions.
- 3) Determination of the activity co-efficient of zinc ions in the solution of 0.002 M Zinc sulphate using Debye-Huckel limiting law.
- 4) Determination of the solubility product of silver bromate and calculate its solubility in water and in 0.01 M  $\text{KBrO}_3$  using Debye-Huckel limiting law.
- 5) Conductometric titrations of a mixture of  $\text{HCl}$ ,  $\text{CH}_3\text{COOH}$  and  $\text{CuSO}_4$  and  $\text{NaOH}$ .
- 6) Determination of the dissociation constant of an acid at different dilution by conductance measurements.
- 7) Determination of the solubility of the lead iodide in water, 0.04 M  $\text{KI}$  and 0.04 M  $\text{Pb}(\text{NO}_3)_2$  at 298 K
- 8) Determine the solubility and solubility product of silver benzoate in water at different temperatures.
- 9) Compare the relative strength of acetic acid and mono chloroacetic acid by conductance method.
- 10) Determine the electrode potentials of  $\text{Zn}$  and  $\text{Ag}$  electrodes in 0.1M and 0.001M solutions at 298 K and find the standard potentials for these electrodes and test the validity of Nernst equation.
- 11) Determine the transport number of cadmium ions and sulphate ions by measuring emf of concentration cells with and without transference.
- 12) Determine the activity co-efficient of an electrolyte at different molalities by EMF measurements.
- 13) Determine the dissociation constant of weak acids by potentiometric method.
- 14) Determine the dissociation constant of acetic acid in  $\text{DMSO}$ ,  $\text{DMF}$  and acetone by titrating it with  $\text{KOH}$ .
- 15) Determination of redox potential and estimation of  $\text{Fe}^{2+}$  ions by potentiometric method.
- 16) Potentiometric titration of a mixture of halides ( $\text{KCl} + \text{KI}$  and  $\text{KCl} + \text{KBr} + \text{KI}$ ) against  $\text{AgNO}_3$
- 17) Potentiometric titration of  $\text{KI}$  Vs  $\text{KMnO}_4$  solution.
- 18) Conductometry – to determine the degree of hydrolysis and hydrolysis constant of aniline hydrochloride.
- 19) Infrared spectral data analysis of inorganic and organic compounds

**SUGGESTED BOOKS**

1. Practical Physical chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels et al.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico – Chemical experiments – J. Rose.
7. Practical Physical Chemistry. - S.R. Palit.

8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994)
11. Experimental physical chemistry, R. C. Das and B. Behera, Tata McGraw-Hill Publishing Company Limited, 1983.
12. Experimental Physical Chemistry, V. D. Athawale and Parul Mathur, New Age International (p) Limited, Publishers, New Delhi, 2001.

**SPP 2.7.B (2.3.B)**  
**Practical Physical Chemistry**

**(64 h)**

1. To determine CMC of the given surfactant by surface tension method.
2. Study of variation of surface tension of solution of n-propyl alcohol with concentration and hence determine the limiting cross section area of alcohol molecule.
3. Clock reaction- activation energy of bromide-bromate reaction.
4. Investigate the Autocatalytic reaction between potassium permanganate and oxalic acid.
5. Determination of  $pK_a$  value of a weak acid by chemical kinetic method (formate-iodine reaction)
6. Hydrolysis constant by aniline-hydrochloride by potentiometry and conductometry
7.  $pK_a$  of weak acids by potentiometry and conductometry.
8. Complexation between  $Hg^{2+}$  and  $I^-$  conductometrically.
9. Estimate the concentration of  $H_2SO_4$ ,  $CH_3COOH$ ,  $CuSO_4 \cdot 5H_2O$  in a given solution by carrying out conductometric titration against NaOH solution.
10. Determine the eq. conductance of strong electrolyte ( $KCl$ ,  $NaCl$ ,  $HCl$ ,  $KNO_3$ ) at several concentration and hence verify Onsager's equation.
11. Carry out the following precipitation titration conductometrically
  - a.  $AgNO_3$  with  $HCl$
  - b.  $AgNO_3$  with  $KCl$
  - c.  $MgSO_4$  with  $Ba(OH)_2$
  - d.  $BaCl_2$  with  $Li_2SO_4$
12. Determination of redox potential of the couples ( $Fe^{2+}/Fe^{3+}$ ,  $Co^{3+}/Co^{2+}$ ,  $Cr^{3+}/Cr^{2+}$ ,  $MnO_4^-/Mn^{2+}$  (any two) and equilibrium constant.
25. Study of complex formation by potentiometry e.g.  $Ag^+ - S_2O_3^{2-}$ ,  $Fe^{3+} - SCN^-$ ,  $Ag^+ - NH_3$  (any two) and calculation of stability constant.

**SUGGESTED BOOKS**

1. Practical Physical chemistry – A.J. Findlay.
2. Experimental Physical Chemistry – F. Daniels et al.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico – Chemical experiments – J. Rose.
7. Practical Physical Chemistry. - S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994)
11. Experimental physical chemistry, R. C. Das and B. Behera, Tata McGraw-Hill Publishing Company Limited, 1983.
12. Experimental Physical Chemistry, V. D. Athawale and Parul Mathur, New Age International (p) Limited, Publishers, New Delhi, 2001.

**Acid – base titrations**

1. Determination of carbonate and bicarbonate in a mixture by pH-metric titration and comparison with visual acid- base titration.
2. Determination of total acidity of vinegar and wines by acid – base titration.
3. Determination of aniline by non – aqueous acid – base titrations.
4. Determination of replaceable hydrogen and relative molecular mass of a weak organic acid by titration with NaOH.
5. Determination of total alkalinity of soda ash by visual and pH-metric titrations.
6. Analysis of sulphathiazole tablets by non-aqueous titration with tetrabutylammonium hydroxide.
7. Determination of saponification value of edible oils.

**Precipitation titrations**

1. Determination of percentage of chloride in a sample by precipitation titration – Mohrs, Volhard and Fajans methods.
2. Determination of sulphate in ground water by titration with  $BaCl_2$  using an adsorption indicator.
3. Determination of saccharin in tablets by precipitation titration.

**Complexometric titrations**

1. Determination of total hardness of water by complexation titration using EDTA.
2. Determination of calcium in milk powder by EDTA titration.
3. Determination of calcium in calcium gluconate / calcium carbonate tablets or injections by EDTA titration.
4. Determination of chloride content of an industrial effluent by conductometric titration with silver nitrate.
5. Analysis of an industrial effluent for sulphate by conductometric titration with  $BaCl_2$ .

**Separation Techniques**

1. Determination of iron as the 8-hydroxyquinolate by solvent extraction method.
2. Determination of total cation concentration of tap water by ion-exchange chromatography.
3. Anion-exchange chromatographic separation of Zinc and Magnesium followed by EDTA titration of the metals.
4. Anion-exchange chromatographic separation of chloride and bromide in a mixture.
5. Determination of magnesium in milk and magnesium tablets by ion-exchange chromatography.
6. Determination of iron in mustard seeds and phosphorus in peas by spectrophotometry
7. Separation of metal ions by paper chromatography and their identification
8. Thin-layer chromatographic separation of nitroanilines on fluorescent sheets.



## SUGGESTED BOOKS

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M West, Holler and Crouch 8<sup>th</sup> edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A Day and A.L. Underwood, 6<sup>th</sup> edition, 1993prentice Hall, Inc. New Delhi.
4. Vogel's Text book of Quantitative Chemical Analysis, J. Mendham, R.C Denney, J.D Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint.2003 Pearson education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principals, John H. Kennedy, 2<sup>nd</sup> edition, Saunders College Publishing California, 1990.

**CPT-3.1**  
**Reactions, Rearrangements and Heterocyclic chemistry**

**UNIT – I**

**(16 h)**

**Free Radical Reactions:** Types, mechanisms of free radical substitution reactions & neighboring group assistance. Reactivity for the aliphatic and aromatic substances at a bridgehead. Reactivity of attacking radical. Effect of solvent on reactivity. Auto-oxidation, coupling of alkynes.

**Reactions of carboxylic acids and their derivatives:** Mechanisms, Base catalyzed  $B_{AC-2}$ ,  $A_{AC-2}$ ,  $A_{AC-1}$ ,  $A_{AI-1}$ ,  $B_{AI-1}$  and  $B_{AI-2}$ . Hydrolysis of Acid Anhydrides and Chlorides, Formation and Hydrolysis of Amides, Decarboxylation mechanisms and Transesterification.

**Substitution reactions** – Kinetics, mechanism and stereochemical factor affecting the rate of  $SN_1$ ,  $SN_2$ ,  $SRN_1$ ,  $SN_i$ ,  $SN_1'$ ,  $SN_2'$ ,  $SN_{1i}$  and  $SRN_1$  reactions, Neighbouring group participation. Electrophilic substitution reactions – Kinetics, mechanism and stereochemical factor affecting the rate of  $SE_1$  &  $SE_2$

**UNIT – II**

**(16 h)**

**Organic Name reactions:** Reactions, Mechanisms and synthetic uses of the following: Stolbe condensation, Darzen condensation, Gattermann-Koch reaction, Cannizzaro reaction, Chichibabin reaction, Benzoin condensation, Claisen-Schmidt condensation, Claisen reaction, Simon-Smith reaction, Stork Enamine reactions, Sharpless asymmetric epoxidation, Hofmann-Löffler-Freytag reaction, Prins reaction, Knoevenagel reaction, Sandmeyer reaction, Ullmann reaction, Paterno Buchi reaction, Wittig reaction-Mitsunobu reaction, Robinson annulation, Dickmann cyclisation and Diel's- Alder reactions.

**UNIT – III**

**(16 h)**

**Molecular rearrangements:** Classification and general mechanistic treatment of nucleophilic, electrophilic and free radical rearrangements. Intermolecular and Intramolecular migration, nature of migration and migratory aptitudes. Mechanism of Wagner-Meerwein, Dienone-Phenol, Pinacol-Pinacolone, Demaynov, Benzil-Benzilic acid, Fries, Wolff, Favorskii, Neber, Benzidine, Baeyer-Villiger, Beckmann, Lossen, Curtius, Schmidt, Stevens, Shapiro, Baker-Venkatraman and Amadori rearrangement.

**UNIT – IV**

**(16 h)**

**Chemistry of Heterocyclic Compounds:** Introduction, Classification, nomenclature and reactivity of Heterocyclic compounds. Five membered simple and fused heterocycles-synthesis & reactions of derivatives of furan, pyrrole and thiophene. Indole and its derivatives. Detail study of Fisher and Bischler syntheses.

Preparation of benzofurans (coumarins). Quinolines and Isoquinolines. Skraup synthesis. Friedlander and Pfintzinger methods for Quinoline derivatives. Preparation of isoquinolines using Bischler-Napieralski and Pictet methods. Electrophilic and Nucleophilic substitution reactions.

Mesoionic compounds: Introduction, Classification, types of mesoionic heterocycles. Synthesis and reactions 1,3-oxazolium-4-olates, 1,3-oxazolium-5-olates.

## SUGGESTED BOOKS

1. Organic Reactions and Their Mechanisms- P.S. Kalsi (New Age, New Delhi),1996.
2. Advanced Organic Chemistry 4th Edn- J. March (Wiley, NY) 2000.
3. Organic Reaction Mechanisms- Bansal (Tata McGraw Hill, New Delhi) 1978.
4. Organic Chemistry-Vol. -I & II-Mukherji, Singh and Kapoor. (Wiley Eastern, New Delhi) 1985.
5. Mechanism and Theory in Organic Chemoistry-Lowry and Richardson Harper and Row, 1987.
6. An Introduction to the Chemistry of Heterocyclic Compounds-Acheson (Wiley – Eastern) 1987.
7. Heterocyclic Chemistry-J. Joule & G. Smith, (Van-Nostrand, ELBS), 1978.
8. Reaction Mechanisms in Organic Chemistry-Mukherji, Singh and Kapoor (McMillan) 1978.
9. Organic Chemistry-P.Y. Bruice (Pearson Education, New Delhi) 2002.
10. F. A. Carey and Sundberg, Advanced Organic Chemistry-Part A and B, 3rd edition, Plenum Press, New York, 1990.
11. Comprehensive Organic Synthesis- B. M. Trost and I. Fleming series, Pergamon Press, New York, 1991.

## CPT 3.2

### Chemical Kinetics, Photochemistry and Surface Phenomena

#### UNIT – I

(16 h)

**Chemical Kinetics:** Different methods for determination of order of reaction. Experimental determination of activation energy. Theories of chemical kinetics (with a brief review of Arrhenius and collision theory): Activated complex theory of reaction rate: Transition state and activated complex, postulates of activated complex theory, classical thermodynamic treatment, statistical thermodynamic treatment.

**Unimolecular reactions:** Lindemann's and Hinshelwood's theory (their success and limitations).

**Kinetics of complex reactions:** Detailed kinetic analysis of Parallel, consecutive and reversible reactions.

**Kinetics of reactions in solution-**Salt effects, effect of dielectric constant (single sphere and double sphere model), effects of pressure, volume and entropy change on reaction rate. Cage effect with an example.

**Surface reactions-**Unimolecular and bimolecular surface reactions: mechanism, inhibition and activation energy.

#### UNIT – II

(16 h)

**Fast reactions:** Study of kinetics by flow techniques, equation for constant time, stopped flow and continuous flow methods. Relaxation method, equation for relaxation time, temperature jump and pressure and pressure jump methods, flash photolysis, pulse radiolysis and shock tube method.

**Potential energy surface:** Features & construction of them theoretical calculation of energy of activation.

**Chain reactions:** Rice-Herzfeld mechanism for the thermal decomposition of acetaldehyde, kinetics of explosive reactions, explosion limits ( $H_2$  and  $O_2$  reaction) Kinetics of autocatalytic and oscillatory chemical reactions.

**Catalysis by enzymes** - Rate of enzyme catalyzed reactions: Michaelis-Menten Equation-Michaelis constant and its determination. Effect of substrate concentration, pH and temperature on enzyme catalyzed reactions - inhibition of enzyme catalyzed reactions.

#### UNIT – III

(16 h)

**Photochemistry:** Introduction to photochemistry, quantum yield and its determination, factors affecting quantum yield, experimental technique in photochemistry, Actinometry-Uranyloxalate and potassium ferrioxalate actinometers, acetone and diethylketone actinometers.

**Term symbols and significance. Photosensitization:** by mercury, dissociation of  $H_2$ , sensitized isomerization. Photodimerization of anthracene, photochemical kinetics of: Decomposition of HI,  $CH_3CHO$ ; formation of HCl, HBr and  $COCl_2$ ; Chlorination of  $ZnO/TiO_2$  in the photo degradation of dyes (IC), pesticides (DDT) and in industrial effluents. Effect of photodegradation on COD value.

Direct spectroscopic identification of primary processes, use of free radical traps in the determination of primary photodecomposition modes. Photophysical properties: Fluorescence, characteristics of fluorescence, resonance fluorescence, sensitized

fluorescence, quenching of fluorescence, phosphorescence, characteristics, chemiluminescence - theory and applications, photochemistry of vision.

#### UNIT – IV

(16 h)

**Surfaces:** Adsorption: Factors affecting adsorption, Types of adsorption, Adsorption isotherms: Assumptions and derivations of Freundlich, Langmuir, Gibbs adsorption isotherm. BET equation (Postulates and derivation). Determination of surface area of adsorbents. Temperature dependence of adsorption isotherms.

**Dispersed systems:** Types of dispersions, Spontaneous self-organization; Surfactants: structure of surfactants in solution; critical micellation concentration (CMC); temperature dependence; influence of chain length and salt concentration; surfactant parameter. Emulsions: macro- and micro-emulsions; aging and stabilization of emulsions; Phase behaviour of microemulsions. Colloids, vesicles, lipid bilayer membrane: structure and properties, monolayers, liquid crystals, foams and aerosols.

#### SUGGESTED BOOKS

1. Chemical Kinetics by K. J Laidler
2. Chemical Kinetics- Moore and Pearson
3. Kinetics and Mechanism of Chemical Transformation by J. Rajaram and J. C. Kuriacose.
4. Chemical Kinetics – S. K Jain
5. Chemical Kinetics- Benson
6. Elements of Physical Chemistry – Lewis and Glasstone
7. Physical Chemistry by P . W Atkins, ELBS, 4<sup>th</sup> Edition, Oxford University Press (1990)
8. Kinetics in Analytical Chemistry- H. B. Mark and G. A Rechnitz. Interscience Publishers. John Willey and Sons, New York.
9. A.W. Adamson, A.P. Gast, Physical chemistry of surfaces, Wiley, 1997.
10. H.-J. Butt, K. Graf, M. Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, 2006.
11. D.K. Chakrabarty and B. Viswanathan, Heterogeneous Catalysis, New Age, 2008.
12. H. Kuhn, H.-D. Forsterling, D.H. Waldeck, Principles of Physical Chemistry, Wiley, 2009.
13. G.A. Somorjai, Y. Li, Introduction to Surface Chemistry and Catalysis (2n ed.), 2010.
14. Surface area and porosity determination by physisorption measurements and theory, James B Condon, Elsevier Science; 1 edition (October 11, 2006).
15. Physical chemistry of surfaces, Arthur W Adamson, Alice P Gast, 6<sup>th</sup> Edition, Wiley India Pvt. Ltd, 2012.
16. Chemical Physics of Colloid systems and interfaces, Peter A Kralchevsky, Krassimir D. Danov and Nikolai D Denkov, <http://lcpe.uni-sofia.bg/publications/2008/2008-09-PK-KD-ND-Handbook-Birdi-3rd-Edition.pdf>
17. Advances in Photochemistry - Rohatgi Mukherjee.
18. Principles and applications of Photochemistry - R.P. Wayne, Elsevier, New York., 1970.
19. Dupey and Chapmann, Molecular reactions and photochemistry, Prentice Hall - International, Tokyo, 1972.
20. N. J. Turro, Modern molecular photochemistry, The Benjamin Cummings Publishing Co. Ltd. Menlo Park, 1978.

**SPT – 3.3.A**  
**ORGANOMETALLIC CHEMISTRY AND CATALYSIS**

**UNIT-I** **(16 h)**

**Organometallic complexes:** Classification of ligands and complexes by bond type ( $\sigma$  and  $\pi$ ). Nomenclature of organometallic complexes. Stability: 16 and 18 electron rules. Electron counting covalent and ionic models.

**Organometallic compounds of main group elements:** General trends, Synthesis, reactions structure and applications in organic synthesis of organo-magnesium, -lithium, -tin and -aluminium, zinc and mercury compounds.

**Metal Carbonyls:** Synthesis, structure, chemical bonding, physical evidence related to M-CO bonding. Preparation of anionic metal carbonyl complexes and substituted metal carbonyl complexes. Metal alkyls, carbenes and carbynes.

**UNIT-II** **(16 h)**

**Metal Nitrosyl complexes:** Methods of preparation of Metal Nitrosyl complexes, structure and bonding in Metal Nitrosyl complexes.

**Cyclopentadienyl Metal Complexes:** Preparation and structures of cyclopentadienyl metal complexes. M.O. diagram for ferrocene. Reactions and aromaticity of ferrocene.

**Metal-arene Complexes:** Methods of preparation of arene complexes, reactions of metal-arene complexes, structure and bonding in arene-metal complexes, M.O. diagram for dibenzene chromium.

**Olefin-transition metal complexes:** Methods of preparation, structure and bonding in metal olefin complexes.

**Conjugated diolefins and related metal complexes:** Preparation, structure and bonding.

**UNIT-III** **(16 h)**

**Acetylene and acetylene derived metal complexes:** Preparation, structure and bonding in acetylene complexes. Reactions of coordinated acetylene.

**Pi-allylic metal complexes:** Preparation of complexes containing allylic ligands, structure and bonding.

**Stereochemically Non-rigid molecules:** Isolobal analogy, Stereochemical non-rigidity- Fluxionality, Fluxional Properties and dynamic equilibria of Organometallics with examples in complexes containing CO,  $\eta^2$ -olefin  $\eta^3$ -allyl and diene complexes. Methods of studying fluxionality -VT NMR and FT-IR. Fluxionality.

**Metal-metal bonding:** Evidences and factors favouring of M-M bonding, synthesis, bonding, structure of bi, tri, tetra, penta and hexa nuclear metal clusters.

**Biological applications and environmental aspects of organometallic compounds:** Introduction, organometallics in medicine, agriculture, horticulture and environmental aspects.

**UNIT-IV** **(16 h)**

**Catalysis** – Basic principles, Reactions of organometallic complexes (Oxidative addition, reductive elimination, migratory insertion and deinsertion reactions), Industrial requirements of catalysts.

**Homogeneous catalysis:** Alkene Hydrogenation; Asymmetric hydrogenation-L-DOPA synthesis; Hydrosilation-Chalk-Harrod mechanism; Hydrocyanation-synthesis of buta-1,3-diene; Hydroformylation or Oxo process-Cobalt and Rh catalysts; Wacker process-acetaldehyde from ethylene; Monsanto and Cativa process-acetic acid from methanol; Tennessee Eastmann process-Acetic anhydride from methyl acetate; C-C coupling reactions: Heck, Suzuki and Sonogashira reactions.

**Heterogeneous catalysis:** Olefin metathesis; Alkene isomerisation; Water-gas shift reaction; Fischer Tropsch Process-synthesis of gasoline; Polymerisation: Ziegler Natta - Olefin Polymerization catalysts, syndiotactic, isotactic and atactic polymers; Shell High Olefin Process (SHOP); Immobilised /Anchored/Supported catalysis- Merits, polymer and metal oxides as supports; catalytic converters.

## SUGGESTED BOOKS

1. Organometallic Chemistry; R. C. Mehrotra and A. Singh; New age international, 2<sup>nd</sup> edition, 2000.
2. The organometallic chemistry of transition metals; R. H. Crabtree; John Wiley, 3<sup>rd</sup> edition, 2001.
3. Organometallic Chemistry, ch. Elschewbroich and Slazer, VCH, 2<sup>nd</sup> edition 1992.
4. Organometallics; Vol 1 & 2; M. Bochmann, Oxford Chemistry Primers, Oxford University Press, 1994. 5. Catalytic chemistry; B. C. Gates; John Wiley and sons, 1992.
5. Applied Organometallic chemistry and catalysis; Robin Whyman, Oxford University Primers, 2001.
6. Basic Organometallic chemistry; B. D. Gupta and A. J. Elias, University Press, 2010.
7. Heterogeneous catalysis; D. K. Chakraborty and B. Viswanathan, New Age International, 2000.

**SPT – 3.3.B**  
**Industrial and Materials Chemistry**

**UNIT – I**

**(16 h)**

Inorganic rings, cages and polymers: Chemistry and structures of boranes, carboranes and metalloboranes; applications of silicates and zeolites; synthesis, properties and structures: isopoly and heteropoly molybdates, phosphates and tungstates; Silicone polymers: silicone oils, rubber, grease and resin. Crown ethers, composites, thermoelectric materials, luminescent and phosphor materials.

**UNIT – II**

**(16 h)**

**Liquid Crystalline Materials** – Introduction, Chemistry and applications: Thermotropic & Lyotropic liquid crystals, structure and property relationship, Smectic, nematic & cholesteric liquid crystals, globular and discotic liquid crystals, liquid crystalline polymers. Applications of liquid crystals in chemistry, electronics, medicine and non destructive testing.

**Molecularly Engineered Structures** – Pillared layered compounds, clay materials, Zeolites, Feldspars, Clathrasils, Zeosils, porosils, micro and meso porous compounds.

**UNIT – III**

**(16 h)**

Introduction to nanoscale, Basic nanotechnology, basic nanostructures; Nanostructures: Nanostructures: tubes, fibers, wires, bricks and building blocks, quantum confinements; **Synthesis of Nanomaterials: Physical Methods:** Mechanical methods– high energy ball milling and melt mixing.

**Film Deposition Methods:** Introduction, fundamentals of film deposition. Evaporation methods– thermal evaporation, with consolidation, ionized cluster beam deposition, laser vapourization, pulsed laser deposition. Sputter deposition (dc and rf), magnetron sputtering, chemical vapour deposition.

**Chemical Methods:** Growth of nanoparticles, Synthesis of metal nanoparticles by colloidal route, Microemulsions, sol-gel method, precipitation.

**Sol-Gel Processing:** Fundamentals of sol-gel process – sol-gel synthetic methods for oxides – silica, zinc oxide, iron oxide, alumina and other inorganics and nano composites

**Biological Methods:** Synthesis using microorganisms, plant extracts, use of proteins and templates like DNA.

**UNIT – IV**

**(16 h)**

**Application of Nanomaterials:** Quantum dot IR photo detectors- Quantum dot lasers – Synthesis of Zinc oxide nanomaterials and its application – Synthesis of group three nitride nanostructures and their applications.

MEMS, field emission display devices, nanodiodes, nanoswitches, molecular switches, Super hard nanocomposite coatings and applications in tooling.

**Magnetic Storage:** magnetic quantum well; magnetic dots - magnetic data storage - high density quantized magnetic disks - magnetic super lattices – MRAMS Nano based drug delivery and imaging.



## SUGGESTED BOOKS

1. Inorganic Chemistry : Shriver & Atkins (4th edition 2003, Oxford)
2. Concise Inorganic Chemistry, J. D. Lee, Fourth Edn.(Chapman and Hall)
3. Inorganic chemistry: principle of structures and reactivity, Huheey, Keiter, Keiter, Medhi, Pearson Education, Fourth Edn.(2007).
4. Inorganic Chemistry: Catherine Housecroft
5. Inorganic Chemistry: Messler & Tarr, Pearson Publishers 3rd Edition
6. Nano Science and nanotechnology in engineering, by V. K. Varadhan, A. S. Pillai, D. Mukharjee,
7. M. Dwivedi and L. Chen, World Scientific Publishing Company, Pvt. Ltd.
8. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
9. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
10. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Publishers.
11. Nano: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
12. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge, UK (2005).
13. Nanocomposite science and technology, Pulickel M. Ajayan, Linda S. Schadler, Paul V. Braun, Wiley-VCH Verlag, Weinheim (2003).
14. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers (1992).
15. Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer (2007).
16. Handbook of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press (2005).
17. Nanochemistry, G. B. Sergeev, Elsevier (2006).
18. T. R. Hsu, MEMS and microsystems design and manufacture, Boston, McGraw Hill, 2002.
19. S. E. Lyshevski, Nano- and microelectromechanical systems, Boca Raton, CRC Press, 2001.
20. R. Waser (ed.), Nanoelectronics and information technology, Aachen, Wiley-VCH, 2003.
21. B. Bhushan, Springer handbook of nanotechnology, Berlin, Springer-Verlag, 2004.
22. J. A. Pelesko and D. H. Bernstein, Modeling MEMS and NEMS, Boca Raton, Chapman & Hall/CRC, 2003.
23. S. K. Kulkarni, Nanotechnology Principles and Practices, Captial Publishing Company, Bangalore, 2009.
24. T. Pradeep, Nano - The essentials, Understanding Nanoscience and Nanotechnology, Tata Mc Graw Hill, 2007.
25. Inclusion Compounds Vol. 4, Ed. by J. L. Atwood, J. E. D. Davies and D.D. McNicol (Oxford University Press), 1991.
26. Liquid Crystals and plastic Crystals eds. P.A. Winsor and G.W. Gray vol. I & II (John Wiley & sons).
27. Molecular structure and properties of Liquid crystals, G.M. Gray.
28. Liquid Crystals – S. Chandrasekhar (Cambridge University Press).

**OET-3.4**  
**Environmental Chemistry**

**UNIT – I**

**(16 h)**

**Atmospheric chemistry:** The structure of the earth's atmosphere- chemistry of the lower and upper atmosphere. The chemistry of air pollution- oxides of nitrogen- hydrogen sulphide and oxides of sulphur- Aerosols – ozone depletion and consequences- dioxins burning plastics- other atmospheric chemicals- smog- Greenhouse effect- Global warming, oxides of carbon.

**UNIT – II**

**(16 h)**

**Water pollution and analysis:** Water resources, origin of waste water, types of water pollutants of their sources and effects, chemical analysis for water pollution control - objectives of analysis, parameters of analysis, sample collection and preservation. Environmental and public health significance and measurement of colour, turbidity, total solids, acidity, alkalinity, hardness chloride, residual chlorine, chlorine demand, sulphate, fluoride, phosphates and different forms of nitrogen in natural and waste/polluted waters, heavy metal pollution-public health significance of Pb, Cd, Cr, Hg, As, Cu, Zn, and Mn, general survey of the instrumental techniques for the analysis of heavy metals in aquatic systems, organic loadings-significance and measurement of DO, BOD, COD, TOD, and TOC, phenols, pesticides, surfactants and tannin and lignin as water pollutants and their determination.

**UNIT – III**

**(16 h)**

**Waste water treatment:** Waste water characteristics, effluent standards, terminology in Waste water treatment. Treatment of domestic waste water - preliminary treatment.

**Primary treatment:** Sedimentation, equalization, neutralization.

**Secondary treatment:** Aerated lagoons, trickling filters, activated sludge process, oxidation ditch, oxidation pond and anaerobic digestion. Sludge treatment and disposal.

**Tertiary treatment:** Evaporation, ion-exchange, adsorption, electrodialysis, electrolytic recovery and reverse osmosis.

**Advanced waste water treatment:** Nutrient removal- nitrogen and phosphorus removal, solids removal.

**Waste water disposal and reuse:** Industrial waste water and its treatment.

**Soil analysis:** Inorganic and organic components of soil, collection and preparation of soil samples for analysis. Measurement of soil pH and conductivity. Determination of organic carbon, total nitrogen, available nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen. Available phosphorus and sulphur – their determination. Analysis of soil for sodium, potassium and calcium and magnesium. Micronutrient elements and their analysis. Pesticide residues in soil, their separation and determination.

**UNIT – IV**

**(16 h)**

**Radioactive pollution:** Radioactive materials, Sources of radioactive pollutants, Effects of radioactive pollutants on living organism, Case study – Chernobyl disaster

**Noise and Thermal Pollution:** Noise pollution – source, measurement, effects and control; Thermal pollution - causes, effects and control.

## SUGGESTED BOOKS

1. Environmental Science (8th Edition) (2010): Daniel D. Chiras, Jones & Bartlett Ltd
2. A textbook of Environment: K. M. Agarwal, P. K. Sikdar & S. C. Deb
3. Environmental Analysis : M. M. Saxena
4. Environmental Chemistry : A. K. De
5. Environmental Chemistry : B.K. Sharma, and H. Kaur
6. Environmental Chemistry : S. E. Manahan
7. Environmental Science : S. C. Santra,
8. Environmental Science (6th ed) (1997): Jr. G. T. Miller, Wadsworth Pub. Co.
9. Environmental Science: D. D. Chiras
10. Forestry – Segreiya : Champion and Seth.
11. Fundamentals of Ecology : E. P. Odum
12. Hydrology – Principles, Analysis and Design: H. M. Raghunath
13. Instrumental Methods of Analysis: Chatwal and Anand.
14. Instrumental Methods of Analysis : G. W. Ewing
15. Introduction to Environmental Engineering and Science: G. M. Masters
16. Introduction to Weather and Climate : Trewartha
17. Modern concepts in Ecology : H. D. Kumar
18. Renewable Energy and Environment: N.H. Ravindranath, K. Usha Rao, Bhaskar  
1. Natrajan and Pradeep Monga.. CEE, Ahmedabad, 2000.
19. The ISO 14000 Handbook: Joseph Cascio.
20. Wasteland Development – Khan, et al.,
21. Environmental Statistics and Data Analysis: Wayne, R. Ott (1995).CRC Press.
22. Environmental Science – A study of Inter relationships, E. D. Enger, B. E. Smith, 5<sup>th</sup>
23. A. K. De. Environmental Chemistry (4th edn.), New Age International Limited (2006).
24. H. H. Willard, L.L. Merritt, J.A. Dean & F. A. Settle. Instrumental Methods of Analysis (7th edn.), Wadsworth Publishing Company, California (1988).
25. J. Mendham, R. C. Denney, J. D. Barnes and M. Thomas. Vogel's Textbook of Quantitative
26. Chemical Analysis, Peterson Education (2000). Chemistry of environmental engineering, Chair
27. The pollution hand Book, Richard Mabey, Penguin 1978. Soil Chemical analysis, M. L. Jackson, Prentice Hall of India pvt. Ltd. New Delhi, 1973.
28. J. W. Moore & E. A. Moore. Environmental Chemistry, Academic Press, London (1976).
29. I. Pulford & H. Flowers. Environmental Chemistry at a Glance, Blackwell Publishing (2006).
30. S. E. Manahan. Environmental Chemistry (6th edn.), Lewis Publishers, London (1994).

**CPP - 3.5 (3.1)**  
**Practical Organic Chemistry – 3**

(64 h)

**Part-I**

**Quantitative Analysis:**

1. Determination of alcoholic group by acylation.
2. Determination of phenolic by bromination.
3. Determination of amino by acylation.
4. Determination of amino by bromination.
5. Determination of nitro group.
6. Estimation of sugars by Fehling's Method
7. Determination of equivalent weight of a carboxylic acid.
8. Estimation of uric acid
9. Estimation of cholesterol.

**Part-II**

**Preparation of the following synthetic compounds**

1. Preparation of Benzimidazole from O-phenylene diamine
2. Preparation of PAS from p-nitrosalicylic acid
3. Preparation of Dichloramine T from toluence p-sulphonamide
4. Preparation of Chloramine T from Dichloramine T
2. Preparation of Fluorescein from Pthalicanhydride
3. Preparation of Eosin from Fluorescein
4. Preparation of Sulphacetamide from sulphanilamide
5. Preparation of Phenothiazine from Diphenylamine
6. Preparation of Cinnamic acid from perkin's reaction
7. Preparation of Benzyl alcohol by cannizzaros reaction
8. Preparation of INH from Isonicotinic acid
9. Preparation of Chlorobutanol
10. Preparation of Napthoquinone
11. Preparation of Quinoxaline
12. Preparation of Benzotriazole
13. Preparation of 3-Diphenyl quinolone
14. Preparation of 2,4,5-Triphenyll imidazole from Benzoin

**SUGGESTED BOOKS**

1. Manual of organic chemistry – Dey and Seetharaman
2. Natural products chemistry by Raphel Ikhan
3. Modern experimental organic chemistry by John H. miller and E. F. Neugil p289.
4. An introduction to practical organic chemistry – Robert, Vingrove etc
5. A text book of practical organic chemistry – A. I. Vogel Vol I
6. Practical organic Chemistry – Mann and Saunders
7. Semimicro qualitative analysis by Cheronis, Entrikin and Hodnet.
8. I.L, Finar, Organic chemistry vol I and II, Sixth Edition, 2003, ELBS.
9. R. O. C. Norman and J. M. Coxon, Principals of Organic Synthesis, Third Edition, 1995, ELBS.
10. R. J. Morrison and R. N. Boyd Organic chemistry, Fifth edition, Prentice Hall of India Pvt. Ltd., New Delhi.
11. A. H. Beckett and Stanlake, Practical pharmaceutical chemistry
12. J. G. Mann and Saunders, Practical organic chemistry

**CPP 3.6 (3.2)**  
**Practical Physical Chemistry - 3**

1. Study the kinetics of the decomposition of sodium thiosulphate by mineral acid (0.5M HCl).
2. Study the primary salt effect on the kinetics of ionic reactions
3. To study the acid catalyzed kinetics of oxidation of glycine by chloramines-T (CAT) - determination of order of reaction w.r.t [CAT], [Glycine] and effect of  $[H^+]$ .
4. Spectrophotometric kinetics of oxidation of indigocarmine by chloramine-T (CAT)
  - a) Determination of order of the reaction w.r.t. (CAT).
  - b) Effect of pH and determination of order of the reaction w.r.t. ( $H^+$ ).
5. To determine conductometrically the second order rate constant for the hydrolysis of ethyl acetate by sodium hydroxide.
6. To investigate the autocatalytic reaction between potassium permanganate and oxalic acid
7. To investigate the reaction between potassium persulphate and potassium iodide by colorimetric measurement
8. To determine the bimolecular rate constant of the oxidation of iodide ion by hydrogen peroxide in aqueous solutions at 300K.
9. Kinetics of reaction between sodium formate and iodine, determination of energy of activation.
10. Study the effect of solvent (DSMO-water, acetone-water system) on the rate of acid catalysed hydrolysis of acetal by dilatometry.
11. To determine the critical micelle concentration of sodium lauryl sulphate from the measurement of conductivities at different concentrations
12. To measure the surface tension of carbon tetrachloride at various temperatures by capillary-rise method and to calculate the relative thermodynamic parameters.
13. To determine the surface tensions of solutions of amyl alcohol in water at different concentrations and to calculate the surface excesses of those solutions.
14. To study the adsorption of acetic acid on activated charcoal.
15. To study the kinetics of solvolysis of t-butyl halide by conductivity method.
16. Kinetics of saponification of ethyl acetate by conductivity method and study the effect of dielectric constant of the medium (Using methanol).
17. Kinetics of acid hydrolysis of methyl acetate (determination of activation energy, determination of the order wrt ester, effect of  $H^+$  concentration, determination of catalytic strength of HCl and  $H_2SO_4$ ). (May be performed as different experiment).
18. Determine the quantum yield of chloride ion during the photohydrolysis of an aqueous solution of monochloroacetic acid by light of different wavelengths
19. Construct a chemical actinometry and determine the quantum yield and calibrate the lamp intensity using  $K_3[Fe(C_2O_4)_3] \cdot 3H_2O$  as reference compound.
20. Photolysis of CAT solution - determination of quantum yield and study of kinetics of photodecomposition.
21. Photo decomposition of HI and determination of its quantum yield.
22. Photodegradation of dyes using inorganic oxides and their kinetics
23. Interpretation of UV-Visible spectra of simple organic/inorganic compounds

## SUGGESTED BOOKS

1. Practical Physical chemistry – A.J. Findlay.

2. Experimental Physical Chemistry – F. Daniels et al.
3. Selected Experiments in Physical Chemistry – Latham.
4. Experiments in Physical Chemistry – James and Prichard.
5. Experiments in Physical Chemistry – Shoemaker.
6. Advanced Physico – Chemical experiments – J. Rose.
7. Practical Physical Chemistry. - S.R. Palit.
8. Experiments in Physical Chemistry – Yadav, Geol Publishing House.
9. Experiments in Physical Chemistry – Palmer.
10. Experiments in Chemistry – D.V. Jahagirdar, Himalaya Publishing House, Bombay, (1994)
11. Experimental physical chemistry, R. C. Das and B. Behera, Tata McGraw-Hill Publishing Company Limited, 1983.
12. Experimental Physical Chemistry, V. D. Athawale and Parul Mathur, New Age International (p) Limited, Publishers, New Delhi, 2001.

**SPP 3.7.A (3.3.A)**  
**Practical Inorganic Chemistry –3**

**(64 h)**

- I. Analysis of alloys:
1. Stainless steel
    - a) Nickel gravimetrically using dimethyl glyoxime
    - b) Chromium titrimetrically by persulphate oxidation
    - c) Iron titrimetrically using cerium sulphate
    - d) Chromium and Manganese (Simultaneous Spectrophotometric method)
  2. Ferromanganese: Manganese using EDTA.
  3. Molybdenum and Tungsten steels; gravimetric
  4. Woods alloy
    - a) Tin (gravimetric)
    - b) Bismuth
    - c) Lead
    - d) Cadmiumtitrimetrically using EDTA
- II. Quantitative analysis of the constituents in mixtures containing the following cations.
- a. Cu(II) + Fe(II)  
Copper gravimetric as CUSCN  
Iron- titrimetric using Cerium (IV) solution.
  - b. Cu(II) + Ni(II)- gravimetric using salicylaldehyde.
  - c. Cr(III) + Fe(III)- Using EDTA (Kinetic Masking)
- III. Semi-microgravimetric estimation of aluminium
- IV. Electrogravimetric Estimation of
- a. Copper
  - b. Nickel
  - c. Copper- nickel alloy
- V. Flame photometric determination of
- a. Sodium
  - b. Potassium
  - c. Calcium
  - d. Lithium
  - e. Sodium + Potassium
- VI. Polarographic determination of
- a. cadmium
  - b. Zinc
  - c. Cadmium + Zinc
- VII. Spectrophotometric determination of the pKa Value of an indicator
- VIII. Potentiometric determination of cobalt.
- IX. Solvent extraction and Spectrophotometric determination of:
- a. Uranium or molybdenum
  - b. Nickel

## **SUGGESTED BOOKS**

1. Advanced physico- chemical experiments- J. Rose
2. Instrumental analysis omanual- Modern Experiments for Laboratory – G. G. Guilbault and L. G Hargis.
3. A Text Book of quanntitaive Inorganic Analysis- 5<sup>th</sup> edidtion- A. I. Vogel.
4. Experimental norganic chemistry- G. Palmer
5. Inorganic synthesis- O. Glemser.
6. Experimental Inorganic/Physical chemistry- Mounir A. Malati.
7. Spectrophotometric determination of elements- A. Marczenko.



**SPP 3.7.B (3.3.B)**  
**Practical Inorganic Chemistry**

**(64 h)**

1. Determination of calcium in milk powder by EDTA titration.
2. Determination of calcium in calcium gluconate / calcium carbonate tablets or injections by EDTA titration.
3. Determination of percentage of chloride in a sample by precipitation titration – Mohrs, Volhard and Fajans methods.
4. Determination of saccharin in tablets by precipitation titration.
5. Analysis of sulphathiazole tablets by non-aqueous titration with tetrabutylammonium hydroxide.
6. Determination of iron in pharmaceuticals by visual and potentiometric titration using cerium (IV) sulphate.
7. Determination of iron in razor blade by visual and potentiometric titration using sodium metavanadate.
8. Determination of calcium in limestone by redox titrations.
9. Determination of copper in an ore/an alloy by iodometric redox titration.
10. Determination of antimony in stibnite by titration with iodine.
11. Analysis of commercial hypochlorite or peroxide solution by iodometric titration.
12. Periodate determination of ethylene glycol (Malprade reaction).
13. Determination of silver in an alloy by Volhard method.
14. Determination of vitamin C in citrus fruit juice by iodimetric/  $\text{BrO}_3$  titration.
15. Synthesis of nano size Metal oxides, its characterization by UV-Visible spectroscopy and its photocatalysis
16. Synthesis of liquid crystals and their applications

**SUGGESTED BOOKS**

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M West, Holler and Crouch 8<sup>th</sup> edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D Christian, 5<sup>th</sup> edition, 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A Day and A.L. Underwood, 6<sup>th</sup> edition, 1993prentice Hall, Inc. New Delhi.
4. Vogel's Text book of Quantitative Chemical Analysis, J. Mendham, R.C Denney, J.D Barnes and M.J.K. Thomas, 6<sup>th</sup> edition, Third Indian Reprint.2003 Pearson education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principals, John H. Kennedy, 2<sup>nd</sup> edition, 1990.

**OEP 3.8 (3.4)**  
**Practical Environmental Chemistry**

**(64 h)**

1. Analysis of ground water sample for sulphate by titrimetry (EDTA) and turbidimetry.
2. Spectrophotometric determination of lead in waste water using solvent extraction procedure.
3. Analysis of waste water for phosphate by Molybdenum blue method
4. Determination of chlorides in water sample
5. Analysis of waste water for total acidity and alkalinity by conductometric titration and comparison with visual methods.
6. Determination of fluoride in drinking water / ground water by spectrophotometry (alizarin red lake method)
7. Analysis of soil sample for organic carbon by titrimetry and spectrophotometry ( $K_2C_2O_7$  method)
8. Determination of dissolved oxygen by winkler or iodometric method.
9. Determination of chemical oxygen demand (COD) of water
10. Determination of Ca and Mg in the given sample
11. Estimation of iron in water samples
12. Estimation of nitrates in water samples
13. Determination of SPM in ambient air
14. Spectrophotometric/colorimetric determination (a) determination of nickel. (b) Determination of hexavalent chromium.
15. Redox titration (a) determination of ferrous iron. (b) determination of copper.
16. Soil physical properties (a) particle size distribution analysis (sand, silt and clay) (b) Determination of specific gravity and water holding capacity

**SUGGESTED BOOKS**

1. Experiments in Environmental chemistry, F. D. Vowler, and D. W. Counel, Pergamon press, Oxford 1980.
2. Manual soil Laboratory Testing- vol I, K. H. Head, Pentech Press, London 1980. A text Book of Environmental chemistry and pollution control. S. S. Dara, S. Chand and Co, Ltd. New Delhi 2004.
3. Air pollution Vol II Edn. By A. C Stern, Academic press New York 1968. Instrumental methods for automatic air monitoring systems in Air Pollution Control, Part-III Edn by W. Stranss, John-Wiley and sons, New York, 1978. Analysis of air pollutants, P. O. Warner, John Wiley and sons, New York, 1976.
4. The Chemical analysis Air Pollutants, Interscience, New York, 1960.
6. The Analysis of Air Pollutants, W. Liethe, Ann Arbor Science Pub Inc. Michigan 1970. Environmental chemistry A. K De.
7. Jackson ML (1973) Soil chemical analysis. Prentice Hall, New Delhi.

**BIOINORGANIC CHEMISTRY AND REACTION MECHANISMS****UNIT-I****(16 h)**

Iron storage and transfer- ferritin, transferrin and siderophores. Oxygen transport and oxygen uptake proteins- transport and storage of dioxygen; Heme proteins and oxygen uptake, structure and functions of haemoglobin and myoglobin, dioxygen binding, Bohr effect, Hill equation, role of distal and proximal histidines; Model complexes for dioxygen binding, non-porphyrin systems- hemerythrin and hemocyanin. Photosynthesis and nitrogen fixation: Nitrogenase: structural aspects and functions, abiological nitrogen fixation. Photosynthesis: Chlorophyll- structural features, role of  $Mg^{2+}$  - Z scheme of photosynthesis-PSI and PSII.

**UNIT-II****(16 h)**

Structure and functions of metalloproteins in electron transfer process- Cytochromes, ferridoxines- 2Fe-2S, Rieske centers, high potential iron proteins; 4Fe-4S, 3Fe-4S, 8Fe-8S and rubredoxin. Mitochondrial flow of electrons from NADH to oxygen, cytochrome C, Cytochrome C oxidase. Metalloenzymes: Structure and reactivity- Zinc enzymes: carboxy peptidase, carbonic anhydrase, alcohol de hydrogenase. Cu enzyme: superoxide dismutase. Mo enzyme: Xanthine oxidase, nitrate reductase. Fe enzymes: catalase, peroxidase and cytochrome P-450. Vitamin B<sub>12</sub>: Coenzyme: B<sub>12r</sub>, B<sub>12s</sub>, biochemical functions of cobalamins; Biomethylation, mutase activity.

**UNIT-III****(16 h)**

$Na^+/K^+$  transport across cell membranes, ionophores, crown ethers,  $Na^+/K^+$  pump. Biological roles of Ca: Binding sites of  $Ca^{2+}$  in proteins, importance of  $Ca^{2+}$  in muscle contraction and in blood clotting process. Metal ligand interactions with DNA. Metal ion deficiency and treatment (Fe, Zn, Cu, Mn); toxicity of Fe, Cu, Heavy metals- As, Hg, Pb and Cd; detoxification; chelation therapy; metal complexes as antimicrobial agents, antiviral agents, anticancer and antiarthritic drugs.

**Treatment of toxicity due to inorganics:** Mechanism of

- (i) Antidote complexes with poison, rendering it inert (heavy metals, iron, copper and thallium)
- (ii) Antidote accelerated metabolic conversion of poison to non-toxic product (cyanide).
- (iii) Antidote competes with poison for essential receptors (carbon monoxide, morphine and morphine like narcotics).

**UNIT-IV****(16 h)**

**Coordination Chemistry-Reaction mechanisms:** Thermodynamic and kinetic stability- Labile, inert, stable and unstable complexes. Classification of reaction mechanisms- energy profile of reactions having different mechanisms.

**Mechanism of ligand substitution in square planar complexes-** Kinetics-Rate law-Mechanism, Factors affecting substitution, Trans effect and Trans influence.

**Mechanism of ligand substitution in octahedral complexes-** Classification of metal ions in rate of exchange of coordinated water. Kinetics-Rate law-Mechanism, Factors affecting substitution in octahedral complexes: Leaving group, chelate and metal effects.

**Reaction rates influenced (catalyzed) by Acid and Base:** Acid catalysed aquation and anation reactions, Base hydrolysis-Mechanism of conjugate base hydrolysis.

**Electron transfer reactions:** Complementary and Non-complementary reactions, Outer sphere electro transfer- Mechanism, Marcus equation and examples, Inner sphere electron transfer reactions – Mechanism, one and two electron transfer reactions with examples.

## SUGGESTED BOOKS

1. Inorganic and organometallic reaction mechanism; J. D. Atwood; Brooks/cole publication co. (1985).
2. Reaction mechanism of inorganic and organometallic systems; J. B. Jordon, Oxford University Press 2nd edition, 1998.
3. Inorganic Chemistry, 3rd Edition; Gary. L. Miessler and Donald . A. Tarr (2007).
4. Inorganic Chemistry; K. F. Purcell and J. C. Kotz, Saunders company, 1977.
5. Bio-inorganic chemistry, I. Bertini, H. B. Gray, S. J. Lippard and J. S. Valentine, Viva Books Pvt. Ltd 1998
6. Bioinorganic Chemistry; Asim. K. Das; Books and allied (p) Ltd., 2007.
7. Principles of Bioinorganic Chemistry; S. J. Lippard and J. M. Berg; Panima Pub. Corporation 1997.
8. Biochemistry –A. L. Lehninger
9. Biochemistry-L. Stryer
10. Bioinorganic Chemistry-R. W. Hay
11. The Inorganic chemistry of Biological Processes –2ndedition, M. N. Hughes.
12. Bioinorganic Chemistry-M. Satake and Y. Mido.
13. Bioinorganic Chemistry-G. R. Chatwal and Ajaykumar Bhagi.
14. Biological aspects of Inorganic chemistry-A. W. Addison, W. R. Cullen, D Dolphin and B. R. James
15. Principles of drug action: The Basis of Pharmacology–Third Edition, William B. Pratt and Palmer Taylor. Churchill Livingstone, 1990.

## CPT – 4.2

### Macromolecules and Solid State chemistry

#### UNIT – I

(16 h)

**Terminology and basic concepts:** Monomers, Functionality, repeat units, degree of polymerization. General structure and naming of polymers.

**Classification based on various considerations**-source, preparation methods, thermal behavior, chain structure etc.

**Types** –Homopolymers and copolymers; Linear, branched and network polymers.

**Techniques of polymerization:** Techniques of preparation of addition and condensation polymers.

**Kinetics of polymerization:** Kinetics of addition and condensation polymerization. Kinetics of copolymerization.

**Determination of molecular weight:** Osmometry, viscometry, ultracentrifugation and GPC methods

**Thermal Characterization:** Glass Transition and melting-correlation with structure-Factors affecting T<sub>g</sub> and T<sub>m</sub>. Techniques of thermal characterization: DSC, DTA, DTG and TGA techniques.

#### UNIT – II

(16 h)

**Crystal Defects and Non-Stoichiometry:** Imperfections and defects in crystals. Vacancy, Schottky and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation, colour centres, non-stoichiometry defects.

**Solid State Reactions:** General Principles, Wagner's theory. Order - disorder transitions in solids- Bragg- William's theory Mechanism of diffusion, Kirkendall effect.

**Preparative Methods of solids:** Ceramic, sol-gel, precursor and chemical vapour deposition (CVD) methods. Nucleation & crystal growth techniques-pulling, zoning, flame fusion & skull melting. Basic methods of preparation of thin films.

#### UNIT – III

(16 h)

**Electronic Properties and Band Theory:** Free electron theory to band theory of solids, electrical conductivity, Hall effect. Metals, Insulators and Semiconductors. Intrinsic and extrinsic semiconductors, hopping semiconductors. Metal – semiconductor and p-n junctions.

**Magnetic properties:** Classification of magnetic materials – dia, para, ferro, ferri, antiferro & antiferri magnetic types, Langevin diamagnetism. Selected magnetic materials such as spinels & garnets.

**Ionic Conductors:** Types of ionic conductors, mechanism of ionic conduction, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples - $\beta$ -alumina, AgI, halide and oxide ion conductors.

#### UNIT – IV

(16 h)

**Crystal geometry:** Crystal system, lattices, Miller planes, crystal packing, symmetry elements for solids (including glide planes and screw axis). Introduction to space groups with examples.

**X-ray diffraction:** Fundamentals of X-ray crystallography, law of interfacial angles, laws of symmetry, X-ray diffraction, Bragg condition, miller indices, Laue method, Bragg method,

Debye-Scherrer method, rotating crystal 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.

Atomic scattering factor, structure factor and its relation to intensity and electron density, Fourier synthesis, phase problem, description of the procedure for an X-ray structure analysis.

Electron diffraction of gases. Experimental technique, Scattering -Intensity curves, Wierl equation (no derivation), Radial distribution method, Determination of bond lengths and bond angles.

**Neutron diffraction:** Scattering of neutrons by solids and liquids, magnetic scattering, measurement, techniques, elucidation of structure of magnetically ordered unit cell.

## SUGGESTED BOOKS

1. Introduction to X-ray crystallography- Azaroff
2. X-ray crystallography – Buerger, M.J. John Wiley and sons.
3. A. R. West. Solid State Chemistry and its Applications, John Wiley (1990).
4. R. J. Young and P. A. Lovell, Introduction to Polymers, 2nd Edition, Chapman and Hall, 2002.
5. F. W. Billmeyer, Textbook of Polymer Science, 3rd Edition, John Wiley, 1994.
6. V. R. Gowariker, N. V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd, 2005.
7. G. Odian, Principles of Polymerization, Fourth edition, Wiley-Interscience, 2004.
8. L. H. Sperling, Introduction to Physical Polymer Science, Wiley- Interscience, 1986.
9. M. Rubinstein and R. A. Colby, Polymer Physics, Oxford University Press, 2003.
10. A. F. Wells, Structural Inorganic Chemistry – 5th edition (1984)
11. J H Huheey, Inorganic Chemisry - Principles, structure and reactivity, Harper and Row Publisher, Inc. New York (1972)
12. J. D. Lee, Concise Inorganic Chemistry, Elbs with Chapman and Hall, London
13. A. R. West, Plenum, Solid State Chemistry and its applications
14. N. B. Hanney, Solid State Physics
15. H. V. Keer, Principles of Solid State
16. S. O. Pillai, Solid State Physics
17. W. D. Callister, Wiley, Material Science and Engineering: An Introduction
18. A. R. West, Basic Solid State Chemistry, 2nd edition
19. U. Schubert and N. Husing, Synthesis of Inorganic Materials, Wiley VCH (2000)
20. Physical Chemistry, Gordon M. Barrow, Mcgraw-Hill College; 6 Sub edition (March 1, 1996).
21. D. K. Chakrabarty, Solid state chemistry (New Age) 1996.
22. L. Smart and E. Moore, Solid State Chemistry –An Introduction (Chapman &Hall)1992.
23. V. Raghavan, Material science and Engineering (3rd Ed), (Prentice Hall India)1993.
24. Thermotropic Liquid Crystals, Ed. G.W. Gray, Wiley.
25. Chandrasekhar, Liquid Crystals, Cambridge University Press (2nd ed), 1994.
26. JAK Tareen and TRN Kutty, A Basic Course in Crystallography, Universities Press.

**SPT – 4.3.A**  
**Chemistry of Natural Products**

**UNIT – I**

**(16 h)**

**Carbohydrates:** Introduction, Ring size determination of monosaccharides, Configuration and conformation of monosaccharides, anomeric effect, Hudsons rule, epimerization and mutarotation. Chemistry of important derivatives of monosaccharides, carboxylic acids, dihydro sugars, deoxysugars, cyclitols, aminosugars and anhydrosugars. Isolation, Importance, synthesis and Structure elucidation of disaccharides- sucrose, maltose, cellobiose General methods of structural degradation of polysaccharides- methylation, partial hydrolysis, periodate oxidation, Smith degradation and alkaline degradation techniques. Structure and importance of cellulose, chitin, starch and glycogen

**UNIT – II**

**(16 h)**

**Steroids:** Introduction, Nomenclature, configuration of substituents, absolute configuration in the ring, configuration in the side chain. Importance and synthesis of cholesterol. Structure and biological importance of Estrone, progesterone, testosterone, androsterone and corticosterone. Introduction to oral contraceptives. Irradiation product of Ergosterols.

**Alkaloids:** Introduction, classification. Isolation, biological importance of alkaloids and general methods of structural elucidation. Structure and synthesis of quinine and morphine. Structure and importance of reserpine, Lysergic acid and Atropine.

**UNIT – III**

**(16 h)**

**Lipids:** Nomenclature, occurrence of triglycerides, classification, purification, reactions of fatty acids, structure and synthesis of lipids, phospholipids, sphingolipids. Biological importance of lipids: Lecithin, sphingolipids, oils and fats.

**Prostaglandins:** Introduction, classification and biological importance and mode of action of prostaglandins in biological system. Constitution of PGE1. Synthesis of PGE & F series.

**Enzymes:** Introduction, nomenclature, classification, General characteristics, Theories of interaction : lock and key model, Koshland induced-fit theory , Coenzymes: coenzyme role of theanine, Riboflavin, Pantothenic acid. Mode action of enzymes in catalyzing the reaction (Chymotrypsin, Ribonuclease, Lysozyme) with examples and their functions.

**UNIT – IV**

**(16 h)**

**Terpenoids:** Introduction, classification and general methods of structural elucidation. Biological importance of terpenoids. Structure elucidation, synthesis and importance of pinene, camphor. Santonin,  $\beta$ -caryophyllene.

**Plant pigments:** Occurrence, nomenclature and general methods of structure determination of Anthocyanidins. Synthesis of Cyanidin Chloride, Chalcones, Flavones, Quercetin.

**Porphyrins:** Introduction, structure and synthesis of haemin. Vitamin B12 structure and as coenzyme in molecular rearrangement reactions: Chlorophyll: structure and biological importance.

**Vitamins:** Classification, Occurrence, Deficiency syndromes, Chemistry of Vitamins A, C and E. Structure elucidation and synthesis of Vitamin-A & C.

## SUGGESTED BOOKS

1. O.L. Chapman, Organic Photochemistry. Vol I & II. Marcel Decker.
2. Francis A Carey and R. J. Sundberg, Advanced Organic Chemistry-Part A & (Plenum).
3. Mukherji Singh and Kapoor , Organic Chemistry, Vol 1-3, (Wiley Eastern, New Delhi)
4. Synthetic Organic Chemistry- G.R.Chatwal (Himalaya, Bombay), 1994.
5. Organic Reaction Mechanisms , V.K. Ahluwalia & R.K.Parashar (Narosa) 2006
6. Organic Chemistry, Vol I-II, I.L.Finar,(Longmann ELBS, London), 1973.
7. Advanced Organic Chemistry- Reaction Mechanisms, Reinhard Bruckner(Academic) 2005.
8. Pericyclic reactions, S.M Mukherji(The McMillan Bangalore), 1979.
9. Organic Reactions and their mechanisms- P.S.Kalsi (New Age, New Delhi), 1996.
10. I. L finar, Organic chemistry, ELBS Longman, Vol I & II, 11984.
11. Harper's Biochemistry, Ed. R. Harper, 22ndedition, prentice Hal Press, New York, 1990.
12. Encyclopedia of Chemicl technology-Kirck-Othmer series.
13. Introduction to alkaloids, G. W Swan.



**SPT – 4.3.B**  
**Medicinal chemistry**

**UNIT – I**

**(16 h)**

**Introduction:** Characteristics of drug-Prodrug – biotransformation of drugs- Routes of drug administration, Dosage forms, drug binding, drug toxicity, drug addiction, development of synthetic drugs, Some important terms used in chemistry of drugs, Medicinal chemistry, Pharmacy, Pharmacology, molecular pharmacology, Pharmacodynamics, Pharmacophore, Pharmacodynamic agents, Antimetabolites- Bacteria, Types of bacteria, Virus, Fungi, Antinomy cites, Mutation

**UNIT – II**

**(16 h)**

**Classification and Nomenclature of drugs:** Importance and Classification of drugs based on the chemical- Analgesics, Antipyretics, Antacids or gastrointestinal agents, sulpha drugs, Antibiotics, Antimalarials, Antidepressants, Antihistamines, Antiinflammatory agents, cardiovascular agents, Diuretic agents, Drugs acting on central nervous system, Nonselective central nervous system depressant, Selective modifiers of central nervous system, Central nervous system stimulants, Drugs stimulating or blocking peripheral nervous system.

**Nomenclature of the drugs:** Introduction, Naming of organic groups, Stereo chemical notations, DL descriptors-Cahn Ingold Prelog convention- R and S configuration- Rules for priority – E and Z isomerism.

**UNIT – III**

**(16 h)**

**Chemistry of drug action:** History of drug discovery and developments: Historical outline, Pharmacodynamics vs. Chemotherapeutic drugs, Accomplishment and challenges in drug development,

**Sources of drugs:** Natural products, Drugs from organic synthesis, drug discovery and developments

**Drug structure and biological activity:** Pharmaceutically important functional groups, Physicochemical properties of drugs, Electronic effects, spatial properties of drugs

**Fate of drugs in the body:** Absorption, distribution, metabolism, Excretion (ADME), Chemistry of drug metabolism, Modification to decrease metabolism, prodrugs

**Molecular mechanism of drug action:** Drug targets, Receptors, Enzymes, Nucleic acids, non-receptor targets.

**UNIT – IV**

**(16 h)**

**Synthesis of selected class of drug and their mode of action:** Anti-bacterial – Sulphamethizole, Sulfasalazine. Analgesics and Anti-inflammatory – Aspirin, Phenacetin. Antibiotics – Benzylpenicilline, Chloromycetin. Hypnotics and Sedatives – Phenobarbital, Chlorodiazopoxide. Antineoplastics – 5-Fluorouracil, Chloroambucil. Cardiovascular agents – Propranolol, Timolol.

**SUGGESTED BOOKS**

1. Burgers medicinal chemistry M. E. Welly Medicinal Chemistry M.E. Walffed John willey and sons, Vo 1, 2 and 3.
2. Wilson and Giswold's, Text Book of Organic and Medicinal Chemistry.
3. William. O. Foye, Princiles of Medicinal chemistry, Lea amd Febiger, Philadelphia.

4. Martindale, the extra pharmacopoeia, J.E. Reynolds. The Pharmaceuticals Press, London.
5. A. M. Beckett and J.B. Stanlake and Garrel, Practical Pharmaceutical chemistry, the Sthalone Press, University of London, London.
6. I. P 85 and 96, Govt. of India, Ministry of India.
7. B.D. Furniss, A.J. Hannaford, V.Regers, P.W.G. Smith and A.R. Tachell, Vogels textbook of practical organic chemistry, including quantitative analysis ELBS Longman, London.
8. J.G.Mann and S.C.Saunders, Practical organic chemistry, Longmann Green and Co. Ltd.,London.
9. Organic drug synthesis-LediserMitzsher Vol. 1 and 2.
10. Current index of medical specialties (CIMS).



**CPP 4.5 (4.1)**  
**Practical Inorganic Chemistry - 4**

**(64 h)**

1. Preparation of any Four of the following complexes and determination of the purity of the prepared sample and structural study of the prepared complexes using physical methods such as magnetic susceptibility measurements, absorption spectra etc.
  - a) Chloropentaammine Cobalt (III) Chloride
  - b) nitropentaammine Cobalt (III) Chloride
  - c) nitritopentaammine Cobalt (III) Chloride
  - d) Hexamine Cobalt (III) Chloride
  - e) mercury tetrathiocyanato cobaltate (II)
  - f) Hexamine nickel (II) chloride
  - g) tris -(thiourea) copper (I) sulphate
  - h) Potassium tris (Oxalato) ferrate (III)
2. Determination of ionisable chloride by ion exchange method.
3. Stabilization of an unstable oxidation state by complexation: Preparation of Manganese (III) acetyl acetonate
4. Preparation of EDTA complex of Mn (III).
5. Determination of the composition of a complex of iron-phenanthroline by
  - a) Mole -ratio method
  - b) Job's method
  - c) Slope ratio method
6. Determination of the stability constant of a complex
  - a) Turner-Aderson method (iron-T iron or iron-phenanthroline complex)
  - b) Bjerrum's method (copper sulphosalicylic acid)
  - c) Kinetic method (KI<sub>3</sub> complex)
7. Preparation and kinetics of the acid hydrolysis of potassium trisoxalato cobaltate (III) trihydrate
8. Preparation and photolysis of potassium trisoxalato ferrate(III).
9. Preparation and screening of copper complex for its fungicidal and bactericidal activity.
10. 10 Demonstration Experiments
  - a) Recording and interpretation of IR and NMR spectra of complexes
  - b) Interpretation of a simple x-ray powder photograph
  - c) TGA of calcium Oxalate monohydrate
  - d) DTA studies of copper sulphate penta hydrate
  - c) Spectrochemical series- evaluation of Dq value.

**SUGGESTED BOOKS**

1. A Text Book of quantitative Inorganic Analysis- 5<sup>th</sup> edition- A. I. Vogel.
2. Experimental inorganic chemistry- G. Palmer
3. Inorganic synthesis- O. Glemser.
4. Experimental Inorganic/Physical chemistry- Mounir A. Malati.
5. Instrumental analysis manual- Modern experiments for Laboratory- G G. Guilbault and L.G. Hargis

**CPP 4.6 (4.2)**  
**Practical Physical Chemistry – 4**

**(64 h)**

1. Determine the limiting viscosity number of polymer (at least two polymers)
2. Determine the chain linkage in poly(vinyl alcohol) from viscosity measurement.
3. Determination of the molecular weight of a polymer material by viscosity measurements (at least four different polymers).
4. Determine the relative molecular mass of hydroxyl terminated polybutadine and carboxyl terminated polybutadiene.
5. X-ray diffraction method-Indexing and unit cell parameters determination of  
a) Simple cubic ( $\text{SrTiO}_3$ ); b) BCC (tungsten and CsI); c) FCC lattice (NaCl).  
(Separate experiments).
6. X-ray diffraction method-Indexing and unit cell parameters determination of potassium chloride. Comparison of the structures of KCl and NaCl.
7. X-ray diffraction method-Indexing of CsCl.
6. Compare the powder diffraction photograph of potassium chloride and compare with that of sodium chloride and ii) to calculate  $\rho$  and  $d$  from the diffraction photograph.
7. Determine the density of solids and comparison with the X-ray diffraction pattern data

**SUGGESTED BOOKS**

1. Textbook of polymer science: F.W. Billmayer Jr. Wiley.
2. Polymer science: V.R. Gowarikar, N. V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Fractional monomers and polymers: K Takemoto, Y. Inaki, and R.M. Ottam Brite.
4. Contemporary polymer chemistry: H.R. Alcock and F. W. Lambe, Prentice Hall.
5. Principles of polymer Chemistry: Flory, Cornell Univ. press.
6. Introduction to polymer chemistry: R. B. Seymour, McGraw Hill.
7. Principles of polymerization: Odian.
8. A first course in polymer chemistry: A. Strepikheyew, V. Derevistkay and G. Slonimasky, Mir Publishers, Moscow.
9. Laboratory preparation of macro chemistry: EMM effery, McGraw Hill Co.
10. A practical course in polymer chemistry: S.J. Punea , Pergamon Press.
11. Practical Physical chemistry – A.J. Findlay.
12. Experimental Physical Chemistry – F. Daniels et al.
13. Selected Experiments in Physical Chemistry – Latham.
14. Experiments in Physical Chemistry – James and Prichard.
15. Experiments in Physical Chemistry – Shoemaker.
16. Advanced Physico – Chemical experiments – J. Rose.
17. Practical Physical Chemistry. - S.R. Palit.
18. Experimental physical chemistry, R. C. Das and B. Behera, Tata McGraw-Hill Publishing Company Limited, 1983.
19. Experimental Physical Chemistry, V. D. Athawale and Parul Mathur, New Age International (p) Limited, Publishers, New Delhi, 2001.

**SPP - 4.7 (4.3.A)**  
**Practical Organic Chemistry**

**PART-I**

**(64 h)**

Quantitative determination of sugars, amino acids, phenols, carboxylic acids, amides, esters, aldehydes, ketones, urea by various methods. Determinations of acid and ester and acid and amide in mixtures of two.

**PART-II**

1. Isolation of piperine from pepper
2. Isolation of caffeine from tea
3. Isolation of cysteine from hair
4. Isolation of hesperidene from orange peel
5. Isolation of azaleic acid from castor oil
6. Isolation and spectroscopic characterization of Lycopene
7. Isolation of lipids from egg yolks
8. Extraction of nicotine from tobacco leaves

**SUGGESTED BOOKS**

1. A text book of practical organic chemistry – AI Vogel Vol I
2. Practical organic chemistry –Mann &Saunders
3. Manual of organic chemistry – Dey and Seetharaman
4. An introduction to practical organic chemistry – Robert, Vingrove etc.
5. Semimicro qualitative organic analysis by Cheronis, Entrikin and holdnet
6. J.N. Guthru & R. Kapoor, Advanced experimental chemistry, S. Chand Company, new Delhi, 1991.
7. R. K. Bansal, laboratory Manual of Organic chemistry, New PGE International (P) Ltd. London, 3rd edition, 1996.
8. N. K. Visno, Practical organic chemistry, New PGE International (P) Ltd. London, 3rd edition, 1996.

**SPP 4.7 (4.3.B)**  
**Practical Organic Chemistry**

**Part I**

**(64 h)**

**Assay of medicinally useful compounds**

1. Ibuprofen by alkalimetry.
2. Diclofenac by alkalimetry.
3. Analgin by iodimetry.
4. Ephedrine hydrochloride by non-aqueous titration.
5. Phenobarbitone sodium by non- aqueous titration.
6. Procaine/Benzocaine by diazotization.
7. Chlorpromazine by Cerrimetry.

**Part II**

**Preparation of medicinally useful compounds**

1. Phenytoin from benzoin.
2. Paracetamol from p-nitro phenol.
3. Benzocaine from [-amino benzoic acid.
4. 4-hydroxy coumarin from resorcinol.
5. Mefenamic acid from anthranilic acid.

**SUGGESTED BOOKS**

1. Indian Pharmacopia.1985.
2. I.L. Finar, Text Book of Organic Chemistry.
3. Lednicer Mitzsher, the Organic Chemistry of drug synthesis, vol 1, and 2.
4. A text book of practical organic chemistry – AI Vogel Vol I
5. J. G. Mann and Saunders, Practical organic chemistry.
6. T. Robinsom, Organic constituents of higher medicinal plants.

**CPDP: 4.8**  
**Core Paper Dissertation Practical**

**(32 h)**

**Chairman**  
**BOS in Chemistry**