Kuvempu University

Department of P.G. Studies and Research in Chemistry

M.Sc. Chemistry Syllabus: 2025-26 (CBCS Scheme)

M.Sc. Course Pattern and Scheme of Examination under CBCS approved by PG-BOS in Chemistry (BOS Meeting held on **23.06.2025**)

Course Pattern:

FIRST SEMESTER

Paper Code	Paper Title	Credits	Teaching Hours/ Week	Theory/ Practical Marks		Total Marks
				I.A.	Exam.	
Theory Papers (Hard Core Papers)						
ChHCT-1.1	Analytical Chemistry – I	4	4	25	75	100
ChHCT-1.2	Inorganic Chemistry – I	4	4	25	75	100
ChHCT-1.3	Organic Chemistry – I	4	4	25	75	100
ChHCT-1.4	Physical Chemistry – I	4	4	25	75	100
Practical Papers						
ChHCP-1.1	Inorganic Chemistry Practicals – I	2	4	10	40	50
ChHCP-1.2	Organic Chemistry Practicals – I	2	4	10	40	50
ChHCP-1.3	Physical Chemistry Practicals – I	2	4	10	40	50
Total		**22**	**-**	-	-	**550**

SECOND SEMESTER

Paper Code	Paper Title	Credits	Teaching Hours/ Week	Theory/ Practical Marks		Total Marks
				I.A.	Exam.	
Theory Papers (Hard Core Papers)						
ChHCT-2.1	Analytical Chemistry – II	4	4	25	75	100
ChHCT-2.2	Inorganic Chemistry – II	4	4	25	75	100
ChHCT-2.3	Organic Chemistry – II	4	4	25	75	100
ChHCT-2.4	Physical Chemistry – II	4	4	25	75	100
Practical Papers						
ChHCP-2.1	Inorganic Chemistry Practicals – II	2	4	10	40	50
ChHCP-2.2	Organic Chemistry Practicals – II	2	4	10	40	50
ChHCP-2.3	Physical Chemistry Practicals – II	2	4	10	40	50
Open Elective Papers (Theory)						
ChELT-2.1	Chemistry in day-to-day life	2	2	10	40	50
ChELT-2.2	Waste Management and Sewage Treatment		2	10	40	50
Total		**24**	**-**	-	-	**600**

THIRD SEMESTER

Paper Code	Paper Title	Credits	Teaching Hours/ Week	Theory/ Practical Marks		Total Marks
				I.A.	Exam.	
Theory Papers (Soft Core Papers)						
ChSCT-3.1	Analytical Chemistry – III	4	4	25	75	100
ChSCT-3.2	Inorganic Chemistry – III	4	4	25	75	100
ChSCT-3.3	Organic Chemistry – III	4	4	25	75	100
ChSCT-3.4	Physical Chemistry – III	4	4	25	75	100
Practical Papers						
ChSCP-3.1	Inorganic Chemistry Practicals – III	2	4	10	40	50
ChSCP-3.2	Organic Chemistry Practicals – III	2	4	10	40	50
ChSCP-3.3	Physical Chemistry Practicals – III	2	4	10	40	50
Open Elective Papers (Theory)						
ChELT-3.1	Fundamentals of Electroplating	2	2	10	40	50
ChELT-3.2	Natural Products: An Overview		2	10	40	50
Total		**24**	**-**	-	-	**600**

FOURTH SEMESTER

Paper Code	Paper Title	Credits	Teaching Hours/ Week	Theory/ Practical Marks		Total Marks
				I.A.	Exam.	
Theory Papers (Soft Core Papers)						
ChSCT-4.1	Analytical Chemistry – IV	4	4	25	75	100
ChSCT-4.2	Inorganic Chemistry – IV	4	4	25	75	100
ChSCT-4.3	Organic Chemistry – IV	4	4	25	75	100
ChSCT-4.4	Physical Chemistry – IV	4	4	25	75	100
Project Work						
ChPR-4.1	Project Work	4	8	25 (Viva)	75 (Dissertation)	100
Total		**20**	**-**	-	-	**500**
Total (A)		**90**				**2250**
Personality Development		**1**				
Communication Skills		**1**				
Computer Skills		**1**				
Total (B)		**3**				
Grand Total (A + B)		**93**				
Total Credits : I - IV SEMESTER (90) + Soft Skills (03) = 93, Total Marks = 2250						

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Examination Pattern:

	Theory Papers					Practical Papers				
Semester	**Paper Code**	**Duration (hrs)**	**Max. Marks**	**IA**	**Total**	**Paper Code**	**Duration (hrs)**	**Max. Marks**	**IA**	**Total**
I	ChHCT-1.1	3	75	25	100	ChHCP-1.1	4	40	10	50
	ChHCT-1.2	3	75	25	100	ChHCP-1.2	4	40	10	50
	ChHCT-1.3	3	75	25	100	ChHCP-1.3	4	40	10	50
	ChHCT-1.4	3	75	25	100					
	Total				**400**					**150**
II	ChHCT-2.1	3	75	25	100	ChHCP-2.1	4	40	10	50
	ChHCT-2.2	3	75	25	100	ChHCP-2.2	4	40	10	50
	ChHCT-2.3	3	75	25	100	ChHCP-2.3	4	40	10	50
	ChHCT-2.4	3	75	25	100					
	ChELT-2.1	1.5	40	10	50					
	Total				**450**					**150**
III	ChSCT-3.1	3	75	25	100	ChSCP-3.1	4	40	10	50
	ChSCT-3.2	3	75	25	100	ChSCP-3.2	4	40	10	50
	ChSCT-3.3	3	75	25	100	ChSCP-3.3	4	40	10	50
	ChSCT-3.4	3	75	25	100					
	ChELT-3.1	1.5	40	10	50					
	Total				**450**					**150**
IV	ChSCT-4.1	3	75	25	100	ChPRJ-4.1	-	-	-	-
	ChSCT-4.2	3	75	25	100					
	ChSCT-4.3	3	75	25	100	Project Report	75	-	-	**75**
	ChSCT-4.4	3	75	25	100	Project Viva	25	-	-	**25**
	Total				**400**					**100**

Theory Marks:	**Practical Marks:**	**Project Marks:**	**Total Marks:**
1700	**450**	**100**	**2250**

Question Paper Pattern – 2025-26
First to Fourth Semesters M.Sc. Examinations
(CBCS Scheme)
CHEMISTRY

Paper Title and Code:
Time: 3 hrs.] [Max. Marks: 75

Note: 1) Answer Part-A and any FIVE questions from Part-B.
2) Figures to the right indicate marks.

PART - A

1. Answer the following: (At least 02 Questions should be selected from each Unit)
a), b), c), d), e), f), g), h), i) and j)

10 x 2 = 20

PART – B

(Answer any FIVE questions)

5 x 11 = 55

2.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
3.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
4.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
5.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
6.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
7.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
8.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks
9.	a)	5 Marks	OR	a) 4 Marks
	b)	6 Marks		b) 7 Marks

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Question Paper Pattern – 2025-26
Second and Third Semesters M.Sc. Examinations
(CBCS Scheme)
CHEMISTRY (Elective Paper)

Paper Title and Code:

Time: 1 ½ hrs.] [Max. Marks: 40

Note: 1) Answer Part-A and any THREE questions from Part- B.
2) Figures to the right indicate marks.

PART - A

1. Answer the following:
a), b), c), d), e) 5 x 2 = 10

PART – B

(Answer any THREE questions)

3 x 10 = 20

2.	a)	5 Marks	OR	a) 4 Marks
	b)	5 Marks		b) 6 Marks
3.	a)	5 Marks	OR	a) 4 Marks
	b)	5 Marks		b) 6 Marks
4.	a)	5 Marks	OR	a) 4 Marks
	b)	5 Marks		b) 6 Marks
5.	a)	5 Marks	OR	a) 4 Marks
	b)	5 Marks		b) 6 Marks
6.	a)	5 Marks	OR	a) 4 Marks
	b)	5 Marks		b) 6 Marks

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M.Sc. Chemistry - Programme Outcomes

After the successful completion of this programme, the student will be able to understand the following:

1. *Appreciate the theory as well as practicals in such a way to foster their core competency and discovery learning.*
2. *Handle the sophisticated equipments for the determination and characterization of chemical compounds.*
3. *Design and carryout scientific experiments and accurately record and analyze the results of the experiments.*
4. *Put on familiarity with data analysis, chemical modelling, and basic computational tools used in chemical research.*
5. *Apply the basic principles of chemistry to solve environmental issues, build small-scale industries, and develop interdisciplinary approaches in natural product isolations, pharmaceuticals, dyes, textiles, polymers, petroleum products, forensic sciences, and more.*
6. *Obtain global level research opportunities to pursue Ph.D. programme.*
7. *Encompass enormous job opportunities at all levels of teaching, and industries (chemical, pharmaceutical, food products, material science, etc).*
8. *Collaborate effectively on Chemistry team projects. Communicate scientific information orally and in writing. Use logic, positivity, and a results-oriented approach.*
9. *Prepare for various competitive examinations, especially UGC-CSIR-NET, KSET, GATE and civil service examinations.*
10. *Pursue jobs in academia, research institutions, or other industries where they can utilise their specialised knowledge and skills.*
11. *Become a responsible citizen who will be aware of most basic domain-independent knowledge including critical thinking and communication.*
12. *Overall M.Sc. in Chemistry offers numerous opportunities for professional development and growth in the field of chemical sciences.*

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M.Sc. Chemistry Syllabus: 2025 - 2026 (CBCS Scheme)
I - SEMESTER
ChHCT-1.1: ANALYTICAL CHEMISTRY-I

Total: 64 hrs.

UNIT-I: EVALUTION OF ANALITYCAL DATA **16 hrs.**

Relevance of analytical chemistry, classification of analytical methods – qualitative, quantitative, instrumental, non-instrumental methods. Limitations of analytical methods, classification of errors (to be discussed in brief), normal error curve and its significance. Accuracy, precision, average deviation, standard deviation, coefficient of variance, reliability of results, confidential interval, comparison of results (student's t-test, F-test), comparing the mean of two samples, paired t-test, number of replicable determinations, correlations and regression, linear regression, errors in the slope and intercept, error in the estimation of concentration, standard additions, non-linear regression, comparison of more than two means, experimental design, two-way analysis of variance, chemometrics and experimental design, factorial design, Yates' method, interaction effect – alternative calculation, factorial design – critical appraisal, optimization methods, sequential simplex optimization, critical appraisal, treatment of multivariate data, factor analysis, quick statistics.

Sampling: Sampling techniques, sampling statistics, variability in the sample, sample stability, regulation and legislation, terminology of sampling, methods of sampling for gases (vapors), liquids and solids, effects of sampling uncertainties, sampling hazardous. Need for quality assurance; ISO 9000 series of quality system. Significance and importance of six sigma concepts in maintaining the quality.

UNIT-II: SEPERATION TECHNIQUES – I **16 hrs.**

General description of chromatography- classification, chromatograms, retention time, relation retention factor, capacity factor, selectivity factor, band broadening and column efficiency, methods for describing column efficiency - plate theory. Theory of band broadening, van Deemter equation, column resolution, variables affecting column resolution.

Column (Adsorption) Chromatography: Introduction, principles of column chromatography, experimental requirements, identification of the compounds, experimental column chromatography, chiral chromatography, applications of column chromatography.

Gas Chromatography: Introduction, an overview of GSC and GLC, instrumentation, various types of detectors, hyphenated techniques in Gas chromatography (GC-MS), derivative gas chromatography, pyrolysis gas chromatography (PGC) – theory and principle, instrumentation, advantages and applications, vapour phase chromatography-principle and applications.

HPLC: Introduction, characteristics features, kinetically controlled mechanisms, instrumentation, types of detectors, quantitative analysis and data display, derivatization technique in HPLC, superiority of HPLC, applications.

Super critical fluid chromatography (SFC): Instrumentation of SFC, comparison of SFC with HPLC and GLC.

UNIT-III: SEPERATION TECHNIQUES-II **16 hrs.**

Size exclusion (Gel) chromatography: Introduction, theory and principles of size exclusion process, materials for size exclusion process, application in polymer chemistry (weight average and number average concept).

Affinity chromatography: Introduction, classification, Selection of matrix, role of spacers, affinity ligands, applications of affinity chromatography in the separation of biomolecules.
Solvent extraction: Theory of extraction, mechanism of solvent extraction, aqueous phase, organic phase, factors favouring solvent extraction of inorganic species, extraction involving ion association complexes, synergic extraction, solvent extraction by crown ethers, cryptands, calixarenes, applications of solvent extraction (determination of copper as diethyldithio carbamate complex, determination of iron as 8-hydroxyquinolate).
Solid-phase extraction: solid-phase micro extraction (SPME), advantages of SPME.
Electrophoresis: Free solution, paper and capillary electrophoresis, theory, instrumentation for capillary electrophoresis, separation of amino acids by capillary zone electrophoresis, applications of capillary electrophoresis, experimental paper electrophoresis

UNIT-IV: ELECTROANALYTICAL TECHNIQUES **16 hrs.**

Introduction, electrochemical cells, electrical double layer, faradic and non-faradic current, mass transfer in cells, schematic representation of cells, galvanic and electrolytic cells, anodes and cathodes, potentials in electroanalytical cells, thermodynamics of cell potentials, liquid junction potential, electrode potentials, nature of electrode potentials, standard electrode potentials, standard hydrogen electrode (SHE), standard calomel electrode (SCE). Classification of electroanalytical techniques.
Polarography: Theory, principle and applications classical polarography, dropping mercury electrode, polarogram, polarographic measurements, polarographic current, Ilkovic equation, current and concentration relationship, half wave potential, oxygen interference- advantages and limitations. Qualitative and quantitative analysis. Derivative polarography.
Amperometry, amperometric titrations, Coulometry at controlled potential and at constant current. Cyclic voltammetry-basic principles, cyclic voltammogram of $K_4[Fe(CN)_6]$ system, irreversible and quasi-reversible curves, instrumentation and applications.
Electrogravimetry: Theory, electrode reactions, over-voltage, characteristics of a good deposit, completeness of deposition, separation of metals at controlled cathode potential. Estimation of copper and nickel in Cu-Ni alloy.

REFERENCES:

1. **Vogel's Text book of Quantitative Chemical Analysis**, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India (2012).
2. **Instrumental methods of Chemical Analysis (covering UGC Syllabus),** H. Kaur, 12th Edition, Pragathi Prakashan, New Delhi, India (2018).
4. **Quantitative Chemical Analysis,** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA (2003).
5. **Fundamentals of Analytical Chemistry**, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore (2004).
6. **Instrumental Analysis**, D.A. Skoog, E.J. Holler, S.R. Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi (2012).
7. **Analytical Chemistry – Theory and Practice,** R.M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India (2007).
8. **Quantitative Analysis,** Day and Underwood, 6th Edition, Prentice / Hall Pvt.Ltd. (1993).

9. **Vogel's text Book of Quantitative Chemical Analysis,** Revised by G.H. Jaffery, J. Bassett, J. Mendham and R.C. Denny, ELBS 5th Edition, Longman Group UK Ltd. (1998).

10. **Analytical Chemistry,** Gray D. Christian, 5th Edition, John Wiley and Sons, Inc (1994).

11. **Introduction to Chromatography-Theory and Practice,** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Classification of errors and their significance, classification of various analytical methods; viz., instrumental and non-instrumental methods.*
2. *Knowledge on comparison of results (student's t-test, F-test).*
3. *Sampling techniques, sampling statistics, variability in the sample, sample stability.*
4. *Concept on Need for quality assurance; ISO 9000 series of quality system.*
5. *Concept of chromatograms, retention time, capacity factor, selectivity factor, band broadening and column efficiency.*
6. *Principle, experimental requirements and applications of column chromatography.*
7. *Chromatographic Method like GLC, GC, SFC, HPLC and IEC.*
8. *Theory, instrumentation and applications of size exclusion and affinity chromatography.*
9. *Concepts of solvent extraction and its applications.*
10. *Theory, instrumentation and applications of electrophoresis.*
11. *Concept of electrochemical cells, electrical double layer, faradic and non-faradic current.*
12. *Electroanalytical techniques like Polarography, Cyclic voltametry, Amperometry, Electrogravimetry and their analytical applications.*

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ChHCT-1.2: INORGANIC CHEMISTRY – I

Total: 64 hrs.

UNIT-I: PERIODIC PROPERTIES OF ELEMENTS **16 hrs.**

A brief review of – division of elements into *s, p, d* and *f*- blocks. Atomic properties, covalent radius, periodic trends in covalent radii, Van der Waals radius, ionic radius, periodic properties. **Chemistry of transition metals:** d-Block elements, electronic configuration, general characteristics and correlation with electronic configuration, comparative study of 3d, 4d and 5d elements by taking titanium sub-group as example.

Chemistry of inner-transition metals: Lanthanides series - general characteristics of lanthanides. Extraction of a mixture of lanthanides from monazite sand, separation of lanthanides by – fractional crystallization and precipitation, solvent extraction, change of oxidation states, ion exchange chromatography and complex formation methods. Uses of lanthanides. Lanthanum compounds – lanthanum oxide, halides, chloride, bromide, iodide, sulphate, nitrate and carbonate. Actinide series – Introduction, electronic configuration, sources of actinides, properties of actinides – oxidation states, ionic radii, colour, formation of actinides compounds. Comparison of actinides with lanthanides. Magnetic properties of lanthanides and actinides. Absorption spectra of lanthanides and actinides. Trans-uranium elements, further extension of periodic table, super heavy elements (SHE).

UNIT-II: CHEMICAL BONDING **16 hrs.**

Introduction, brief review of – octet rule, ionic bond, electrovalence, inert pair effect, covalent bond, maximum covalency rule and its applications, failure of octet rule. Valence bond theory, Heitler – London theory, Pauling – Slater's theory, orbital overlap theory, sigma and pi-bonds, non-polar and polar covalent bonds. Coordinate bond, concept of resonance, polarization of ions, Fajan's rules, variation of acidic, amphoteric and basic character of the oxides and hydroxides of elements of group IIIA, bond length, bond energy, Pauling's formula, odd-electron bonds, odd-electron molecules and ions.

Molecular orbital theory (MOT): Salient features of MOT, variation of electron-charge density with inter-nuclear distance in H_2 molecule, characteristics of bonding and anti-bonding molecular orbitals, bond order, homonuclear diatomic molecules A_2 type (Li_2, Be_2, B_2, C_2, N_2, N_2^+, O_2, O_2^+, O_2^-, O_2^{2-}, F_2, Ne_2), heteronuclear diatomic molecules AB type (CO, CN, CN^-, NO, NO^+, NO^{2+}, NO^-, HF), molecular orbitals for larger molecules (CO_2 and H_2O). Comparison between VBT and MOT.

UNIT-III: VALENCE SHELL ELECTRON PAIR REPULSION THEORY **16 hrs.**

Postulates of VSEPR theory, hybridization, structure and geometry of – AB_2 type species ($BeCl_2$, CO_2), AB_3 type species (BCl_3, SO_3), AB_4 type species (CH_4, NH_4^+, SO_4^{2-}), AB_5 type species (PF_5), $AB_2(lp)$ type species ($SnCl_2$, $PbCl_2$, SO_2), $AB_3(lp)$ type species (NH_3, PH_3, PCl_3, ClO_3^-), $AB_2(lp)_2$ type species (H_2O, OF_2, SCl_2, $SeCl_2$, NH_2^-, ICl_2^+), $AB_4(lp)$ type species (OF_4, $TeCl_4$, $SeCl_4$), $AB_3(lp)_2$ type species (ClF_3, BrF_3, ICl_3, IF_3), $AB_2(lp)_3$ type species (XeF_2, ICl_2^-), $AB_5(lp)$ type species (IF_5, BrF_5, ClF_5, $[SbF_4]^{2-}$), $AB_4(lp)_2$ type species (XeF_4, BrF_4^-).

Formation of adducts ($H_3N \rightarrow BF_3$, $H_2S \rightarrow BF_3$), hybridization, structure and geometry of inter-halogen compounds (ICl, ClF_3, $(ICl_3)_2$, IF_5, IF_7), structure and geometry of xenon compounds (XeF_2, XeF_4, XeF_6, XeO_3, XeO_4, $XeOF_4$, XeO_2F_2, XeO_3F_2, XeO_3F_4). Structure and geometry of – PCl_6^-, P_2O_5, P_2O_{10}, SOCl, SO_2Cl, $SnCl_4^{2-}$, SnF_6^{2-}, AlF_6^-, SbF_5^{2-}, SbF_6^{3-}, SeO_2, SeO_3, TeO_2, TeO_3, PoO_3.

UNIT-IV: STRUCTURE OF SOLIDS **16 hrs.**

Structure of solids: Introduction, brief review of classification of solids (true, pseudo, crystalline, polycrystalline and amorphous solids). conductors, insulators and semiconductors (*n*-type and *p*-type extrinsic semiconductors), superconductivity and super conducting materials, Magnetic properties – paramagnetic, diamagnetic, ferromagnetic, anti-ferromagnetic and ferromagnetic substances, dielectric properties, ionic crystals, metallic crystals, atomic and covalent crystals, molecular crystals. Isomorphism and Mitcherlich's law of isomorphism, allotropy, structure and type of ionic crystals – AB type (NaCl, ZnS, CsCl), AB_2 type (CaF_2, TiO_2, CaC_2, FeS_2), A_2B type (Na_2O). Lattice energy, Born-Lande equation, salvation process and salvation energy, hydration process and hydration energy, stoichiometric and non-stoichiometric crystals, defects in crystals, atomic and point defects, Schottky and Frenkel defects, non-stoichiometric defects, normal and inverse spinel structure.

REFERENCES:

1. **Inorganic Chemistry – Principles of Structure and Reactivity**, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, 4th Edition, Pearson Education, Indian Edition, New Delhi, India, 2013.
2. **Concise Inorganic Chemistry,** 5th Edition, J.D. Lee, Blackwell Science Ltd., London, 2003.
3. **Inorganic Chemistry,** James E. House, First Indian Reprint, Academic Press, USA, 2010.
4. **Inorganic Chemistry,** Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, 5th Edition, Oxford University Press, UK, 2013.
5. **Inorganic Chemistry – Principles of Structure and Reactivity**, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, 4th Edition, Pearson, Indian Edition, New Delhi, India, 2004.
6. **Inorganic Chemistry,** Gary L. Miessler, Donald A. Tarr, 3rd. Edition, Pearson Education, New Delhi, India, 2004.
7. **Inorganic Chemistry,** Keith F. Purcell, John C. Kotz, First Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, India 2010.
8. **Advanced Inorganic Chemistry, Volume-I,** Satya Prakash, G.D. Tuli, S, K, Basu, R.D. Madan, S. Chand and Company, New Delhi, India, 2008.
9. **Principles of Inorganic Chemistry (UGC Syllabus)**, B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
10. **Basic Concepts of Inorganic Chemistry,** D.N. Singh, Pearson Education, New Delhi, 2010.
11. **Advance Inorganic Chemistry,** F. Albert Cotton, Geoffrey, Wilkinson, Carlos A. Murillo, Manfred Bochmann, 6th Edition, Wiley Student Edition, John Wiley and Sons, INC, New York, 2004.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Division of elements into s, p, d and f-blocks and learn the concepts of transition and inner transition elements, lanthanides and actinides series.*
2. *Chemical bonding, orbital overlapping, valence bond theory and molecular orbital theory, coordinate bond, Fajan's rule, bond length, bond energy and Pauling's formula.*
3. *Postulates of VSEPR theory. Hybridization, structure and geometry of xenon compounds.*
4. *Important features like conductor, insulator, lattice energy, Born-Lande equation, etc.*

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ChHCT-1.3: ORGANIC CHEMISTRY – I

Total: 64 hrs.

UNIT-I: AROMTICITY AND REACTIVE INTERMEDIATES 16 hrs.

Aromaticity: Concept of aromaticity, Huckel's rule, aromaticity of benzene, dienes, cyclopentadienyl anion, tropylium cation, cyclopropenyl cation. The aromaticity of [12], [14], [16] and [18] annulenes, annulenes, azulene, heterocyclic compounds. Aromatic dications and dianions. Concept of homoaromaticity, nonaromatic and antiaromatic compounds.

Reactive intermediates: Formation, structure and stability of carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, ylides (phosphorous and sulphur ylides) and enamines.

Methods of determining reaction mechanisms: Kinetic method, identification of products, detection of intermediates, study of catalysts, isotopic labeling, cross-over experiments and stereochemical evidences.

UNIT-II: SUBSTITUTION REACTIONS 16 hrs

Nucleophilic substitution reactions: Introduction to nucleophiles, hard and soft nucleophiles. Nucleophilic substitution at saturated carbon - S_N1, S_N2 and S_Ni reactions and mechanisms. Factors affecting substitution reaction – substrate (neighbouring group participation and conjugation), nucleophile, leaving group, solvent, steric and strain effect on substitution and ionization rates.

Nucleophilic substitution at aromatic compounds: Addition-elimination mechanism, nucleophilic substitution via aryne intermediate, nucleophilic substitution by unimolecular mechanism, preparation of aryl halides through radical mechanism. Nucleophilic substitution by rearrangements.

Electrophilic substitution reactions: General mechanism in aromatic electrophilic substitution reaction, nitration, halogenations, sulphonation, Friedal Craft alkylation and acylation. Orientation and reactivity. Effect of substituent's on aromatic ring system. Diazo-coupling, Vilsmeir-Hack, Gattermann Koch reactions and their applications in organic synthesis.

UNIT-III: ADDITION AND ELIMINATION REACTIONS 16 hrs.

Addition Reactions: Addition involving electrophiles, nucleophiles and free radicals, concerted addition. Mechanism, orientation and stereochemistry of addition reactions. Addition of hydrogen halides to alkenes. Addition of HCN, bisulphate, Grignard reagent, hydride, amino compounds, alcohols and thioalcohols to C=O system. Acid-catalyzed hydration, Addition of halogens, Addition reactions involving epoxides – epoxide from alkenes and peroxidic reagents, subsequent transformation of epoxides.

Elimination Reactions: E_1, E_2 and E_{1CB} reactions, regioselectivity in β-elimination reactions (orientation of π-bonds), Saytzeff and Hoffmann rules, elimination vs substitution, E_1, E_2 and E_{1CB} comparative study, 1,1-elimination (α-elimination) - dehalogenation of vicinal dihalides, elimination reactions without involving hydrogen, dehalogenation and related

reactions, decarboxylative elimination. Pyrolytic eliminations. Chugaev and Cope eliminations, Hoffmann degradation. Competition between substitution and elimination.

UNIT-III: STEREOCHEMISTRY **16 hrs.**

Stereoisomerism: Introduction, Molecular symmetry and symmetry elements. Chirality and stereoisomerism. Enantiomers, diastereomers, epimers, anomers (definition and examples). Racemic mixture, Racemization involving – carbanion, carbocation as intermediates, Walden inversion, rotation about carbon-carbon single bond. Resolution (racemic modification) – mechanical separation, preferential crystallization, chemical, biochemical, and chromatographic method. D, L-configuration threo, erythro – configuration. R, S-nomenclature for isomers with more than one Chirality centre.

Optical isomerism: Conditions for optical isomerism: Elements of symmetry-plane of symmetry centre of symmetry, alternating axis of symmetry (rotation-reflection symmetry). Optical isomerism due to molecular dissymmetry: Eg. allenes, spiranes and biphenyls.

Geometrical isomerism: Due to C=C, C=N and N=N bonds, E, Z conventions, determination of configuration by physical and chemical methods. Geometrical isomerism in cyclic systems. **Conformational analysis:** Elementary account of conformational equilibria of ethane, butane and cyclohexane. Conformation of cyclic compounds such as cyclopentane, cyclohexane, cyclohexanones and decalins. Conformational analysis of 1,2-, 1,3- and 1,4-disubstituted cyclohexane derivatives.

REFERENCES:

1. **Organic Chemistry**, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press, UK, 2001.
2. **Organic Chemistry – Solution Manual**, S. Warren, Oxford University Press, UK, 2009.
3. **Advanced Organic Chemistry, Part-A: Structure and Mechanisms**, 5th Edition, Francis A. Carey, Richard J. Sundberg, Springer, New York, 2007.
4. **Principles of Organic Synthesis, R.O.C. Norman, J.M. Coxon,** 3rd Edition (First Indian Reprint), Nelson Thrones, UK, 2003.
5. **Advance Organic Chemistry – Reactions, mechanisms and structure**, Jerry March, 4th Edition, Wiley India Pvt. Ltd., New Delhi, 2008.
6. **Organic Reaction Mechanisms,** V.K. Ahluwalia, R.K. Parashar, 3rd Edition, Narosa Publishing House, New Delhi, 2009.
7. **Pathway to Organic Chemistry – Structure and Mechanism**, P. Bhattacharjee, Arunabha Sen Books and Allied Pvt. Ltd., Kolkta, India, 2012.
8. **Organic Chemistry**, Paula Yurkanis Bruice, 3rd Edition, Pearson Education, Sai Printo Pack Pvt. Ltd., New Delhi, India, 2007.
9. **Organic Chemistry (As per UGC Syllabus)**, S.M. Mukherji, S.P Singh, R.P. Kapoor, R. Dass, Vol. I, New Age International Pvt. Ltd., New Delhi, 2010.
10. **Stereochemistry of Organic Compounds – Principles and applications**, D. Nasipuri, Revised 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2009.
11. **Stereochemistry – Conformation and Mechanism**, P.S. Kalsi, 7th Edition, New Age International Publishers, New Delhi, India, 2008.

12. **Organic Reactions and their Mechanisms**, P.S. Kalsi, 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2007.
13. **Organic Chemistry,** Solomons, Fryhle, 8th Edition (Wiley Student Edition), Brijbasi Art Press Ltd., Noida, India 2004.
14. **Organic Chemistry,** G. Marc Loudon, 4th Edition, Oxford University Press, UK, 2000.
15. **Organic Chemistry**, R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.
16. Organic Chemistry, L.G. Wade, JR., 5th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2004.
17. **Organic Chemistry**, M.A. Fox, J.K. Whitesell, 2nd Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, London, 1997.
18. **Organic Chemistry**, M. Jones, Jr., 2nd Edition, W.W. Norton and Company, New York, 2000.
19. **Organic Chemistry**, David Klein, Fourth edition, Wiley Publications, 2021
20. **Organic Chemistry**, Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
21. **Modern Methods of Organic Synthesis**, W. Carruthers, 3rd Edition, Cambridge University Press, UK, 2004.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Fundamental knowledge of organic structures and reactions.*
2. *Mechanism of nucleophilic and electrophilic substitution reactions.*
3. *Different types of addition and elimination reactions.*
4. *Concepts of stereoisomerism including optical and geometrical isomerism.*

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ChHCT-1.4: PHYSICAL CHEMISTRY – I

Total: 64 hrs.

UNIT-I: THERMODYNAMICS **16 hrs.**

The laws of thermodynamics (Statements, significances and limitations), concepts of free energy, enthalpy, entropy, free energy functions, thermodynamic criteria for equilibrium and spontaneity, Maxwell's relations (Derivations), thermodynamic equations of state (Derivations), principle of equipartition energy. Entropy of vapourisation and Trauton's rule, limitations of Van't Hoff's equation, Nernst heat theorem, determination of free energy change. Third law of thermodynamics, determination of third law entropies, concepts of residual entropy.

Thermodynamics of systems of variable compositions, partial molar properties, partial molar volume and its determination (Intercept method), partial molar free energy – chemical potential and its significance, Gibbs-Duhem equation, thermodynamics of ideal and real gases and gas mixtures. Fugacity - its variation and determination, activity and activity coefficient. Gibbs-Duhem-Margules equation and its application. Thermodynamics of ideal and non-ideal dilute solutions.

UNIT-II: STATISTICAL THERMODYNAMICS **16 hrs.**

Maxwell-Boltzmann distribution law (sterling's approximations), Types of statistics - Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics. Evaluation of Lagrange's undetermined multipliers, Molecular partition function for an ideal gas, evolution of translational, rotational, vibration, electronic and nuclear partition functions. Thermodynamic properties in terms of the partition function. Thermodynamic properties of an ideal monoatomic gas and diatomic gas. Molar partition function of a system. Partition function of a real gas. Calculation of thermodynamic functions and equilibrium constant in terms of partition functions. Entropy of mono atomic gas, Sackur-Tetrode equation (derivation). Comparison of third law and statistical entropies. Statistical thermodynamic properties of solids, thermal characteristics of crystalline solid, heat capacities of monoatomic crystals, Einstein theory of heat capacity, Debye theory of heat capacity, Debye-T^3 law.

UNIT-III: CHEMICAL DYNAMICS **16 hrs.**

The rate of reactions, the rate law and the rate constant, order of a reaction, integration of rate expressions [first, second, third and zero order reactions], half-life of a reaction, methods of determining order of a reaction [differential, integral, half-life and isolation methods], order and molecularity of a reaction, mechanism of complex reactions, collisions and encounters, effect of temperature and catalyst on reaction rates, the Arrhenius equation. Theories of reaction rates [collision theory and activated complex theory of bimolecular gaseous reactions], the Erying equation, the Lindemann theory of unimolecular gaseous reactions. Kinetics of complex reactions [reversible, consecutive, and chain reactions].

Kinetics of reactions in solution [diffusion- controlled reactions-the Debye-Smoluchowski equation]. Influence of ionic strength and solvent on reaction rates. Kinetic isotopic effects. Kinetics of fast reactions: flow methods, pulse method, flash photolysis method, pulse radiolysis method, relaxation method (Temperature-Jump Method), Femtochemistry.

UNIT-IV: ELECTROCHEMISTRY **16 hrs.**

Electrolytic solutions, Activity and activity coefficients, mean ionic activity coefficient, dependence of activity coefficients on ionic strength (Debye - Huckel limiting law), Debye -Huckel equation for appreciable concentration [Debye - Huckel - Bronsted equation]. Thermodynamics of electrolytic cells, polarization and over voltage, decomposition potential. Half-cell reactions, reversible electrodes, single electrode potential, standard electrode potentials, electrochemical series, Nernst equation. Electrochemical energy systems - introduction, fundamentals of batteries, dry cell, alkaline MnO_2 batteries and other secondary batteries, Lead acid and alkaline storage batteries. Battery charging-theory and practice. Energy economics, Fuel cells – types, electrochemistry of fuel cells.

REFERENCES:

1. **Quantum Mechanics for Chemists**, David O. Hayward, The Royal Society of Chemistry, UK, 2002.
2. **Principles of Physical Chemistry (Comprehensive UGC Syllabus)**, B.R. Puri, L.R. Sharma, M.S. Pathania, 46th Edition, Vishal Publishing House, Jalandhar, India, 2012.
3. **Physical Chemistry – A Molecular Approach**, Donald A. McQuarrie, John D. Simon, 3rd Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
4. **Elements of Physical Chemistry**, B.R. Puri, L.R. Sharma, M.S. Pathania, 1st Edition, Vishal Publishing House, Jalandhar, India, 2013.
5. **Quantum Chemistry**, John P. Lowe, Kirk A. Peterson, 3rd Edition, Academic Press, London, UK, 2009.
6. **Quantum Chemistry**, Donald A. McQuarrie, 1st Indian Edition, Viva Books Pvt. Ltd., New Delhi, 2003.
7. **Physical Chemistry**, N.B. Singh, S.S. Das, R.J. Singh, 2nd Edition, New Age International Publishers, New Delhi, 2007.
8. **Atkins' Physical Chemistry**, Peter Atkins, 8th Edition, Jolio De Paula, International Student Edition, Osford University Press, New York, 2010.
9. **Physical Chemistry**, Ira N Levine, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
10. **Physical Chemistry,** R. Stephen Berry, Stuart A. Rice, John Ross, 2nd Edition, Oxford University Press, New York, 2007.
11. **Quantum Chemistry**, Ira N. Levine, 5th Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
12. **Chemical Kinetics**, K.J. Laidler, 3rd Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
13. **Electrochemistry – Principles and Applications,** Porter
14. **Electrochemistry,** B.K. Sharma, Krishna Prakashan Media (p) Ltd, 1998.
15. **Fundamentals of Molecular Spectroscopy**, Colin N. Banwell, Elaine M. McCash, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.

16. **Thermodynamics, Kinetic Theory, and Statistical Thermodynamics**, Francis W. Sears Gerhard L. Salinger, 3rd Edition, Narosa Publishing House, New Delhi, 1998.

17. **An Introduction to Electrochemistry**, Samuel Glasstone, Litton Educational Publishing, Inc., New York, 2008.

18. **Industrial Electrochemistry**, D. Pletcher and F.C. Walsh, Chapman and Hall, II Edition, 1984.

19. **Industrial Electrochemistry**, F. C. Walsh D. Pletcher, Kluwer Academic Pub, II Edition, 1990.

20. **Principles of Physical chemistry**, Puri, Sharma, Pathania, Vishal publishing co.2017-2018.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Definition of thermodynamics and concept of enthalpy, free energy and entropy.*
2. *Maxwell's relations (Derivations), thermodynamic equations of state (Derivations), principle of equipartition energy and partial molar volume.*
3. *Principle of microscopic reversibility, Onsager reciprocal relation and its applications, Maxwell-Boltzmann distribution law (sterling's approximations).*
4. *Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics.*
5. *Evaluation of Lagrange's undetermined multipliers and translational, rotational, vibration, electronic and nuclear partition functions.*
6. *Sackur-Tetrode equation (derivation), third law and statistical entropies.*
7. *Einstein theory of heat capacity, Debye theory of heat capacity and Debye-T^3 law.*
8. *Reaction rates [collision theory and activated complex theory of bimolecular gaseous reactions].*
9. *Erying equation, Lindemann theory of unimolecular gaseous reactions.*
10. *Kinetics of reactions in solution and the kinetics of fast reactions.*
11. *Debye -Huckel equation for appreciable concentration and the electrochemical energy systems.*

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I – Semester M.Sc. Chemistry Practicals

ChHCP-1.1: Inorganic Chemistry Practicals – I

Total: 64 hrs.

COMPLEXOMETRIC TITRATIONS

1. Determination of **Calcium** and **Magnesium** ions present in the given solution by using EDTA.
2. Determination of **Copper** ions by using EDTA solution.
3. Determination of **Lead** ions by using EDTA solution.
4. Determination of **Nickel** ions by using EDTA solution.

REDOX TITRATIONS

5. Determination of Fe (II) and Fe (III) present in the given solution using $K_2Cr_2O_7$.
6. Determination of Fe (II) and Fe (III) present in the given solution by using ceric ammonium sulphate solution.
7. Determination of chromium and manganese in a sample.

GRAVIMETRIC ESTIMATIONS

8. Determination of **Nickel** as nickel dimethyl glyoximate.
9. Determination of **Lead** as lead chromate.
10. Determination of **Calcium** as calcium carbonate.
11. Determination of **Silver** as silver chloride.
12. Determination of **Zinc** as zinc ammonium phosphate.

REFERENCES:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. College Practical Chemistry, V.K. Ahluwalia, 1st Edition, University Press, 2005.
3. Analytical Chemistry, G.D. Christian, Petra Rector, 7th Edition, Wiley India, 2013.
4. Practical Inorganic Chemistry, K. Somashekara Rao, 1st Edition,
5. Principles of Inorganic Chemistry (UGC Syllabus), B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
5. Advanced Inorganic Chemistry, Gurudeep Raj, 26th Edition, GOEL Publishing House, Krishna Prakashan Media (P) Ltd., 2015.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Demonstration proficiency in complexometric titration.*
2. *Redox titration principles to accurately estimate iron in different oxidation states (Fe(II) and Fe(III)) using potassium dichromate, ceric ammonium sulfate, and vanadium solutions.*
3. *Analysis of multivalent metal ion systems through selective titration methods and interpretation of redox behavior.*
4. *Procedures of gravimetric determination of nickel, lead, calcium, silver, and zinc using appropriate precipitating agents.*

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ChHCP-1.2: Organic Chemistry Practicals – I

Total: 64 hrs.

PREPARATIONS

At least ten preparations must be carried out involving the following reactions.

Preparation of acetanilide from acetophenone, para nitroaniline from acetanilide, para bromoaniline from acetanilide, azlactone from hippuric acid, benzilic acid from benzil, anthranilic acid from phthalimide, 2-Phenyl indole from Phenyl hydrazine and acetophenone, 2,5 Dihydroxy acetophenone from Hydroquinone, Acridone from 2- Choro benzoic acid, 1,2,3,4 tetrahydro carbazole from Phenyl hydrazine, cinnamic acid from Perkin reaction,7-hydroxy-4-methyl coumarin, benzanilide from benzophenone, Anthraquinone from Anthracene, diphenylmethane from benzyl chloride.

REFERENCES:

1. **Advanced Practical Organic Chemistry,** N K Vishnoi, second edition, Vikas Publishing House Pvt. Ltd, 1996.
2. **Comprehensive Practical Organic Chemistry:** Preparation and Quantitative Analysis Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001.
3. **Systematic Laboratory Experiments in Organic Chemistry,** Arun Sethi, New Age International, 2003.
4. **Comprehensive Practical Organic Chemistry:** Qualitative Analysis Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004.
5. **Practical Organic Chemistry: Qualitative Analysis,** Bhutani S.P. Chhikara A, First edition, ANE books-new Delhi, 2009.
6. **Vogel's Textbook of Practical Organic Chemistry,** Brian S. Furniss, 5th Edition, Pearson India, 2005.
7. **Laboratory techniques in Organic chemistry,** V.K. Ahluwalia, Pooja Bhagat & Renu Aggarwal, I.K. International Publishing House Pvt. Ltd.
8. **Laboratory Manual of Organic Chemistry**, Raj K. Bansal. 5th edition, New Age international, 2008.
9. **Practical Organic Chemistry,** F.G. Mann, B.C Saunders, Fourth edition, Pearson India, 2009.
10. **Modern Organic Synthesis in the Laboratory,** Jie Jack Li, Chris Limberakis, Derek A.P. Flum, Oxford University Press, 2007.
11. **A small-scale approach to organic Laboratory Techniques,** Donald L. Pavia, Gary M. Lampman, George S. Kriz, third edition, Mary Finch, 2011.
12. **Microscale Organic laboratory with Multistep and Multiscale Syntheses**, Dana W. Mayo, Ronald M. Pike, David C. Forbes, fifth edition, John Wiley & Sons, Inc, 2011.
13. **Macroscale and Microscale Organic Experiments,** Kenneth L. Williamson, Katherine M. Masters, sixth edition, Charles Hartford, 2011.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Preparation of various organic compounds viz., acetanilide, para-nitroaniline, para-bromoaniline, etc.*
2. *Principle and mechanism of organic reactions involved in the synthesis.*
3. *Concepts of product yield, physical characterization like melting point and purification methods such as recrystallization, distillation, etc.*

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ChHCP-1.3: Physical Chemistry Practicals – I

Total: 64 hrs.

1. Conductometric titration of oxalic acid v/s strong base.
2. Conductometric titration of mixtures of acetic acid and dichloroacetic acid with sodium hydroxide.
3. Conductometric titration of mixtures of and acetic acid, monochloroacetic and trichloroacetic acid with sodium hydroxide.
4. Determination of strength of $ZnSO_4$ solution using $BaCl_2$ solution by conductometry.
5. Determination of strength of $NiSO_4$ solution using $BaCl_2$ solution by conductometry.
6. Determination of pK_a value of weak electrolyte (acetic acid) by conductometry.
7. Determination of pK_a value of weak electrolyte (formic acid) by conductometry.
8. Potentiometric titration of ceric ammonium sulphate (CAS) v/s ferrous ammonium sulphate (FAS).
9. Determination of pK_a value of polybasic acids by potentiometry.
10. Determination of pK_a value of weak electrolyte (acetic acid) by potentiometric titration.
11. Determination of pK_a value of weak electrolyte (formic acid) by potentiometric titration.
12. To study the effect of ionic concentration on the rate constant of the reaction.
13. To study the effect of ionic concentration on the rate constant of the reaction.
14. Partial molar volume of ethanol-water system.
15. Polymer viscosity.

REFERENCES:

1. College Practical Chemistry, V.K. Ahluwalia, Sunitha Dhingra, Adarsh Gulati, I Edition, University Press, 2005.
2. Experimental Physical Chemistry, V.D. Athawale, Parul Mathur, I Edition, New Age International Publishers, 2001.
3. Practical Physical Chemistry, B. Viswanathan, P.S. Raghavan, I Edition, Viva Books, 2009.
4. Experimental Physical Chemistry: A Laboratory Textbook, Arthur M. Halpern, George C. McBane, III Edition, W.H. Freeman and Company, 2006.
5. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh, I Edition, New Central Book Agency, 2012.
6. Vogel's Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas, VI Edition, Pearson Education, 2000.
7. Practical Physical Chemistry, Findlay Alexander, XVII Edition, Longman, 1966.
8. A Textbook of Practical Physical Chemistry, K. Fajans, J. Wüst, Revised Edition, Macmillan, 1957.
9. Experiments in Physical Chemistry, Carl W. Garland, Joseph W. Nibler, David P. Shoemaker, VIII Edition, McGraw-Hill, 2008.
10. Practical Physical Chemistry, James Brierley Firth, I Edition, Longmans, Green & Co., 1911.

11. Findlay's Practical Physical Chemistry, B.P. Levitt, IX Edition, Longman, 1985.
12. Experiments in Physical Chemistry, J.M. Wilson, R.J. Newcombe, A.R. Denaro, II Edition, Pergamon Press, 1968.
13. A Manual of Practical Physical Chemistry (Classic Reprint), Francis William Gray, Reprint Edition, Forgotten Books, 2017 (original 1908).
14. Advanced Practical Physical Chemistry, J.B. Yadav, I Edition, Goel Publishing House, 2011.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Practical knowledge on conductometry, potentiometry and their analytical applications.*
2. *Rate constant of a given reaction and its determknation.*
3. *Concept of partial molar volume and its determination.*
4. *Practical knowledge of viscosity and its determination.*

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M.Sc. Chemistry Syllabus: 2025 - 2026 (CBCS Scheme)
II - SEMESTER
ChHCT-2.1: ANALYTICAL CHEMISTRY-II

Total: 64 hrs.

UNIT-I: ELECTRONIC SPECTROSCOPY **16 hrs.**

Introduction: Nature and interaction of electromagnetic radiation with matter, types of molecular spectra, selection rules, characteristic features for absorption or emission of electromagnetic radiation, band width, factors contributing to the band width, Doppler broadening, intensity of spectral lines and transition probability, factors influencing positions and intensity of spectral lines, energy dissipation from excited states.

Electronic Spectroscopy: Energy levels, molecular orbitals, theory of electronic spectroscopy, Frank-Condon principle, transition probability, the designation of various transitions, types of absorption bands, solvent effect on electronic transitions, electronic spectra of polyatomic molecules, Woodward-Fieser rules, calculation of absorption maximum in conjugated dienes, trienes, polyenes, poly-ynes, aromatic compounds, heterocyclic systems and α,β- unsaturated carbonyl compounds. Stereochemical factors in electronic spectroscopy - biphenyls and binaphthyls. Angular distortion and cross-conjugation, Steric inhibition of resonance. Instrumentation for electronic spectroscopy.

UNIT-II: INFRARED SPECTROSCOPY AND RAMAN SPECTROSCOPY **16 hrs.**

Vibrational motion of a diatomic molecule, force constant and bond strengths, vibration-rotation spectroscopy, characteristic features.

Infrared (IR) spectroscopy: Origin of IR spectrum, IR regions (finger print and group frequency regions). Absorption of infrared radiation, molecular vibrations, fundamental vibrations and overtones. Factors influencing vibrational frequencies (physical states of the sample, vibrational coupling, electrical effect, inductive effects, hydrogen bonding and ring structure), metal-ligand vibrations, instrumentation – FTIR, sampling handling techniques, interpretation and examination of IR spectrum, group frequencies of - alkanes, alkenes, alkynes, aromatic hydrocarbons, alcohols, phenols, aldehydes, ketones, carboxylic acids, acid halides, acid anhydrides, acid amides, amino acids, amines, isocyanates, thiocyanites, esters, lactones, ethers, epoxides, peroxides, nitro and nitroso groups, heteroaromatic compounds, sulphur and silicone compounds, applications of IR spectroscopy. Applications of IR to inorganic complexes – amino, sulphato, thiocyanato and thiourea complexes.

Raman spectroscopy: Brief introduction-Raman effect (Rayleigh scattering, Raman scattering - Stokes and Anti-Stokes lines), rotational and vibrational Raman spectra, rule of mutual exclusion, Raman intensity and bandwidth, instrumentation, Raman effect in solids, liquids and gases, applications of Raman spectroscopy (Inorganic, Organic, Physical and Polymer chemistry), Resonance Raman Spectroscopy (RRS) and its applications, Resonance Raman Effect (RRE), non-linear Raman effects, Coherent Anti-Stokes Raman Scattering (CARS) and its applications. Comparison between IR and Raman spectroscopy.

UNIT-III: NMR SPECTROSCOPY **16 hrs.**

^{1}H NMR spectroscopy: Introduction to nuclear spin states, nuclear magnetic moments and absorption of energy. The mechanism of absorption (resonance). Instrumentation & Chemical Shift: sample handling, shielding, deshielding and chemical shift, standard for proton NMR, Tetramethyl silane (TMS) as reference compound, advantages of TMS as a reference compound, measurement of chemical shift: NMR Scale, δ (or ppm) and τ scale, factors

affecting chemical shift: electronegativity-inductive effect, anisotropic effects, hydrogen bonding, van der Waals deshielding.
Magnetic anisotropy, spin-spin splitting, (n+1) rule, Pascal's triangle, the coupling constant, Typical ^{1}H NMR absorption of - alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, amines, nitriles, aldehydes, ketones, esters, carboxylic acid and amide compounds.
Applications of NMR spectroscopy in hydrogen bonding, keto-enol tautomer, cis-trans isomers, conformational analysis and deuterium exchange reactions.

UNIT-IV: FES, AAS, AES, MOLECULAR LUMINESCENCE SPECTROSCOPY

16 hrs.

Flame emission spectroscopy (FES): Basic principles, flames and flame temperatures, excitation profiles and chemical reactions in flame, spectra of metals in flame, instrumentation (single beam and double beam), evaluation methods in flame photometry, factors affecting intensity of emitted radiation, interferences, background correction methods, applications, flame emission experiments, limitations of FES.
Atomic absorption spectroscopy (AAS): Basic principles, absorption of radiation energy by atoms, instrumentation (single beam and double beam), detection limits, interferences, advantages of AAS over FES, some typical AAS determinations.
Atomic emission spectroscopy (AES): Basic principles, advantages and disadvantages of AES, origin of spectra, instrumentation, measurement of light intensity, applications.
Molecular luminescence spectroscopy: Basic principles of fluorescence and phosphorescence, excitation and deactivation processes (energy level diagram), factors affecting fluorescence and phosphorescence, quenching of fluorescence, Stem-Volmer equation, fluorescence (or phosphorescence) intensity, fluorescence and chemical structure, instrumentation for fluorimetry and phosphorimetry, application of fluorimetry and phosphorimetry, fluorescent indicators, comparison between fluorimetry and phosphorimetry, chemiluminescence.

REFERENCES:

1. **Vogel's Text book of Quantitative Chemical Analysis**, J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India (2012).
2. **Principles of Instrumental Analysis**, D. A. Skoog, E. J. Holler, T. A. Nieman, 5th Edition, Thomson Aisa Pvt. Ltd., Singapore (2004).
3. **Instrumental methods of Chemical Analysis,** H. Kaur, 12th Edition Pragathi Prakashan, New Delhi, India (2018)
4. **Quantitative Chemical Analysis,** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA (2003).
5. **Fundamentals of Analytical Chemistry**, D. A. Skoog, D. M. West, E. J. Holler, S. R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore (2004).
6. **Introduction to Spectroscopy,** D. L. Pavia, G. M. Lampman, G. S. Kriz, 3rd Edition, Cengage Learning India Pvt. Ltd., New Delhi (2008).
7. **Spectrometric Identification of Organic Compounds,** R. M. Silverstein, F.X. Webster, 6th Edition, Wiley Student Edition, New Delhi, India (2007).
8. **Applications of Absorption Spectroscopy of Organic Compounds**, John R. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi, India (2007).
9. **Instrumental Analysis**, D. A. Skoog, E. J. Holler, S. R. Crouch,11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi (2012).
10. **Molecular Structure and Spectroscopy**, G. Aruldhas, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, India (2007).

11. **Analytical Chemistry – Theory and Practice,** R. M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India (2007).
12. **Vibrational Spectroscopy – Theory and Applications**, D. N. Sathyanarayana, New Age International Publishers, New Delhi, India (2004).
13. **Organic Spectroscopy**, William Kemp, 3rd Edition, Palgrave, New York, USA (2004).
14. **Basic Atomic and Molecular Spectroscopy**, J. Michael Hollas, Royal Society of Chemistry, Cambridge, UK (2002).
15. **Quantitative Analysis,** Day and Underwood, Prentice/Hall Pvt. Ltd. 6th Edition (1993).
16. **Vogel's text Book of Quantitative Chemical Analysis,** Revised by G. H. Jaffery, J. Bassett, J. Mendham and R.C. Denny, ELBS 5th Edition (1998).
17. **Analytical Chemistry,** Gray D. Christian,5th Edition, John Wiley and Sons, Inc.
18. **Instrumental Methods of Analysis**-Willard, Merrit and Dean, 7th Edition, (1998).
19. **Instrumental Methods of Chemical Analysis** - B. K. Sharma, Goel Publishing House. Meerut, (2000).

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Nature and interaction of electromagnetic radiation with matter, types of molecular spectra and selection rules of electronic spectra.*
2. *Theory of electronic spectroscopy and Frank-Condon principle.*
3. *Concepts of vibration motion of a diatomic molecule, force constant, bond strengths, vibration-rotation spectroscopy and its characteristic features.*
4. *Concepts of infrared spectroscopy and its role in structure elucidation of organic compounds.*
5. *Basic theory and instrumentation of Raman spectroscopy.*
6. *Important concept of FES, AAS, AES, Molecular luminescence spectroscopy.*
7. *Concept of symmetry elements and symmetry operations of different molecules.*
8. *Infrared and Raman activity of molecules belong to C_{2V} (H_2O, ClF_3, cis-N_2F_2) and C_{3V} (NH_3) point groups.*

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ChHCT-2.2: INORGANIC CHEMISTRY - II

Total: 64 hrs.

UNIT-I: CONCEPTS OF ACIDS AND BASES **16 hrs.**

Arrhenius concept, Bronsted-Lowry concept, conjugate acid-base pairs, amphiprotonic substances, leveling and differentiating solvents, Bronsted base, variation of basicity of the anions (CH_3^-, NH_2^-, OH^-, F^-), variation of acidity (H_2O, H_2S, H_2Se, H_2Te), order of acidity of HX molecules in aqueous solution, stability and acidity of the oxyanions (ClO^-, ClO_2, ClO_3^-, ClO_4^-, BrO^-, BrO_3^-, IO^-, IO_3^-, IO_4^-, NO_2^-, NO_3^-, SO_4^{2-}, SO_3^{2-}), Relative strength of oxy acids ($HClO$, $HClO_2$, $HClO_3$, $HClO_4$), relative acids strength of oxy acids of the elements of the same group ($HClO_3$, $HBrO_3$, HIO_3), acidic strength of H_3PO_2, H_3PO_3 and H_3PO_4, solvent system (auto-ionization) concept, Lewis acids and bases, relative order of Lewis acidic strengths (BF_3, BCl_3, BBr_3 and BI_3), relative order of Lewis basic strengths (NH_3, H_2O and HF), relative order of Lewis basic strengths of NH_3, PH_3, AsH_3, SbH_3 and BiH_3, Pearson's classification of Lewis acids and bases into hard and soft acids and bases, HSAB principle, Usanovich concept.

UNIT-II: INORGANIC POLYMERS AND CAGES **16 hrs.**

Inorganic Polymers: Preparation, structure and reactivity of borazine, substituted borazines (B-trimethyl borazine, boroxine, N-trimethyl borazine), boron nitride. Polymers containing phosphorous – chain polymers and network polymers, preparation and properties of polyphosphonitrilic chlorides, structure of $(NPCl_2)_3$, $(NPCl_2)_4$, vitreous polyphosphates – phosphate glasses, crystalline polymetaphosphates, structure of HPO_3, $(HPO_3)_2$, $(HPO_3)_4$, polyorthophosphoric acids. Borophosphate glasses.

Polymeric compounds of sulphur: nitrides of sulphur, preparation, structure and properties of $(SN)_4$, preparation of S_2N_2, S_5N_2. Thiazyl halides – trithiaziyl trifluoride $(NSF)_3$, tetrathiazyl tetrafluoride $(NSF)_4$, trithiazyl trichloride $(NSCl)_3$. Imides of sulphur – preparation, structure and properties.

Cages: Structure and properties of P_4O_6, P_4O_7, P_4O_8, P_4S_3, P_4S_4, P_4S_5, P_4S_6, P_4S_7 and P_4S_8.

UNIT-III: BORON HYDRIDES AND METAL CLUSTERS **16 hrs.**

Boron hydrides, neutral boron hydrides, $(BH)_pH_q$ – structure and bonding, topological approach to boron hydride structure (styx numbers), preparation, structure and properties of B_4H_{10}, $[B_8H_8]^{2-}$, $[B_{12}H_{12}]^{2-}$. Structural relationship of closo, nido, arachno, hypo, conjucto boranes. Carboranes - preparation, structure and properties of $[C_2B_9H_{11}]^{2-}$. Structure and bonding of metalloboranes and metallacarboranes, isolobal fragments, Zintl ions, carbide clusters.

Metal clusters: Dinuclear clusters, structure, preparation and properties of dinuclear compounds -$[Re_2Cl_8]^{2-}$, $[Re_2Cl_4(PMe_2Ph_4)]^+$, $[Mo_2(SO_4)_4]^{3-}$, $[Fe_2(CO)_9]$, $[Mo_2(OR)_6]$ and $[W_2(OR)_6]$. Trinuclear clusters – structure, preparation and properties of $[(ReCl_3)_3]$, $[(Fe_3(CO)_{12}]$ and $[(Ru_3(CO)_{12}]$. Tetranuclear clusters – structures of $[W_4(OR)_{12}]$, $[Co_4(CO)_{12}]$ and $[Ir_4(CO)_{12}]$.

UNIT-IV: COORDINATION CHEMISTRY – I **16 hrs.**

Effective atomic number (EAN) rule, stability of complexes, stability constants, factors affecting the stability of complexes (nature of metal ion, ligand, chelate effect), step-wise stability (K_n) and Overall stability constant (E_n), relation between K_n and E_n, Irving William series. Determination of stability constants from - thermodynamic, spectrophotometric, pH, polarographic, ion-exchange and solubility methods, determination of composition of complexes– Jobs, mole ratio and slope ratio methods.

Stereochemistry of coordination compounds with different coordination numbers, isomerism in coordination compound– structural (hydrate, coordination, linkage, position isomerism), stereo isomerism (geometrical and optical isomerism).

REFERENCES:

1. **Inorganic Chemistry – Principles of Structure and Reactivity**, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Okhil K. Medhi, 4th Edition, Pearson Education, Indian Edition, New Delhi, India, 2013.
2. **Inorganic Chemistry,** Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, 5th Edition, Oxford University Press, UK, 2013.
3. **Inorganic Chemistry – Principles of Structure and Reactivity**, James E. Huheey, Ellen A Keiter, Richard L. Keiter, 4th Edition, Pearson, Indian Edition, New Delhi, India, 2004.
4. **Inorganic Chemistry,** Gary L. Miessler, Donald A. Tarr, 3rd Edition, Pearson Education, New Delhi, India, 2004.
5. **Inorganic Chemistry,** Keith F. Purcell, John C. Kotz, First Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi, India 2010.
6. **Concise Inorganic Chemistry,** 5th Edition, J.D. Lee, Blackwell Science Ltd., London, 2003.
7. **Advanced Inorganic Chemistry, Volume-I,** Satya Prakash, G.D. Tuli, S, K, Basu, R.D. Madan, S. Chand and Company, New Delhi, India, 2008.
8. **Principles of Inorganic Chemistry (UGC Syllabus)**, B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
9. **Inorganic Chemistry,** James E. House, First Indian Reprint, Academic Press, USA, 2010.
10. **Basic Concepts of Inorganic Chemistry,** D.N. Singh, Pearson Education, New Delhi, 2010.
11. **Advance Inorganic Chemistry,** F. Albert Cotton, Geoffrey, Wilkinson, Carlos Murillo, Manfred Bochmann, 6th Edition, Wiley Student Edition, John Wiley and Sons, INC, New York, 2004.
12. **Vogel's Qualitative Inorganic Analysis,** 7th Edition, G. Svehla, Pearson Education, New Delhi, 1996.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Concepts of acid and bases including HSAB theory.*
2. *Knowledge on the structure and reactivity of borazine, substituted borazines boron nitride chain polymers and network polymers.*
3. *Metal clusters: structure, preparation and properties of dinuclear, trinuclear clusters and tetranuclear clusters.*
4. *Concepts on stability of complexes, EAN rule and isomerism in coordination compounds.*

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ChHCT-2.3: ORGANIC CHEMISTRY – II

Total: 64 hrs.

UNIT-I: MOLECULAR REARRANGEMENTS 16 hrs

General mechanistic treatment of nucleophilic, electrophilic and free-radical rearrangements.

Rearrangements involving migration to electron deficient Carbon: Wagner-Meerwein rearrangement, dienone-phenol rearrangement, benzil-benzilic rearrangement. Rearrangements involving diazomethane and alkanes- Wolf rearrangement, migration of hetero atoms, rearrangement of aryl hydroxylamines- Bamberger rearrangement.

Rearrangements reactions involving migration to electron rich Carbon: Favorskii, Sommlet-Hauser, Neber, Stevens and Wittig rearrangements.

Rearrangements reactions involving migration to electron deficient Nitrogen: Hoffmann, Curtius, Lossen, Schmidt, and Beckmann rearrangement.

Rearrangements reactions involving migration to electron deficient Oxygen: Bayer-Villiger oxidation and Dakin rearrangement.

Aromatic Rearrangements: Migration around the aromatic nucleus – migration of alkyl groups and halogens. Migration of group from the side chain to the nucleus – rearrangement of aniline derivatives (N-haloacetanilides, Hofmann-Martius rearrangement, phenylhydroxylamine, diazoamino compounds, N-nitroanilines, N-nitosoanilines).

UNIT-II: OXIDATION AND REDUCTION REACTIONS 16 hrs.

Oxidation reactions: Introduction, oxidation by potassium permanganate - alcohols, alkenes, alkynes, aldehydes, ketones, amines, nitro compounds, aromatic side chains, aromatic rings. Oxidation by manganese dioxide: allylic and benzylic alcohols. Oxidation of alcohols and phenols by chromic acid and potassium dichromate, Jones reagent, chromium trioxide-pyridine complex, pyridinium chlorochromate (PCC), pyridinium dichromate (PDC), oxidation of alkenes, aromatic side chains and aromatic rings. Oxidation with peracids – oxidation of alkenes and ketones. Oxidation with miscellaneous oxidants: Ozones, Lead tetra-acetate, selenium dioxide, osmium tetroxide and periodic acid.

Reduction reactions: Homogeneous hydrogenation - reduction with metal hydrides (LiAlH4, NaBH4, B2H6), reduction by dissolving metals (Na-alcohol, Na-liq. ammonia, Mg-Hg, Zn-HCl), reduction by miscellaneous reducing agents (di-imide, hydrazine, silanes, $SnCl_2$, Zn-acetic acid and Zn-NaOH).

Heterogeneous hydrogenation – introduction to Pt, Pd, Ni, Copper chromite catalysts, reduction of alkenes, alkynes, aldehydes, ketones, aromatic compounds, nitriles, oximes and nitro compounds.

UNIT-III: HETEROCYCLIC COMPOUNDS 16 hrs.

Introduction and nomenclature of heterocyclic compounds.

Five-membered heterocycles with one hetero atom: Synthesis and reactivity of pyrrole, furan thiophene, indole, benzofuran and benzothiophene.

Five-membered heterocycles with two hetero atoms: Synthesis and reactivity of imidazoles, thiazoles, oxazoles and pyrazoles.

Six-membered heterocycles: Synthesis and reactivity of pyridine, quinoline and isoquinoline.

Seven-membered heterocycles: Synthesis and reactivity of azepine, oxepine and thiepine.

Mesoinonic compounds: Nomenclature, synthesis, reactions and applications of sydnones, oxadiazolium and thiadiazolium compounds.

UNIT-IV: REAGENTS IN ORGANIC SYNTHESIS **16 hrs.**

2,3-Dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) – Preparation, Synthetic Applications - dehydrogenation, aromatization, oxidative cyclization, oxidation of benzylic and allylic alkyl groups.

N, N-Dicyclohexylcarbodiimide (DCC) – Preparation, Synthetic Applications - synthesis of peptides, esters, and peroxides. Heterocylisation reactions, synthesis of amides from carboxylic acids and amines. Synthesis of α,β-unsaturated ketones and esters.

Lithium diisopropyl amide (LDA) – Preparation, Synthetic Applications - alkylation and acylation of ketones, aldol condensation, alkylation of acids, esters, amides, imides and nitriles.

Diisobutylaluminium hydride (DIBAL) – Preparation, synthetic applications [reduction of alkynes, carboxylic acids, amides, ketones, esters, lactones and nitriles].

Aluminium isopropoxide – Reduction of carbonyl compounds, oxidation of alcohols, hydrolysis of oximes, preparation of ethers, reaction with epoxides.

Diazomethane – Preparation of diazomethane, methylation, homologation, addition reactions, miscellaneous reactions.

Organosilicon compounds – Preparation, reactions involving chlorotrialkylsilanes, trimethylsilyl iodide, arylsilanes, vinylsilanes and allylsilanes. Preparation and synthetic applications of Gilman reagent.

REFERENCES:

1. **Organic Chemistry**, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press, UK, 2001.
2. **Organic Chemistry** – Solution Manual, S. Warren, Oxford University Press, UK, 2009.
3. **Advanced Organic Chemistry**, **Part-A: Structure and Mechanisms,** 5th Edition, Francis A. Carey, Richard J. Sundberg, Springer, New York, 2007.
4. **Principles of Organic Synthesis**, R.O.C. Norman, J.M. Coxon, 3rd Edition (First Indian Reprint), Nelson Thrones, UK, 2003.
5. **Advance Organic Chemistry – Reactions, mechanisms and structure,** Jerry March, 4th Edition, Wiley India Pvt. Ltd., New Delhi, 2008.
6. **Organic Reaction Mechanisms**, V.K. Ahluwalia, R.K. Parashar, 3rd Edition, Narosa Publishing House, New Delhi, 2009.

7. **Organic Chemistry**, Solomons, Fryhle, 8th Edition (Wiley Student Edition), Brijbasi Art Press Ltd., Noida, India 2004.

8. **Organic Chemistry**, G. Marc Loudon, 4th Edition, Oxford University Press, UK, 2000.

9. **Organic Chemistry**, R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.

10. **Organic Chemistry**, L.G. Wade, JR., 5th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, India, 2004.

11. **Organic Chemistry**, M.A. Fox, J.K. Whitesell, 2nd Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, London, 1997.

12. **Organic Chemistry,** Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.

13. **Heterocyclic Chemistry**, Thomas L. Gilchrist, 3rd Edition, Pearson Education, New Delhi, India, 2007.

14. **Heterocyclic Chemistry**, Raj K, Bansal, 4th Edition, New Age International Publishers, New Delhi, India, 2009.

15. **Organic Chemistry**, I.L. Finar, 5th Edition (Volume-2), Pearson Education, New Delhi, India, 2009.

16. **Organic Chemistry**, I.L. Finar, 6th Edition (Volume-1), Pearson Education, New Delhi, India, 2007.

17. **Heterocyclic Chemistry**, J.A. Joule, K. Mills, 4th Edition, Blackwell Publishing, Wiley India Pvt. Ltd., New Delhi, 2009.

18. **Heterocyclic Chemistry:** Five-Membered Heterocycles, R. R. Gupta, M. Kumar, V. Gupta, Springer-Verlag Berlin Heidelberg New York in 1999.

19. **The Chemistry of Heterocycles:** Structure, Reactions, Syntheses, and Applications, Theophil Eicher, Siegfried Hauptmann, Wiley publications, 2003.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Rearrangement reactions involving migration to electron-rich and electron-deficient carbon, nitrogen, and oxygen atoms.*
2. *Oxidation reactions using different reagents to change alcohols, alkenes, alkynes, and Heterogeneous hydrogenation involving Pt, Pd, Ni etc.*
3. *Synthesis and reactions of different heterocyclic compounds. Concepts of Mesoinonic compounds.*
4. *Concepts of reagents used in organic synthesis, like DDQ, DCC, LDA, DIBAL, aluminium isopropoxide, etc.*

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ChHCT-2.4: PHYSICAL CHEMISTRY – II

Total: 64 hrs.

UNIT-I: QUANTUM MECHANICS - II **16 hrs.**

Particle wave–the Schrödinger equation (one-dimensional time-dependent and time independent), the wave function and its physical meaning, condition for acceptable wave function, conditions of normalization and orthogonality.

Eigen values and eigen functions, Hamiltonian property of operators, postulates of quantum mechanics. Matrix, vector and quantum mechanics-Matrices, algebra of matrices, vectors, algebra of vectors, vector representation of wave functions, matrix representation of operators, free particle system position, momentum and uncertainty relations, energy of the particle, motion in three dimensions, formulation of Schrödinger's equation (application to particle in one- and three-dimensional boxes). Particle in a box– infinite potential barriers, one dimensional box, three-dimensional box, particle with finite potential barrier of definite thickness, the quantum mechanical tunnelling.

UNIT-II: MOLECULAR SPECTROSCOPY **16 hrs.**

The theoretical treatment of rotation, (rigid and non-rigid rotator models), isotopic effect in rotation spectra, intensity of rotational lines, rotational spectra of polyatomic molecules, vibrational excitation effect, linear poly-atomic molecules, linear harmonic oscillator model. The anharmonic vibrations, Morse potential, Potential energy surfaces, fundamental vibrational frequency, overtones and hot bands. Degree of freedom of polyatomic molecules. Vibrational energy of a diatomic molecule, vibrating diatomic molecules, PQR branches diatomic vibrating rotator, asymmetry of rotation-vibration band, vibration of polyatomic molecules, vibrational Raman spectra and NMR spetra.

UNIT-III: RADIATION AND PHOTOCHEMISTRY **16 hrs.**

Photochemistry: Photophysical processes, A review of laws of photochemistry (Beer-Lambert law, Grotthus-Draper law, Bunsen and Roscoe law, Stark-Einstein law and Platnikow law). Quantum yield and its determination. Actinometers (Bunsen and Roscoe's actinometer, Eder's actinometer, Uranyl Oxalate actinometer, Malachite Green Leucocyanide actinometer, Ferrioxalate actinometer and Reinecke's salt actinometer). Lasers in photochemical studies, photo-electrochemistry, solar energy conversion and storage.

Radiation chemistry: Interaction of radiation with matter, method of losing energy and common units, dosimetry (terms and units, chemical dosimeters - Fricke and Ceric sulphate dosimeters). Radiation chemistry of gases, water, aqueous solution and solids. Biological effects of radiation. Safety measures against radiation hazards.

UNIT-IV: POLYMER CHEMISTRY **16 hrs.**

Types of polymers (linear, branched, cross linked and copolymer with example - a qualitative account). Molecular weight distributions: number average and weight-average molecular weight. Thermoplastics and thermosets, fibers and plastics (only qualitative account). Determination of average molecular weight – end group analysis, viscosity method, ultra-centrifugation method, osmotic pressure method [derivation of equations not necessary], sedimentation velocity method, turbidity method and light scattering method [Zimm plot]. Kinetics of polymerization-condensation and step-growth polymerization, kinetics of free radical polymerization, chain transfer reactions, anionic polymerization, co-polymerization. Polydispersivity.

Analysis and testing of polymers, chemical analysis of polymers, spectroscopy method, X-ray diffraction study, microscopy and thermal analysis. Physical testing: tensile strength, fatigue, impact tear resistance hardness and abrasion resistance. Properties of commercial polymers-fire retarding polymers-electrically conducting polymers, biomedical polymers, polymer blends, alloys and composites. Polymer additives (Fillers, Plasticizers, Antioxidants, Colorants, Flame Retardants, Stabilizers) and compounding.

REFERENCES:

1. **Quantum Chemistry**, R.K. Prasad, 4th Edition, New Age International Publishers, New Delhi, 2010.
2. **Polymer Chemistry,** Malcolm P. Stevans, First Indian Edition, Oxford University Press, New York, 2008.
3. **Quantum Mechanics for Chemists**, David O. Hayward, The Royal Society of Chemistry, UK, 2002.
4. **Principles of Physical Chemistry**, B.R. Puri, L.R. Sharma, M.S. Pathania, 45th Edition, Vishal Publishing House, Jalandhar, India, 2012.
5. **Physical Chemistry – A Molecular Approach**, Donald A. McQuarrie, John D. Simon, 3rd Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
6. **Elements of Physical Chemistry**, B.R. Puri, L.R. Sharma, M.S. Pathania, 1st Edition, Vishal Publishing House, Jalandhar, India, 2013.
7. **Quantum Chemistry**, John P. Lowe, Kirk A. Peterson, 3rd. Edition, Academic Press, London, UK, 2009.
8. **Quantum Chemistry**, Donald A. McQuarrie, 1st Indian Edition, Viva Books Pvt. Ltd., New Delhi, 2003.
9. **Physical Chemistry**, N.B. Singh, S.S. Das, R.J. Singh, 2nd Edition, New Age International Publishers, New Delhi, 2007.
10. **Atkins' Physical Chemistry**, Peter Atkins, 8th Edition, Jolio De Paula, International Student Edition, Oxford University Press, New York, 2010.
11. **Physical Chemistry**, Ira N Levine, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
12. **Physical Chemistry,** R. Stephen Berry, Stuart A. Rice, John Ross, 2nd Edition, Oxford University Press, New York, 2007.
13. **Quantum Chemistry**, Ira N. Levine, 5th Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
14. **Chemical Kinetics**, K.J. Laidler, 3rd Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
15. **Textbook of Polymer Science**, Fred W. Billmayer, 3rd. Edition, John Wiley & Sons Pvt. Ltd., Singapore, Indian Edition, 2007.

16. **Fundamentals of Molecular Spectroscopy**, Colin N. Banwell, Elaine M. McCash, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
17. **Polymer Science – A Textbook**, V.K. Ahluwalia, Anuradha Mishra, Ane Books India, Noida, 2008.
18. **Thermodynamics, Kinetic Theory, and Statistical Thermodynamics**, Francis W. Sears Gerhard L. Salinger, 3rd Edition, Narosa Publishing House, New Delhi, 1998.
19. **Polymer Science**, V.R. Gowarikar, N.V. Viswanathan, Jayadev Sreedhar, 5th Edition, New Age International Publishers, New Delhi, 2005.
20. **An Introduction to Electrochemistry**, Samuel Glasstone, Litton Educational Publishing, Inc., New York, 2008.
21. **Industrial Electrochemistry**, D. Pletcher and F.C. Walsh, Chapman and Hall, 2nd Edition, 1984.
22. **Molecular structure and spectroscopy**- G. Aruldhas, second edition PHI learning private limited Delhi-110092, 2017.
23. **Spectroscopy** H. Kaur, A Pragati edition, 2009.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Basic concept of quantum mechanics and its importance.*
2. *Schrodinger wave equation and its applications.*
3. *Principles of rotational, vibrational, Raman and NMR spectroscopy.*
4. *Laws of photochemistry, radiation dosimeters, biological effects of radiation and precautionary measures.*
5. *Polymers definition, classification, properties, applications and average molecular weight concept.*

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II –SEMESTER M.Sc. Chemistry Practicals
ChHCP-2.1: Inorganic Chemistry Practicals – II

Total: 64 hrs.

ORE ANALYSES:

1. Determination of calcium carbonate present in limestone ore.
2. Determination of iron present in hematite ore.
3. Determination of MnO_2 present in pyrolusite ore.
4. Determination of nitrite present in sodium nitrite ore.

DETERMINATIONS:

1. Determination of chlorine in bleaching powder.
2. Determination of O_2 in hydrogen peroxide.
3. Determination of chromium and manganese in steel samples.
4. Determination n of copper in copper sulphate.
5. Separation and determination of copper and iron in a given mixture.
6. Separation and determination of nickel and iron in a given mixture.
7. Determination of ascorbic acid by redox method.
8. Determination of chlorate in potassium chlorate solution.

REFERENCES:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. College Practical Chemistry, V.K. Ahluwalia, 1st Edition, University Press, 2005.
3. Analytical Chemistry, G.D. Christian, Petra Rector, 7th Edition, Wiley India, 2013.
4. Practical Inorganic Chemistry, K. Somashekara Rao, 1st Edition,
5. Principles of Inorganic Chemistry (UGC Syllabus), B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
6. Advanced Inorganic Chemistry, Gurudeep Raj, 26th Edition, GOEL Publishing House, Krishna Prakashan Media (P) Ltd., 2015.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Practical skills of ore analysis such as calcium carbonate, iron, MnO_2 and nitrite by quantitative approach.*
2. *Skills on ore sampling and analysis of sample solutions.*
3. *Titrimetric estimations of chlorine, O_2, chromium, manganese, copper, ascorbic acid and chlorate.*

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ChHCP-2.2: Organic Chemistry Practicals – II

64 hrs.

Carry out at least six preparations and six estimations.

I. PREPARATION OF DYES AND DRUGS

Preparation of methyl orange, fluorescein, crystal violet and phenolphthalein. Preparation of paracetamol, phenacetin, sulphanilamide, antipyrine, aspirin and benzocaine.

II. QUANTITATIVE ANALYSES

Estimation of hydroxyl, amino, ester and nitro groups. Estimation of glycine by Sorensen's method, ascorbic acid by iodometry, paracetamol by hydrolysis. Determination of saponification value and iodine value of oils and fats.

REFERENCES:

1. **Advanced Practical Organic Chemistry,** N K Vishnoi, second edition, Vikas Publishing House Pvt. Ltd, 1996.
2. **Comprehensive Practical Organic Chemistry:** Preparation and Quantitative Analysis Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001.
3. **Systematic Laboratory Experiments in Organic Chemistry,** Arun Sethi, New Age International, 2003.
4. **Comprehensive Practical Organic Chemistry:** Qualitative Analysis Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004.
5. **Practical Organic Chemistry: Qualitative Analysis,** Bhutani S.P. Chhikara A, First edition, ANE books-new Delhi, 2009.
6. **Vogel's Textbook of Practical Organic Chemistry,** Brian S. Furniss, 5th Edition, Pearson India, 2005.
7. **Laboratory techniques in Organic chemistry,** V.K. Ahluwalia, Pooja Bhagat & Renu Aggarwal, I.K. International Publishing House Pvt.Ltd.
8. **Laboratory Manual of Organic Chemistry**, Raj K. Bansal. 5th edition, New Age international, 2008.
9. **Practical Organic Chemistry,** F.G. Mann, B.C Saunders, Fourth edition, Pearson India,2009.
10. **Microscale Organic laboratory with Multistep and Multiscale Syntheses**, Dana W. Mayo, Ronald M. Pike, David C. Forbes, fifth edition, John Wiley & Sons, Inc, 2011.
11. **Macroscale and Microscale Organic Experiments,** Kenneth L. Williamson, Katherine M. Masters, sixth edition, Charles Hartford, 2011.
12. **Modern Organic Synthesis in the Laboratory,** Jie Jack Li,Chris Limberakis, Derek A. Pflum, Oxford University Press, 2007.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Methods for the synthesis of dyes such as methyl orange, fluorescein, crystal violet, phenolphthalein.*
2. *Synthesis of paracetamol, phenacetin, sulphanilamide, antipyrine, aspirin, and benzocaine.*
3. *Quantitative organic analyses of various functional groups.*
4. *Experiments related to the determination of solubility product.*

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ChHCP-2.3: Physical Chemistry Practicals – II

Total: 64 hrs.

1. Determination of mean ionic activity co-efficient of formic acid.
2. Determination of mean ionic activity co-efficient of acetic acid.
3. Determination of equivalent conductance at infinite dilution for KCl.
4. Determination of equivalent conductance at infinite dilution for NaCl.
5. Potentiometric titration of mixture of HCl and CH_3COOH.
6. pH titration of HCl v/s NaOH.
7. pH titration of CH_3COOH v/s NaOH.
8. pH titration $CuSO_4$ v/s NaOH.
9. Spectrophotometric/colorimetric determination of chromium.
10. Spectrophotometric/colorimetric determination of manganese.
11. Spectrophotometric/colorimetric determination of copper.
12. Determination of heat of solution of benzoic acid.
13. Determination of heat of solution of salicylic acid.
14. Determination of isoelectric point of glycine.
15. Determination of solubility product of calcium sulphate.

REFERENCES:

1. College Practical Chemistry, V.K. Ahluwalia, Sunitha Dhingra, Adarsh Gulati, I Edition, University Press, 2005.
2. Experimental Physical Chemistry, V.D. Athawale, Parul Mathur, I Edition, New Age International Publishers, 2001.
3. Practical Physical Chemistry, B. Viswanathan, P.S. Raghavan, I Edition, Viva Books, 2009.
4. Experimental Physical Chemistry: A Laboratory Textbook, Arthur M. Halpern, George C. McBane, III Edition, W.H. Freeman and Company, 2006.
5. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh, I Edition, New Central Book Agency, 2012.
6. Vogel's Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas, VI Edition, Pearson Education, 2000.
7. Practical Physical Chemistry, Findlay Alexander, XVII Edition, Longman, 1966.
8. A Textbook of Practical Physical Chemistry, K. Fajans, J. Wüst, Revised Edition, Macmillan, 1957.
9. Experiments in Physical Chemistry, Carl W. Garland, Joseph W. Nibler, David P. Shoemaker, VIII Edition, McGraw-Hill, 2008.
10. Practical Physical Chemistry, James Brierley Firth, I Edition, Longmans, Green & Co., 1911.
11. Findlay's Practical Physical Chemistry, B.P. Levitt, IX Edition, Longman, 1985.
12. Experiments in Physical Chemistry, J.M. Wilson, R.J. Newcombe, A.R. Denaro, II Edition, Pergamon Press, 1968.
13. A Manual of Practical Physical Chemistry (Classic Reprint), Francis William Gray, Reprint Edition, Forgotten Books, 2017 (original 1908).

14. Advanced Practical Physical Chemistry, J.B. Yadav, I Edition, Goel Publishing House, 2011.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Principles of potentiometer, pH meter and spectrophotometer experiment.*
2. *Heat of solution of benzoic acid and salicylic acid.*
3. *Isoelectric point of amino acid.*
3. *Experiments related to solubility product.*

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Open Elective Paper (Interdepartmental Elective)
ChELT-2.1: Chemistry in day-to-day life

Total: 32 hrs.

Chemistry in the environment. 8 hrs.

Earth's Atmosphere, Phenomena in the Outer Layers of the Atmosphere, Depletion of Ozone in the Stratosphere, Volcanoes, natural versus anthropogenic air pollution, Air a source of pure gases: oxygen, nitrogen and noble gases. The Greenhouse Effect, Acid Rain, Photochemical smog, Indoor Pollution. Ozone, Nitrogen oxide, Sulfur dioxide and hydrocarbons as pollutants. Biochemical effects of – As, Cd, Pb, Hg, PAN, cyanide, pesticides, and carcinogens.

Chemistry of life 8 hrs.

Carbohydrates: monosaccharides, disaccharides, artificial sweeteners, polysaccharides (starch, glycogen and cellulose), Lipids: steroids and waxes. Soaps, Detergents and Shampoos, Creams and Lotions, Amino Acids, Peptides and Proteins, Protein Structure and Function, Enzymes, Hair Protein and Permanent Waves, Energy and Biochemical Systems, Nucleic Acid.

Chemistry and Medicine 8 hrs.

Introduction to medicine and drugs, neurotransmitters: Acetylcholine, Dopamine, Norepinephrine and Serotonin, Glutamate, Gamma-Aminobutyric Acid. Synthesis, application and structural elucidations of sulphanilamide, aspirin and paracetamol. Structure, properties and uses of Ibuprofen, diclofenac. Different types of anticancer platinum Complexes.

Synthetic polymers 8 hrs.

Introduction to Synthetic Polymers, Nomenclature of Synthetic Polymers, Copolymers, Polymer Classification by Reaction Type: Addition and condensation polymers, Polymer Classification by Mode of Assembly: Chain growth and step growth polymers, Polymer Classification by Structure: branched, linear and cross-linked polymers, Polymer Classification by Properties: thermoplastics, elastomers, fibers and thermosetting resins., Polymer Recycling

REFERENCES:

1. **The World of Chemistry: Essentials,** Melvin Joesten, Mary E. Castellion, John L. Hogg. Brooks/Cole; 3rd edition,2003.
2. **Chemistry,** Raymond Chang, Kenneth A. Goldsby, 12th edition, McGraw-Hill Education,2016.
3. **Fundamental Pharmacology for Pharmacy Technicians,** Jahangir Moini Delmar Cengage Learning, 2nd edition,2015.
4. **Medicinal Chemistry**, Ashutosh Kar, 4th Edition, New Age International Pvt. Ltd., New Delhi, India, 2007.
5. **Medicinal Chemistry**, Ashutosh Kar, 5th Revised Edition, New Age International Pvt. Ltd., New Delhi, India, 2010.
6. **Medicinal Chemistry: A Molecular and Biochemical Approach**, 3rd Edition, by Thomas Nogrady and Donald F. Weaver, 2005.
7. **Organic Chemistry**, David Klein, Fourth edition, Wiley Publications, 2021.
8. **Environmental Chemistry,** A.K. De, 6th Edition, New Age International Publishers, New Delhi, India, 2008.
9. **Environmental Pollution Analysis,** S.M. Khopkar, Wiley International Publishers.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Concepts of Environmental chemistry related to atmospheric composition and biochemical effects of various pollutants and toxic substances.*
2. *Chemistry of biomolecules, including the structure, classification, and functions of carbohydrates, lipids, proteins, enzymes, nucleic acids.*
3. *Role of chemistry in medicine, covering drug classification, neurotransmitter functions, and the synthesis, structure, and applications of key drugs.*
4. *Different classes of synthetic polymers, their nomenclature, types, structures and properties.*
5. *Chemical principles to real-world health and environmental issues, analyzing the impact of pollutants and drugs on human health and ecosystems.*

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ChEL-2.2: Waste Management and Sewage Treatment

Total: 32 hrs.

Waste Management: Sources and types of Waste, Concept of Municipal solid waste (MSW), Classification of MSW (Hazardous and Non-hazardous waste), Waste treatment and Disposal of waste (Reuse and Recycling of waste, Chemical treatment of waste before the disposal), Integrated waste management of plastics.

Sewage and Sewage treatment: Sewage and its composition, Physical, Chemical and biological properties of Sewage, Purpose of sewage treatment, Methods of Sewage treatment (Primary or Mechanical treatment and Secondary or Biological treatment), Removal of Phosphorous and Nitrogen from wastewater. Analysis of Sewage (Physical, Chemical and Biological Tests), Methods of Sludge disposal.

Health care wastes treatment: General definition, classification: infectious, Pathological, Pharmaceutical, Chemical, radioactive and non-hazardous general waste. Chemical treatment technologies: Internal shredding of waste, Chemical disinfectants, microbial resistance and alkaline hydrolysis.

REFERENCES:

1. Solid waste management, K Sasikumar and Sanoop Gopi Krishna PHI Publication, 2009.
2. Environmental Chemistry with Green Chemistry, Asim K Das, Books and Allied Pvt Ltd. 2010.
3. Industrial Chemistry-1, B K Sharma, Krishna Prakashan Media Pvt ltd. 2018.
4. Safe Management of Wastes from Health-care Activities, Yves Chartier, World Health Organization (WHO), 2010.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Identification of various sources and types of waste, including municipal solid waste (MSW).*
2. *Principles and methods of waste treatment and disposal, such as reuse, recycling, chemical treatment, and integrated plastic waste management.*
3. *Sewage composition and treatment processes, including physical, chemical, and biological methods, and the removal of nutrients like phosphorus and nitrogen from wastewater.*
4. *Analysis of sewage using physical, chemical, and biological tests, and understand the methods of sludge disposal.*
5. *Classification and treatment of healthcare wastes, including infectious, pathological, pharmaceutical, and radioactive wastes, and chemical treatment technologies like shredding, disinfection, and alkaline hydrolysis.*

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M.Sc. Chemistry Syllabus: 2025 - 2026 (CBCS Scheme)
III - SEMESTER
ChSCT-3.1: ANALYTICALCHEMISTRY – III

Total: 64 hrs.

UNIT-I: MOLECULAR SYMMETRY AND GROUP THEORY **16 hrs.**

Introduction to symmetry: symmetry operations, symmetry elements – rotational axis of symmetry, plane of symmetry, rotation-reflection axis (improper rotational axis), center of symmetry (inversion centre), identity element, Cartesian coordinate system and symmetry elements, mathematical requirement for a point group.

Group theory: Concept of group, properties of group, Abelian and non-Abelian groups, definition of point groups, classification of molecules into point groups, group multiplication tables (C_{2V} and C_{3V} point groups).

Matrix methods in symmetry: Definition and types of matrices, block-factorization of matrix, matrix representation of symmetry elements, matrix mathematics (addition, subtraction, multiplication, determinants, inverse and diagonalization of matrices), representation of symmetry operations as matrices, product of symmetry operations (in terms of matrices), matrix representation of point groups ($C_{2V,}$ C_{3V} and C_{4V} point groups).

Character Tables: Reducible and irreducible representations, character of a representation, properties of irreducible representations, structure of character tables, construction of character tables (C_{2V}, C_{3V} and C_{4V} point groups), Mulliken symbols for irreducible representations, determination of symmetry species for translations and rotations (C_{2V} and C_{2h}), the standard reduction formula (C_{2V} and C_{3V}).

Symmetry of normal modes of molecules: Cartesian coordinate method and internal coordinate method (molecules belong to C_{2V} and C_{3V} point groups), Infrared and Raman activity of molecules belong to C_{2V} (H_2O, ClF_3, *cis*-N_2F_2) and C_{3V} (NH_3) point groups.

UNIT-II: ADVANCED NMR SPECTROSCOPY **16 hrs.**

Advanced NMR spectroscopy: Pulse sequences, pulse widths, spins, magnetization vectors, DEPT experiment, determining the number of attached hydrogens (methine, methylene, methyl, quaternary carbons), introduction to 2D-NMR, an overview of the COSY technique and how to read COSY spectra, an overview of the HETCOR technique and how to read HETCOR spectra, an overview of Magnetic Resonance Imaging (MRI), some sample 1H NMR spectra.

Carbon-13 NMR: Caron-13 nucleus, ^{13}C chemical shifts – correlation charts, calculation of chemical shifts, proton-coupled ^{13}C spectra, spin-spin splitting of Carbon-13 signals, proton-decoupled ^{13}C spectra, Nuclear Overhauser Enhancement (NOE), cross-polarization – the origin of Nuclear Overhauser effect, problems with integration in ^{13}C spectra, molecular relaxation processes, off-resonance decoupling, Carbon-13 NMR solvents, hetero nuclear coupling of carbon to Deuterium, ^{19}F and ^{31}P, some sample Carbon-13 NMR spectra.

UNIT-III: MASS SPECTROMETRY **16 hrs.**

Introduction, ion production-EI, CI, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance, fundamental fragmentation processes(Stevenson's rule, Radical-Site-Initiated Cleavage: α-Cleavage, Charge-Site-Initiated cleavage: Inductive Cleavage, Two bond cleavage, Mc-Lafferty rearrangement, Retro Diels-Alder reaction, ortho effect, determination of molecular formulas (precise-mass determination, isotope ratio data), nitrogen rule, some fragmentation patterns of – alkanes, cycloalkanes, alkenes, alkynes,

aromatic hydrocarbons, alcohols, phenols, ethers, aldehydes, ketones, esters, carboxylic acids, amines, nitrogen and sulphur compounds and alkyl halides, some sample mass spectra. An overview of the MALDI technique.

UNIT-IV: ESR, MOSSBAUER and NQR SPECTROSCOPY 16 hrs.

Electron spin resonance (ESR) spectroscopy: Basic theory and instrumentation, experimental technique, FTESRS, double resonance spectrometers, ENDOR and ELDOR, interpretation of derivative curve in an ESR spectrum, ESR spectra of DPPH, intensity of ESR lines, g-value, factors affecting ESR lines, hyperfine interaction, Fermi (or contact or isotopic) hyperfine interaction,hyperfine splitting constant, anisotropic hyperfine interaction, Zero-field splittingand Kramer's degeneracy, Spin-Hamiltonian, spin densities and McConnell relationship, applications of ESR, ESR spectra of free-radical containing a single set of equivalent protons (methyl, p-benzoquine anion, cyclopentadienyl, benzene, cycloheptatrienyl anions), study of transition metal complexes, biological applications of ESR, spin labeling ESR spectroscopy.

Mossbauer spectroscopy: Basic principles, Mossbauer nuclides, spectral parameters required for evaluating Mossbauer spectra, isomer shift, quadrupole interactions, magnetic interactions (time and temperature dependent effect), instrumentation, Lamb Mossbauer factor, application – bonding in Fe-complexes, study of Sn compounds, structure determination, biological applications.

Nuclear quadrupole resonance (NQR) spectroscopy: Quadrupole nuclei, quadrupole moment, electric field gradient and coupling constant, theory of NQR, splitting in NQR spectra, Zeeman effect, instrumentation, applications, interpretation of eQq data, effect of crystal lattice on the magnitude of eQq, structural information from NQR spectra.

REFERENCES:

1. **Symmetry and Spectroscopy of Molecules,** K. Veera Reddy, New Age International Pvt. Ltd., New Delhi, India (2009).
2. **Molecular Symmetry and Group Theory,** Robert L. Charter, John Wiley & Sons, Inc. New York, 2004.
3. **Group Theory and its Chemical Applications,** P.K. Bhattacharya, Himalaya Publishing House, New Delhi, 1999.
4. **Group theory and its applications to Chemistry**–K.V. Raman, Tata Mc Graw Hill (1997).
5. **Vogel's Text book of Quantitative Chemical Analysis**, J.Mendham, R.C.Denney, J.D.Barnes, M.Thomas, B.Sivasankar, 6th Edition, Pearson Education, New Delhi, India (2012)
6. **Principles of Instrumental Analysis**, D.A. Skoog, E.J. Holler, T.A. Nieman, 5th Edition, Thomson Aisa Pvt. Ltd., Singapore (2004).
7. **Instrumental methods of Chemical Analysis,** H.Kaur, Pragathi Prakashan, New Delhi, India
8. **Quantitative Chemical Analysis,** Daniel C.Harris,6th Edition,W.H. Freeman and Company, New York, USA (2003).
9. **Fundamentals of Analytical Chemistry**, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8thEdition, Thomson Aisa Pvt. Ltd., Singapore (2004).
10. **Introduction to Spectroscopy,** D.L.Pavia, G.M.Lampman, G.S.Kriz, 3rd Edition,Cengage Learning India Pvt. Ltd., New Delhi (2008).
11. **Spectrometric Identification of Organic Compounds,** R.M. Silverstein, F.X.Webster, 6th Edition, Wiley Student Edition, New Delhi, India (2007).

12. **Applications of Absorption Spectroscopy of Organic Compounds**, John R. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi, India (2007).

13. **Instrumental Analysis**, D.A. Skoog, E.J. Holler, S.R. Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi (2012).

14. **Molecular Structure and Spectroscopy**, G.Aruldhas, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, India (2007).

15. **Analytical Chemistry–Theory and Practice,** R.M.Verma,3rd Edition, CBS Publishers and Distributors, New Delhi, India (2007).

16. **Vibrational Spectroscopy – Theory and Applications**, D.N. Sathyanarayana, New Age International Publishers, New Delhi, India (2004).

17. **Organic Spectroscopy**, William Kemp, 3rd Edition, Palgrave, New York, USA (2004).

18. **Basic Atomic and Molecular Spectroscopy**, J. Michael Hollas, Royal Society of Chemistry, Cambridge, UK (2002).

19. **Quantitative Analysis,** Day and Underwood, Prentice/Hall Pvt. Ltd. 6th Edition (1993).

20. **Vogel's text Book of Quantitative Chemical Analysis,** Revised by G.H. Jaffery, J. Bassett, J. Mendham and R.C. Denny, ELBS 5th Edition (1998).

21. **Analytical Chemistry,** Gray D. Christian,5th Edition, John Wiley and Sons, Inc.

22. **Introduction to Chromatography- Theory and Practice,** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).

23. **Instrumental Methods of Analysis**-Willard, Merrit and Dean,7th Edition, (1998).

24. **Instrumental Methods of Chemical Analysis**-B.K.Sharma, Goel Publishing House. Meerut, (2000).

25. **Fundamentals of Molecular Spectroscopy**, 3rd edition – C.N. Banwall, McGraw Hill, Book co, (UK) Ltd (1983).

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Concepts of ^{1}H NMR spectroscopy and its role in structure elucidation of organic compounds.*
2. *Concepts of advanced NMR (COSY, 2D NMR and HETCOR) and ^{13}C NMR techniques.*
3. *Concepts of mass spectrometry and its role in structure elucidation of organic compounds*
4. *Basic principles, instrumentation, experimental techniques and applications of ESR spectroscopy.*
5. *Basic principles, instrumentation, experimental techniques and applications of Mossbauer spectroscopy.*
6. *Basic principles, instrumentation, experimental techniques and applications of NQR spectroscopy.*
7. *Differences between ESR, Mossbauer and NQR spectra.*

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ChSCT-3.2: INORGANIC CHEMISTRY - III

Total: 64 hrs.

UNIT-I: COORDINATION CHEMISTRY – II **16 hrs.**

Valence bond theory (VBT), crystal field theory (CFT), spectrochemical series, orientation of d-orbitals and crystal field splitting of energy levels in tetrahedral and octahedral complexes, CFSE, factors influencing the magnitude of crystal field splitting – nature of ligands, oxidation state of metal ions, size of d-orbitals, geometry of complexes. Colour of transition metal complexes, modified crystal field theory (ligand field theory), evidence of covalent bonding in metal ligand bonding – Lande's splitting factor, ESR spectra, NMR spectra, NQR spectra and inter-electronic repulsion.

Molecular orbital theory of coordination complexes - Sigma and pi bonding in octahedral, tetrahedral and square planar complexes.

UNIT-II: COORDINATION CHEMISTRY – III **16 hrs.**

Crystal field effects on – ionic radii, lattice energy, heats of ligation, heats of hydration, heats of ligation of other ligands, geometry of complexes, spinel and inverse spinel. John-Teller distortion in octahedral complexes.

Electronic spectra of atoms – spectroscopic terms, classification of microstates, coupling of single electron angular momenta (spin-spin, orbital-orbital and spin-orbital coupling), Russel-Saunders and j-j coupling, energies of terms (Hund's rule), Racah parameters, Electronic spectra of complexes – ligand filed transition, spectroscopic terms, correlating terms, energies of weak and strong field limits, Tanabe-Sugano diagrams, Orgel diagrams and ground term symbols (d^1 to d^{10} systems), calculation D_q, B and E, nephelauxetic series, charge-transfer bands (LMCT and MLCT transitions), selection rules and intensities (spin and Laporte selection rules), tetragonal distortion from octahedral symmetry. Magnetic properties of complexes by Gouy balance method.

UNIT-III: REACTION MECHANISM IN COORDINATION COMPOUNDS **16 hrs.**

Reactions, kinetics and mechanism - substitution reaction in octahedral complexes (associative and dissociative mechanism), types of intermediates formed in associative and dissociative reactions, lability and inertness of octahedral complexes, interpretation of lability and inertness of transition metal complexes – valence bond theory, crystal field theory, crystal field activation energy, factors affecting lability of non-transition metal complexes (charge, size of the central metal atom, charge/ionic size ration, geometry of the complex), acid and base hydrolysis of octahedral complexes, direct and indirect evidences of conjugate mechanism, anation reactions, isomerization and racemization of trischelate complexes, substitution reaction in square planar complexes, trans effect, thermodynamic and kinetic stability, theories of trans effect (polarization and pi-bonding theory).

Oxidation – Reduction reactions: Classification of redox reactions, inner-sphere and outer-sphere mechanisms, excited state outer-sphere electron transfer reaction, mixed valency complexes, two-electron transfer reactions (complementary and non-complementary reactions). Photochemical reactions: Prompt and delayed reactions, d-d and charge-transfer reactions, transition in metal-metal bonded systems.

UNIT-IV: ORGANOMETALLIC CHEMISTRY **16 hrs.**

Introduction, organic ligands, nomenclature, 18-electron rule, electron counting in complexes, metal carbonyl complexes, preparation and properties of carbonyl complexes, polynuclear carbonyl complexes, carbonylate ions, bridging modes of CO,

carbonyl hydride, binary carbonyl complexes, carbenes (Fischer and Schrock types), carbynes and carbides complexes, non-aromatic alkene and alkyne complexes, synthesis and structure of complexes with metals (alkene, alkyl, butadiene, cyclobutadiene, cyclooctatetraene, allyl, cyclopentadiene, and arene complexes), substitution reactions in carbonyl complexes, oxidative addition and reductive elimination, insertion and elimination, nucleophilic and electrophilic attack of coordinated ligands, Olefin (sigma-bond) metathesis.

Catalysis by organometallic compounds: Importance and mechanism of - Alkene hydrogenation (Wilkinson's catalysis), hydroformylation (Oxo-process), Monsanto acetic acid process, Wacker process (Smidt process), synthetic gasoline, synthesis of H_2 gas, Ziegler-Natta polymerization, Fisher-Tropsch reaction. Fluxional behavior in organometallic compounds.

REFERENCES:

1. **Advanced Inorganic Chemistry**, 5th edition, F.A. Cotton and G. Wilkinson, John-Willey and sons 1988.
2. **Inorganic Chemistry, principles of structure and reactivity**, 3rd Ed. James E. Huheey, Ellen E Keithr and Richard L Keither, Harper Collins college pub, 1993.
3. **Inorganic Chemistry**, 3rd ed. D.P. Shriver and P.W. Atkins, Oxford University press, 1999.
4. **Comprehensive coordination Chemistry.** Eds: G. Wilkinson, R.D. Gillers and J.A. McCleurry, Pergomon Press.
5. **Synthesis and Characterization of Inorganic Compounds**, W. L. Jolly, Prentice Hall Concise Coordination Chemistry, R. Gopalan and V. Ramalingam.
6. **Inorganic Photochemistry: Introduction to Photochemical and Photophysical Aspects of Metal Complexes,** Kala Publications, Thiruchirapally, India, 2002.
7. **A.W. Adamson and P.D. Fleischauer,** Concepts of Inorganic Photochemistry, Johan Wiley, 1975.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Fundamental concepts of coordination chemistry including valence bond theory (VBT), crystal field theory (CFT), and spectrochemical series*
2. *Theory of crystal field effects, geometry of complexes, John-Teller distortion in octahedral complexes.*
3. *Concepts of kinetics and their reaction mechanism in coordination compounds.*
4. *Concepts of naming of organometallic compounds and 18 electron rules.*
5. *Importance and mechanism of catalysis by organometallic compounds.*

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ChSCT-3.3: ORGANIC CHEMISTRY - III

Total: 64 hrs.

UNIT-I: NAMED REACTIONS **16 hrs.**

C–C Bond forming reactions: Aldol condensation, Claisen condensation, Dieckmann condensation, Knoevenagel condensation, Mannich reaction, Michael reaction, Robinson annulations, Stobbe condensation, Wittig reaction, Acylion synthesis.

Coupling reactions: Hiyama cross-coupling reaction, Kumada cross-coupling reaction, McMurry coupling reaction, Negishi cross-coupling reaction, Stille coupling, and Suzuki – Miyaura coupling.

C–N Bond forming reactions: Bucherer reaction, Buchwald – Hartwig amination, Stork enamine reaction, Doebner – von Miller reaction, Hofmann – Loffler – Freytag reaction, Barton reaction.

C–O Bond forming reactions: Mislow – Evans rearrangement, Mukaiyama reagent.

C–X Bond forming reactions: Chan – Lam coupling reaction, Hell – Volhard – Zelinsky reaction, Hunsdiecker – Borodin reaction.

UNIT-II - PHOTOCHEMISTRY AND PERICYCLIC RTEACTIONS **16 hrs**.

Photochemistry: Bonding and antibonding orbitals, singlet and triple states, modes of energy transfers from the excited states- Jablonski diagram. Photochemical reactions: Photoaddition- alkenes to carbonyl compounds - Paterno-Buchi reaction, Photochemical fragmentation: Photolysis of carbonyl compounds-Norrish type-I and Norrish type-II reactions, di-pi-methane rearrangement.

Pericyclic reactions: Introduction, Classification: Electrocyclic, cycloaddition, sigmatropic, chelotropic and ene reaction. Definition of various terms: Con-rotatory, disrotatory, suprafacial, antarafacial, HOMO, LUMO, etc. Frontier molecular orbitals, formation and properties of molecular orbitals of ethene, 1,3-butadiene, 1,3,5-hexatriene, allyl and pentadienyl system. Electrocyclic reactions – FMO approach for electrocyclic reactions, electrocyclic reactions of butadiene-cyclobutene and hexatriene-cyclohexadiene interconversions.

Cycloaddition reactions: Classification, thermal and photochemical cycloaddition. [2 + 2] and [4+2] cycloaddition reaction (Diels-Alder reaction), FMO approach for [2+2] and [4 + 2] cycloaddition reaction,

Sigmatropic rearrangements: Nomenclature, suprafacial and antarafacial processes, [1,3], [1,5], and [3,3] sigmatropic rearrangement, Cope and Claisen rearrangement. FMO approach for sigmatropic shift of hydrogen and carbon (suitable examples are to be taken for each class of transformation). Woodward-Hofmann rules.

UNIT-III: RETRO SYNTHESIS VIA DISCONNECTION APPROACH **16 hrs.**

An introduction to synthons, synthetic equivalents and functional group interconversions.

Disconnection approach: One group C-X disconnection- Carbonyl compounds, ethers and sulphides (Benzyl benzoate, propanil, p-methylanisole, isopentyl benzyl ether, Chlorobenside).

Two group disconnection- 1, 1- difunctionalized compounds (Acetals, cyanohydrins, amino acids, etc.), 1,2-difunctionalized compounds (1,2-dicarbonyl compounds, hydroxyl carbonyl compounds). Diels-Alder reactions, 1,3 difunctionalized compounds and α, β-unsaturated compounds, control in carbonyl condensations, 1,5 difunctionalized compounds, Michael addition and Robinson annulation.

Retrosynthesis: Retrosynthesis of benzocaine, 4-methoxy acetophenone, saccharin, aspirin, paracetamol, phenaglycodol, venlafaxine.

Protection and de-protection in organic synthesis – Protection of hydroxyl, carboxyl, carbonyl, amino, and thiol groups and their de-protection. Illustration of protection and deprotection in organic synthesis with examples.

UNIT-IV: MEDICINAL CHEMISTRY AND CHEMOTHERAPY 16 hrs.

Drug design: Introduction, Concept of Lead, Factors governing drug design. Drug Design Through Disjunction and Conjunction, rational approach to drug design.

Prodrugs: Introduction, Classification and Applications of Prodrugs.

Sulphonamides: Introduction, classification, synthesis and SAR studies of – Sulfanilamide, Sulfacetamide, Sulphaguanidine, Mafenide, Dapsone.

Antimalarials: Introduction, classification, synthesis and SAR studies of – Chloroquine, Pamaquine, Mepacrine, and Pyrimethamine.

Antibiotics: Introduction, classification, synthesis and SAR studies of – Penicillin, Chloramphenicol.

Antivirals: Introduction, classification and synthesis of – Amantadine hydrochloride, Idoxuridine, Methisazone.

Antipsychotics (Tranquilizers): Introduction, classification and synthesis of – Pipradrol, Captodiame, Chlorpromazine.

REFERENCES:

1. **Modern Synthetic Reactions**, H.O. House, W.A Benjamin, Second edition, 1972.
2. **Some Modern Methods of Organic Synthesis,** W Carruthers, Cambridge Univ. Press 1987.
3. **Principles of Organic Synthesis**, R.O.C Norman and J.M. Coxon, Blackie Academic & Professional, 2012.
4. **Advanced organic chemistry.** F.A. Carey and R.J.sunderberg, fourth edition, Kluwer academic/Plenum Publisher, 2000.
5. **Organic Synthesis-Concept, Methods and Starting Materials,** J. Fuhmop and G. Penzillin. Wiley VCH, 2nd Edition, Revised and Enlarged, 1993.
6. **Guide Book to Organic Synthesis**, R.K. Mackie & D.M. Smith, ELBS, Prentice Hall, 3rd Ed., 1999.
7. **Introduction to Organic Photochemistry**, John D. Coyle, John Wiley and Sons, New York 1986.

8. **Molecular Reactions and Photochemistry,** C.H. Depuy and O.L. Chapman, 2nd Edition Prentice-Hall of India (P) Ltd., New Delhi, 1988.
9. **Modern Molecular Photochemistry,** N.J. Turro, University Science Books, Sausalito 1991.
10. **Organic Synthesis,** V.K. Ahluwalia and Renu Agarwal, Narosa, 2009.
11. **Synthesis, Approaches in Organic Chemistry**, R.K. Bansal, Narosa, 2001.
12. **Advanced Organic Chemistry** -Reactions, Mechanism and Structure, Jerry March, John Wiley, 2015.
13. **Organic Chemistry**, David Klein, Fourth edition, Wiley Publications, 2021.
14. **Designing Organic Synthesis**, S. Warren, John Wiley, 1978.
15. **Organic Synthesis,** Stuart warren, John Wiley and sons Cambridge University, 2012.
16. **Medicinal Chemistry**, Ashutosh Kaur, 4th Edition, New Age International Pvt. Ltd., New Delhi, India, 2007.
17. **Medicinal Chemistry, An Introduction,** by Gareth Thomas, John Wiley & Sons, 2000.
18. **Medicinal Chemistry**, Ashutosh Kaur, 5th Revised Edition, New Age International Pvt. Ltd., New Delhi, India, 2010.
19. **An Introduction to Medicinal Chemistry**, Graham L. Patrick, 4th Edition, Oxford University Press, New York, 2009.
20. **Medicinal Chemistry: A Molecular and Biochemical Approach**, 3rd Edition, by Thomas Nogrady and Donald F. Weaver, 2005.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Mechanism of named reactions, such as Aldol, Dieckmann, Mislow-Evans, Mukaiyama and Hunsdiecker – Borodin reactions.*
2. *Photochemical and pericyclic reactions including the concept of Woodward-Hofmann rules.*
3. *Methods of retrosynthetic analysis, protection and deprotection in organic synthesis.*
4. *Basics of medicinal chemistry and chemotherapy, including drug design, prodrugs, sulphonamides, antimalarials, antibiotics, antivirals, and antipsychotics.*

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ChSCT-3.4: PHYSICAL CHEMISTRY - III

Total: 64 hrs.

UNIT-I: QUANTUM MECHANICS-II **16 hrs.**

Application of Schrödinger's wave-equation to harmonic oscillator, rigid-rotor and H-atom (separation of r, T, I equation and their solutions). Approximate methods– Necessity of approximate methods, perturbation method, the theory of perturbation method – first and second order correction, 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, linear oscillator, H and He-atoms, Problems to be solved.

UNIT-II QUANTUM MECHANICS-III **16 hrs.**

SCF method for many electron systems. Slater orbitals – Effective Nuclear Charge (ENC), expressions for Slater's orbitals for 1s, 2s, 3s, 2p and 3d electrons (no derivation), Slater's rules for calculation of ENC – Slater's orbitals for helium, carbon and nitrogen atoms. Chemical bonding in diatomic, elementary concept of MO and VB theories; Huckel molecular orbital (HMO) theory for conjugated S-electron systems and its applications to 1,3-butadiene and benzene, Problems to be solved.

UNIT-III: MOLECULAR INTERACTIONS **16 hrs.**

Electric properties of molecules, electric dipole moments, polarizabilities, polarization- the frequency dependence of the polarization and molar polarization, relative permittivities, Interactions between molecules, interactions between partial charges, Interactions between dipoles, hydrogen bonding, the hydrophobic interaction, repulsive and total interactions. Molecular interactions in liquids, liquid–vapor interface, surface films, condensation.

Molecules in motion:

Transport in gases: The phenomenological equations, transport parameters- the diffusion coefficient, thermal conductivity, viscosity and effusion.

Motion in liquids: Experimental results: liquid viscosity, electrolyte solutions, the mobilities of ions-the drift speed, mobility and conductivity, the Einstein relations.

Diffusion: The thermodynamic view, the diffusion equation: simple diffusion, diffusion with convection, solutions of the diffusion equation, the statistical view.

UNIT-IV: COLLOIDS **16 hrs.**

Colloids: Colloidal systems, classification of colloids, lyophobic and lyophilic sols, preparation of lyophobic colloidal solutions (dispersion and condensation methods), purification of colloidal solutions, Properties of colloidal systems: Electrical properties – charge on colloidal particles, electrical double layer, zeta potential, DLVO theory of the stability of lyophobic colloids, flocculation values, coagulation of colloidal solutions. Electrokinetic properties – electrophoresis and electro-osmosis streaming and sedimentation potential. Determination of size of colloidal particles, surfactants, hydrophile-lypophile balance (HLB). Emulsions, gels, elastic and non-elastic gels. Micelle formation – mass action model and phase separation model, shape and structure of micelles, micellar aggregation numbers, critical micelle concentration (CMC), factors affecting CMC in aqueous media, thermodynamic approach to CMC, thermodynamics of micellization, micelle temperature range (MTR) or Krafft point. Solubilization – location of solubilizates in micelles, the phase rule of solubilization. Micellar catalysis, importance and applications of colloids.

REFERENCES:

1. **Quantum Chemistry**, R.K. Prasad, 4th Edition, New Age International Publishers, New Delhi, 2010.
2. **Atkins' Physical Chemistry**, Peter Atkins, Jolio De Paula,10th Edition, South Asia Edition, Oxford University Press, New York, 2010.
3. **Polymer Chemistry,** Malcolm P. Stevans, First Indian Edition, Oxford University Press, New York, 2008.
4. **Quantum Mechanics for Chemists**, David O. Hayward, The Royal Society of Chemistry, UK, 2002.
5. **Principles of Physical Chemistry**, B.R. Puri, L.R. Sharma, M.S. Pathania, 45th Edition, Vishal Publishing House, Jalandhar, India, 2012.
6. **Physical Chemistry – A Molecular Approach**, Donald A. McQuarrie, John D. Simon, 3rd Edition (Viva Student Edition), Viva Books Pvt. Ltd., New Delhi, 2011.
7. **Elements of Physical Chemistry**, B.R. Puri, L.R. Sharma, M.S. Pathania, 1st Edition, Vishal Publishing House, Jalandhar, India, 2013.
8. **Quantum Chemistry**, John P. Lowe, Kirk A. Peterson, 3rd Edition, Academic Press, London, UK, 2009. **Quantum Chemistry**, Donald A. McQuarrie, 1st Indian Edition, Viva Books Pvt. Ltd., New Delhi, 2003.
9. **Physical Chemistry**, N.B. Singh, S.S. Das, R.J. Singh, 2nd Edition, New Age International Publishers, New Delhi, 2007.
10. **Physical Chemistry**, Ira N Levine, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2007.
11. **Physical Chemistry,** R. Stephen Berry, Stuart A. Rice, John Ross, 2nd Edition, Oxford University Press, New York, 2007.
12. **Quantum Chemistry**, Ira N. Levine, 5th Edition, Pearson Education Pvt. Ltd., New Delhi, 2004. **Chemical Kinetics**, K.J. Laidler, 3rd Edition, Pearson Education Pvt. Ltd., New Delhi, 2004.
13. **Textbook of Polymer Science**, Fred W. Billmayer, 3rd Edition, John Wiley & Sons Pvt. Ltd., Singapore, Indian Edition, 2007.
14. **Fundamentals of Molecular Spectroscopy**, Colin N. Banwell, Elaine M. McCash, 4th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
15. **Polymer Science – A Textbook**, V.K. Ahluwalia, Anuradha Mishra, Ane Books India, Noida, 2008.
16. **Thermodynamics, Kinetic Theory, and Statistical Thermodynamics**, Francis W. Sears Gerhard L. Salinger, 3rd Edition, Narosa Publishing House, New Delhi, 1998.
17. **Polymer Science**, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, 5th Edition, New Age International Publishers, New Delhi, 2005.
18. **An Introduction to Electrochemistry**, Samuel Glasstone, Litton Educational Publishing, Inc., New York, 2008.
19. **Industrial Electrochemistry**, D. Pletcher and F.C. Walsh, Chapman and Hall, 2nd Edition, 1984.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Applications of Schrodinger's wave equation, the approximation methods and their solved problems.*
2. *Screening effect of different molecules and understand the SCF method & HMO concept.*
3. *Slater orbitals and expressions for Slater's orbitals for 1s, 2s, 3s, 2p and 3d electrons*
4. *Molecular interaction and motion of molecules.*
5. *Concept of colloids studies the different method of colloid interactions.*

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III – Semester M.Sc. Chemistry Practicals

ChSCP-3.1: Inorganic Chemistry Practical – III

Total: 64 hrs.

COMPLEX PREPARATIONS

1. Preparation of tetraammine cupric sulphate complex.
2. Preparation of bisoxalatocuprate(II)dihydrate complex.
3. Preparation of tris-oxalatoferrate(III) complex.
4. Preparation of sulphatotristhioureazinc(II) complex.
5. Preparation of nitropentammine cobalt (III) chloride.
6. Preparation of cis and trans diaquadioxalatochromate(III) complex.
7. Preparation of hexammine cobalt (III) sulphate.

COMPLEX ANALYSIS

1. Determination of cobalt in chloropentammine cobalt(III) chloride complex.
2. Determination of copper and oxalate in bisoxalato cuprate(II)-di hydrate complex.
3. Determination of iron and oxalate in trisoxalatoferrate(III) complex.
4. Colorimetric determination of Fe(III) using thiocyanate.
5. Colorimetric determination of metal ligand composition by Job's method of continuous variation.
6. Colorimetric estimation of metal ligand composition by mole ratio method.

REFERENCES:

1. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, B. Sivasankar, 6th Edition, Pearson Education, New Delhi, India, 2012.
2. College Practical Chemistry, V.K. Ahluwalia, 1st Edition, University Press, 2005.
3. Analytical Chemistry, G.D. Christian, Petra Rector, 7th Edition, Wiley India, 2013.
4. Practical Inorganic Chemistry, K. Somashekara Rao, 1st Edition,
5. Principles of Inorganic Chemistry (UGC Syllabus), B.R. Puri, L.R. Sharma, K.C. Kalia, Milestone Publishers, New Delhi, India, 2008.
6. Advanced Inorganic Chemistry, Gurudeep Raj, 26th Edition, GOEL Publishing House, Krishna Prakashan Media (P) Ltd., 2015

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Methods of preparation of complexes by using common metal salt with ligands such as oxalate, EDTA, sulphate, etc.*

2. *Colorimetric and titrimetric methods of complex analysis, Job's method and mole ratio method.*

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ChSCP-3.2: Organic Chemistry Practicals – III

Total: 64 hrs.

I. CHROMATOGRAPHIC TECHNIQUES AND COLORIMETRIC ESTIMATIONS (At least Six Experiments).

1. Separation of mixtures and measure the Rf value for o nitrophenol and p-nitrophenol / o-aminophenol and p-aminophenol through thin-layer chromatography.
2. Separate mixtures and measure the Rf value for o-aminophenol and p-aminophenol through thin-layer chromatography.
3. Extraction and separation of green leaf pigments (spinach leaves) through thin-layer chromatography.
4. Separation of mixtures of amino acids by paper chromatography.
5. Separation of mixtures of 2-nitroaniline and 4-nitroaniline by column chromatography method.
6. Estimation of Cholesterol by Colorimetry.
7. Estimation of Amino acids by Colorimetry.
8. Estimation of Proteins by Colorimetry.
9. Estimation of Carbohydrates by Colorimetry.

II. ISOLATION AND SEPARATION OF NATURAL PRODUCTS (At least Six Experiments).

1. Isolation of Piperine from pepper
2. Isolation of Caffeine from tea leaves
3. Isolation of Casein from milk
4. Isolation of Nicotine from tobacco leaves
5. Isolation of Hesperidin from peal of orange
6. Isolation of Cineole from Eucalyptus leaves
7. Isolation of Cinnamaldehyde from Cinnamon
8. Isolation of Eugenol from Clove
9. Isolation of Lycopene from tomato
10. Isolation of Carotene from Carrots
11. Isolation of Cysteine from Hair.
12. Isolation of β-carotene from carrots.

REFERENCES:

1. **Advanced Practical Organic Chemistry,** N K Vishnoi, second edition, Vikas Publishing House Pvt. Ltd, 1996.
2. **Comprehensive Practical Organic Chemistry:** Preparation and Quantitative Analysis Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001.
3. **Systematic Laboratory Experiments in Organic Chemistry,** Arun Sethi, New Age International, 2003.
4. **Comprehensive Practical Organic Chemistry:** Qualitative Analysis Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004.
5. **Practical Organic Chemistry: Qualitative Analysis,** Bhutani S.P. Chhikara A, First Edition, ANE books-new Delhi, 2009.

6. **Vogel's Textbook of Practical Organic Chemistry,** Brian S. Furniss, 5th Edition, Pearson India, 2005.
7. **Laboratory techniques in Organic chemistry,** V.K. Ahluwalia, Pooja Bhagat & Renu Aggarwal, I.K. International Publishing House Pvt. Ltd., 2005.
8. **Laboratory Manual of Organic Chemistry**, Raj K. Bansal. 5th edition, New Age international, 2008.
9. **Practical Organic Chemistry,** F.G. Mann, B.C Saunders, Fourth edition, Pearson India, 2009.
10. **Microscale Organic Laboratory with Multistep and Multiscale Syntheses**, Dana W. Mayo, Ronald M. Pike, David C. Forbes, fifth edition, John Wiley & Sons, Inc, 2011.
11. **Macroscale and Microscale Organic Experiments,** Kenneth L. Williamson, Katherine M. Masters, sixth edition, Charles Hartford, 2011.
12. **Separation methods**, M.N. Sastri, 2nd Edition, Himalaya Publishing House, 1996.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Practical approach of chromatographic techniques including separation of mixtures through thin-layer chromatography, extraction and separation of green leaf pigments, separation of amino acids.*
2. *Colorimetric estimations of cholesterol, amino acids, proteins, and carbohydrates.*
3. *Isolation methods and separation of natural products such as piperine, caffeine, casein etc.*

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ChSCP-3.3: Physical Chemistry Practicals – III

Total: 64 hrs.

1. Determination of the rate of reaction between potassium bisulphate and potassium iodide by colorimetry.
2. Determination of chemical oxygen demand in water samples.
3. Estimation of sulphate in water samples using EDTA solution.
4. Phase diagram for three component system.
5. Kinetics study on the oxidation of ethyl alcohol by $K_2Cr_2O_7$.
6. Estimation of iodine in common salt.
7. Adsorption characteristics of acetic acid on charcoal.
8. Estimation of nitrite ions by using $K_2Cr_2O_7$.
9. Electrogravimetric estimation of copper and nickel.
10. Determination of half wave potential of Cd^{2+}, Cu^{2+} and Zn^{2+} in 0.1M solution.
11. Determination of corrosion rate of steel samples in acid media.
12. Determination of unknown concentration of $ZnSO_4$ by polarography.
13. Determination of unknown concentration of mixtures ($KMnO_4$ + $K_2Cr_2O_7$) by spectrophotometric method.
14. Determination of CMC of SLS by conductometry.
15. Determination of complex formation between Ni(II) ions and 1,10-phenanthroline by spectrophotometric method.

REFERENCES:

1. College Practical Chemistry, V.K. Ahluwalia, Sunitha Dhingra, Adarsh Gulati, I Edition, University Press, 2005.
2. Experimental Physical Chemistry, V.D. Athawale, Parul Mathur, I Edition, New Age International Publishers, 2001.
3. Practical Physical Chemistry, B. Viswanathan, P.S. Raghavan, I Edition, Viva Books, 2009.
4. Experimental Physical Chemistry: A Laboratory Textbook, Arthur M. Halpern, George C. McBane, III Edition, W.H. Freeman and Company, 2006.
5. Physical Chemistry Practical, Saroj Kumar Maity, Naba Kumar Ghosh, I Edition, New Central Book Agency, 2012.
6. Vogel's Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas, VI Edition, Pearson Education, 2000.
7. Practical Physical Chemistry, Findlay Alexander, XVII Edition, Longman, 1966.
8. A Textbook of Practical Physical Chemistry, K. Fajans, J. Wüst, Revised Edition, Macmillan, 1957.
9. Experiments in Physical Chemistry, Carl W. Garland, Joseph W. Nibler, David P. Shoemaker, VIII Edition, McGraw-Hill, 2008.
10. Practical Physical Chemistry, James Brierley Firth, I Edition, Longmans, Green & Co., 1911.
11. Findlay's Practical Physical Chemistry, B.P. Levitt, IX Edition, Longman, 1985.

12. Experiments in Physical Chemistry, J.M. Wilson, R.J. Newcombe, A.R. Denaro, II Edition, Pergamon Press, 1968.
13. A Manual of Practical Physical Chemistry (Classic Reprint), Francis William Gray, Reprint Edition, Forgotten Books, 2017 (original 1908).
14. Advanced Practical Physical Chemistry, J.B. Yadav, I Edition, Goel Publishing House, 2011.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Chemical oxygen demand of sewage/pond water by titrimetric method.*
2. *Adsorption characteristics of acetic acid on charcoal by titrimetric method.*
3. *Practical approach of conductometry, electrogravimetry, polarography and spectrophotometric method.*
4. *Phase diagram for three components system.*

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Open Elective Paper (Interdepartmental Elective)
ChELT-3.1: Fundamentals of Electroplating

Total: 32 hrs.

Electrochemistry: Introduction, Electrolyte – strong and weak electrolytes, Ohm's law, Faraday's laws, Electrodes – anode and cathode, Electrochemical cells - Galvanic and Electrolytic cells, Electrode potentials, Standard electrode potentials, Application of electrode potential, Nernst equation for electrode reaction, Electrical double layer, Decomposition potential, Polarization, Over-voltage.

Electroplating: Introduction, Basic experimental set-up for electroplating, Theory of electroplating, anodes – soluble and insoluble anodes, current density, Limiting current density.

Preparation of the work surface for electroplating: Removal of heavy grease and oil, descaling, bright dipping, polishing and buffing, preplating operations – degreasing with organic solvents, alkali cleaning, acid dipping, water wash and drying.

Electroplating baths: Metal ion, Electrolytes, Complexing agents, Organic additives, Brighteners, Levellers, Structure modifiers, Wetting agents and buffers. Hull cell experiments, current efficiency, covering power, throwing power and its determination by Haring - Blum cell experiment.

Parameters influencing electroplating: Current density, temperature, pH, metal ion concentration, addition agents, and type of bath.

Testing of electrodeposits: Thickness, adhesion, corrosion resistance, porosity and hardness of the deposit.

Applications of electroplating, Electroplating of Cu, Zn, Ni, Gold, Cr, Zn-Ni, Zn-Fe and Zn-Cu.

REFERENCES:

1. Electrochemistry, B.K. Sharma, Revised Edition, GOEL Publishing House, Meerat, India, 1998.
2. Practical Electroplating Handbook, N.V. Parthasaradhy, Prentice Hall Inc., ISBN, New Jersey, 1989.
3. Industrial Electrochemistry, Derek Pletcher and Frank C.Walsh, II Edition, Chapman and Hall, New York, 1990.
4. Principles of Physical Chemistry, Puri, Sharma and Pathania, Millennium Edition, Chand and Co., New Delhi, 2000.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Basic principles of electrochemistry, including strong and weak electrolytes, Ohm's and Faraday's laws, electrochemical cells, electrode potentials, and the Nernst equation.*
2. *Key electrochemical concepts such as electrical double layer, decomposition potential, polarization, over-voltage, and their significance in electrochemical processes.*
3. *Principles and processes of electroplating, including cell setup, electrode types, current density, surface preparation techniques, and the composition of electroplating baths.*
4. *Analysis of electroplating efficiency and quality using methods such as Hull cell and Haring-Blum cell experiments, and evaluate key parameters like current efficiency, covering and throwing power.*
5. *Assess the quality and applications of electroplated coatings.*

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ChELT-3.1: Natural Products - An Overview

Total: 32 hrs

Vitamins: Introduction, occurrence, classification, structure and biological importance of Vitamin-B_1, B_2, B_3, B_6, B_{12}, Folic acid (Folate), Vitamin-A., A_1, A_2, Vitamin-E and Vitamin-C, D and K.

Alkaloids: Introduction, occurrence, classification, properties, structure and biological importance of Nicotine, Papaverine, Atropine, Morphine, Quinine, Reserpine, Ephedrine and Hygrine.

Terpenoids: Introduction, occurrence, classification, general characteristics, isoprene rule, structure and biological importance of Citral, Camphor, Menthol, α-Pinene, α-Terpineol, Zingiberene and Cadinene.

Steroids and Sex Hormones - Occurrence, basic skeleton, Diel's hydrocarbon, properties, classification, structure and biological importance of Cholesterol, Lanosterol, Ergosterol, Stigmasterol, Androsterone, Testosterone, Estrone, Progestrone and Aldosterone.

Carbohydrates: Introduction, occurrence, classification, properties, structure and biological importance of Glucose, Fructose, Galactose, Sucrose, Lactose, Maltose, Starch, Glycogen, Cellulose and Chitin.

Enzymes: Introduction, occurrence, structure and functions of Cocarboxylase (Thiamine pyrophosphate), Nicotinamide adenine dinucleotide (NAD^+), Nicotinamide adenine dinucleotide phosphate ($NADP^+$), Coenzyme-A, Pyridoxal phosphate, Flavin adenine dinucleotide (FAD), Adenosine diphosphate (ADP), Adenosine triphosphate (ATP).

REFERENCES

1. O**rganic Chemistry of Natural products**, Gurudeep R. Chatwal, (Edited by M. Arora), Vol. 1, Himalaya Publishing House, Mumbai, India, 2007.
2. O**rganic Chemistry of Natural products**, Gurudeep R. Chatwal, (Edited by M. Arora), Vol. 2, Himalaya Publishing House, Mumbai, India, 2008.
3. **Organic Chemistry – Natural Products**, O.P. Agarwal, Vol. I, GOEL Publishing House, Meerut, India, 2003.
4. **Organic Chemistry – Natural Products**, O.P. Agarwal, Vol. II, GOEL Publishing House, Meerut, India, 2004.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Structure, classification, and biological functions of essential vitamins, including water- and fat-soluble types such as Vitamin B-complex, A, D, E, K, and C.*
2. *Occurrence, classification, chemical structure, and pharmacological significance of key alkaloids like nicotine, morphine, atropine, and quinine.*

3. *Structural features and biological roles of terpenoids, applying the isoprene rule to compounds like citral, menthol, camphor, and zingiberene.*
4. *Sructure and functions of steroids and sex hormones, including cholesterol, testosterone, estrone, and progesterone, and relate them to physiological processes.*
5. *Chemical and biological importance of carbohydrates and enzymes, focusing on monosaccharides, disaccharides, polysaccharides, and coenzymes such as NAD^+, FAD, ATP, and CoA.*

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M.Sc. Chemistry Syllabus: 2025 - 2026 (CBCS Scheme)
IV - SEMESTER
ChSCT-4.1: ANALYTICAL CHEMISTRY – IV

Total: 64 hrs.

UNIT-I: COMBINED APPLICATIONS OF SPECTROSCOPIC TECHNIQUES FOR STRUCTURAL ELUCIDATION OF ORGANIC COMPOUNDS. 16 hrs.

Brief introduction about UV-Visible, IR, NMR spectroscopy and Mass spectrometry. Basic steps involved in the structure elucidation of organic compounds, empirical formula, molecular formula, molecular weight, elements present, hydrogen deficiency index, DBE, nitrogen rule, chromophores and auxochromes, functional groups, chemical shift values, coupling constants, fragmentation patterns – base peak, molecular ion peak and isotopic peaks.

Structure elucidation of – hydrocarbons (normal, branched-chain and cyclo alkanes, alkenes, alkynes), aromatic and polynuclear aromatic hydrocarbons, alcohols, phenols, esters, epoxides, peroxides, aldehydes, ketones, carboxylic acids, acid halides, acid anhydrides, amides, lactones, lactams, amines, nitriles, iso-nitriles, azo, nitro, sulphur, halogen containing compounds and heterocyclic compounds (at least one example has to be studied under each category).

UNIT-II: X-RAY, ELECTRON AND NEUTRON DIFFRACTION STUDIES. 16 hrs.

X-Ray diffraction studies: Theory, Mosley's law, interaction of X-ray with matter, Auger and Coster Kronig processes, instrumentation, X-ray absorption and emission methods, X-ray diffraction, automated X-ray diffractometry, Miller indices, Bragg's condition for diffraction, X- ray detection and measurement, structural analysis of crystals, Laue method, Bragg's method, Rotating crystal method, Debye and Scherrer powder method, simple lattices and X-ray intensities, scattering factors, structure factor and its relation to electron density, identification of unit cells from systematic absences in diffraction patterns, predicting diffraction pattern of lattices, phase problem, procedure for X-ray structure analysis, Ramachandran diagram.

Electron diffraction: Basic principle, scattering intensity and scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, electron diffraction studies of some compounds, low-energy electron diffraction (LEED) and structure of surfaces.

Neutron diffraction: Introduction, theory, scattering of neutrons by solids and liquids, magnetic scattering, measurement technique, elucidation of structure of magnetically ordered unit cell, applications of neutron diffraction studies.

UNIT-III: AUTOMATIC AND THERMAL METHODS OF ANALYSIS. 16 hrs.

Automatic methods of analysis: Specifications and performance of automated methods, automation strategy, advantages and disadvantages of automated techniques, infrared process analyzers, selection of on-line analyzers, on-line potentiometric analyzers, chemical sensors (optodes and microsensors), automatic chemical analyzers, discrete analyzers, continuous analyzers (single channel and multi-channel), continuous flow methods, flow-injection analysis, centrifugal analyzers, automatic elemental analyzers, laboratory robots.

Thermal methods of analysis: Introduction, thermogravimetric methods, thermogram, factors affecting thermogram, thermo gravimetric analysis (TGA) – instrumentation and applications (TGA analysis of polymers and inorganic compounds), static and dynamic thermogravimetry.

Differential thermal analysis (DTA) – theory, instrumentation and applications (DTA analysis of polymers and inorganic compounds). Differential scanning calorimetry (DSC) – theory, instrumentation and applications, factors affecting DTA and DSC.

UNIT-IV: SURFACE CHARACTERIZATION TECHNIQUES. 16 hrs.

Surface characterization techniques: Introduction, definition of solid surface, types of surface measurements, spectroscopic surface methods – general technique in surface spectroscopy. Electron spectroscopy: Basic principle, instrumentation and applications of X-ray photoelectron spectroscopy (XPS) and Auger electron spectroscopy (AES). Secondary-ion mass spectrometry, laser microprobe mass spectrometry, Electron microprobe spectrometry: Basic principle, instrumentation and applications of scanning electron microscopy (SEM), scanning probe microscopy, scanning tunneling microscopy (STM) – principle, instrumentation and applications, atomic force microscopy (AFM) - principle, instrumentation and applications.

Transmission electron microscopy (TEM) - principle, instrumentation and applications. High resolution transmission electron microscopy (HR-TEM), Comparison between SEM and TEM techniques. Energy-Dispersive Analysis of X-rays (EDAX): Introduction, working principle and Applications of EDAX.

REFERENCES:

1. **Vogel's Text book of Quantitative Chemical Analysis**, J. Mendham, R. C. Denney, J. D. Barnes, M.Thomas, B.Sivasankar, 6th Edition, Pearson Education, New Delhi, India (2012).
2. **Principles of Instrumental Analysis**, D.A.Skoog, E.J. Holler,T.A. Nieman, 5th Edition, Thomson Aisa Pvt. Ltd., Singapore (2004).
3. **Instrumental methods of Chemical Analysis (covering UGC Syllabus),** H.Kaur, Pragathi Prakashan, New Delhi, India
4. **Quantitative Chemical Analysis,** Daniel C. Harris, 6th Edition, W.H. Freeman and Company, New York, USA, 2003.
5. **Fundamentals of Analytical Chemistry**, D.A. Skoog, D.M. West, E.J. Holler, S.R. Crouch, 8th Edition, Thomson Aisa Pvt. Ltd., Singapore (2004).
6. **Introduction to Spectroscopy,** D.L. Pavia, G.M. Lampman, G.S. Kriz, 3rd Edition, Cengage Learning India Pvt. Ltd., New Delhi (2008).
7. **Spectrometric Identification of Organic Compounds,** R.M. Silverstein, F.X. Webster, 6th Edition, Wiley Student Edition, New Delhi, India (2007).
8. **Applications of Absorption Spectroscopy of Organic Compounds**, John R. Dyer, Prentice-Hall of India Pvt. Ltd., New Delhi, India (2007).
9. **Instrumental Analysis**, D.A. Skoog, E.J. Holler, S.R.Crouch, 11th Indian Reprint, Cengage Learning India Pvt. Ltd., New Delhi (2012).
10. **Molecular Structure and Spectroscopy**, G. Aruldhas, 2nd Edition, Prentice-Hall of India Pvt. Ltd., New Delhi, India (2007).
11. **Symmetry and Spectroscopy of Molecules,** K. Veera Reddy, New Age International Pvt. Ltd., New Delhi, India (1998).
12. **Analytical Chemistry – Theory and Practice,**, R.M. Verma, 3rd Edition, CBS Publishers and Distributors, New Delhi, India (2007).
13. **Vibrational Spectroscopy–Theory and Applications**, D.N. Sathyanarayana, New Age International Publishers, New Delhi, India (2004).

14. **Organic Spectroscopy**, William Kemp, 3rd Edition, Palgrave, New York, USA (2004).
15. **Basic Atomic and Molecular Spectroscopy**, J. Michael Hollas, Royal Society of Chemistry, Cambridge, UK (2002).
16. **Quantitative Analysis,** Day and Underwood, Prentice/Hall Pvt. Ltd. 6th Edition (1993).
17. **Vogel's text Book of Quantitative Chemical Analysis,** Revised by G.H. Jaffery, J. Bassett, J. Mendhrn and R.C. Denny, ELBS 5th Edition (1998).
18. **Analytical Chemistry,** Gray D. Christian, 5th Edition, John Wiley and Sons, Inc
19. **Introduction to Chromatography-Theory and Practice,** V.K. Srivatsan and K.K. Srivatsan, S. Chand Company Ltd. 4th Edition (1991).
20. **Instrumental Methods of Analysis**-Willard, Merrit and Dean,7th Edition (1998).
21. **Instrumental Methods of Chemical Analysis,** B.K. Sharma, Goel Publishing House. Meerut (2000).
22. **Group theory and its applications to Chemistry,** K.V. Raman, Tata McGraw Hill (1997).
23. **Fundamentals of Molecular Spectroscopy**, 3rd edition – C.N. Banwall, McGraw Hill, Book co, (UK) Ltd (1983).
24. **Materials Characterization Techniques,** Sam Zhang, Lin Li, Ashok Kumar, 1 st edition, CRC press (2008).
25. **The physical Chemistry of Materials**, M.A. Rolando, Roque-Malherbe, CRC press (2010).

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Basic steps involved in the structure elucidation of organic compounds.*
2. *Theory, instrumentation and its applications of X-Ray diffraction techniques.*
3. *Basic principle, instrumentation and its applications of electron and neutron diffraction techniques and the automatic methods of analysis.*
4. *Thermoanalytical methods like TGA, DTA and DSC and their applications.*
5. *Definition of solid surface, types of surface measurements and spectroscopic surface methods.*
6. *Basic principles, instrumentation and applications of XPS, AES, SEM, STM, EDAX. and AFM.*

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ChSCT-4.2: INORGANIC CHEMISTRY – IV

Total: 64 hrs.

UNIT I: BIOINORGANIC CHEMISTRY- I: 16 hrs.

Essential and trace metal ions in biological process, bioligands- amino acids, proteins, nucleic acids, nucleotides and their potential metal binding sites; special ligands- porphyrins, chlorin and corrin. Metalloproteins- role of protein and metal ions in metalloproteins; metalloenzymes and metal activated enzymes.

Ion transport across cell membrane:

Structure and function of biological membranes, concentration of metal ions outside and inside cells, ion transport across cell membrane; crown ethers, ionophores-channel forming and carrier ionophores; active and passive transport; transport Na^+& K^+ ions: Na^+/K^+ pump- importance and mechanism of action; Ca^{2+} storage and transport, Ca^{2+} pump- importance and mechanism of action, role of Ca^{2+} in muscle contraction and blood clotting.

Transport and storage of Fe: Structure and roles of ferritin, transferrin and siderophores; Transport of Cu: - Structure and role of ceruloplasmin.

Biological oxygen carriers: Heme proteins - O_2 uptake, transport and storage. Thermodynamic and kinetic aspects of dioxygen as oxidant, activation of O_2 through transition metal complexation; basic requirements for effective O_2 carriers, Structure and functioning of hemoglobin (Hb) and myoglobin (Mb) proteins, O_2 binding-cooperativity effect, Perutz trigger mechanism, Bohr effect, role of distal and proximal histidine; role of protein chains; CO and CN^-poisoning and treatment. Model compounds for O_2 binding and synthetic O_2 carriers; non-porphyrin systems- hemerythrin and hemocyanin. Photosynthesis: Chlorophyll: structural features, role of Mg^{2+}; light and dark reactions, PS-I and PS-II, Z-scheme of photosynthesis, oxygen evolving complex (OEC).

UNIT II: BIOINORGANIC CHEMISTRY - II 16 hrs.

Nitrogen fixation: Chemical inertness of N_2- thermodynamic and kinetic aspects, activation of N_2 through metal interaction. Biological nitrogen fixation: Nitrogenase enzyme, structure, N_2 binding sites and mechanism of action.

Electron transfer proteins: organic cofactors-FAD, NAD, FMN, ubiquinone; Structure and functions of: - blue copper protein (plastocyanin); Fe-S protein- rubredoxin, ferredoxin and HIPIP; heme proteins: cytochromes- cytochrome c and cytochrome c-oxidase. Electron transport chain (ETC) in respiration.

Metalloenzymes: Zinc enzymes- nature's choice of Zn(II) for non-redox enzymes; structure of active site and function of carboxypeptidase, carbonic anhydrase and alcohol dehydrogenase. Copper enzyme-super oxide dismutase. Molybdenum enzyme-xanthineoxidase. Iron enzyme-catalase, peroxidase and cytochrome p-450.

Vitamin B12 and Coenzymes: Structural features of vitamin B_{12}, Different Forms of vitamin B_{12}, chemistry of cobalamins, biochemical functions of cobalamins - isomerase reaction. Models of vitamin B_{12}, special characteristics of B_{12}-coenzyme. Methanogenic bacterial factor (F-430M).

Vitamin B6 and Coenzymes: Transamination reaction and probable role of metal ions, copper(II)-activated model -lysyl oxidase.

UNIT-III: METALS AND CHELATION IN MEDICINAL ACTION 16 hrs.

Introduction: Biological growth on the concentration of essential and toxic elements.

Disease due to metal deficiency and treatment: Iron deficiency and anaemia and its

treatment, zinc deficiency and treatment, copper deficiency and treatment, manganese deficiency and treatment.

Metal ion toxicity: Sources of toxicity. General aspects of mechanism of metal ion toxicity, importance of biomethylation in metal ion toxicology, chemical speciation of Hg, As, Cu, Pb, Se, Cr and Cd metals in environment.

Toxic effects of metals: Iron toxicity, copper toxicity and Wilson's disease. Arsenic poisoning, mercury, lead, cadmium, aluminium and calcium toxicity. Radionuclide toxicity, metals as carcinogens. Natural detoxification of metal ion induced toxicity and cleanup of toxic metals by plants.

Metal ion detoxification: Required thermodynamic and pharmacokinetic property. Chelating antidote in metal ion detoxification. Basic requirements of a chelating drug, double ligand therapy.

Some Representative Chelating Drugs used in Metal ion Detoxification:

Chelating Drugs Having the SH Groups, Polyaminocarboxylic acids and desferrioxamines as the Chelating Drugs. Chelating ligands in the treatment of human stones. Limitations of chelation therapy in metal ion detoxification. Beneficial effects from blocking the metalloenzymes by chelating agents.

Lithium therapy in psychiatric mind disorder.

Metals Used in Diagnosis: Radio diagnostic agents and boron neutron capture therapy, magnetic resonance imaging (MRI) and MRI contrast agents. X-ray contrast agents in diagnostic imaging.

Anticancer Activity of Platinum Complexes: Different types of anticancer platinum complexes. Toxic effects of anticancer Pt-complexes. Mechanism of anticancer activity of cis-DDP. Nonactivity of trans-DDP (i.e. trans-platin).

UNIT-IV: ENVIRONMENTAL CHEMISTRY 16 hrs.

Concept and scope of environmental chemistry, environmental segments, natural cycles of the environment (hydrogen, carbon, oxygen, nitrogen, phosphorus and sulphur cycles), Atmosphere – composition of the atmosphere, Earth's radiation balance, particles, ions and radicals in the atmosphere, chemical and photochemical reactions in atmosphere – oxygen and ozone chemistry, SO_2, NO_x, organic compounds, Greenhouse effect (Global warming), ozone depletion (making a hole in the sky), Hydrosphere – the hydrologic cycle, physical chemistry of sea water, aquatic biochemical processes. Chemical toxicology – toxic chemicals in the environment, impact of toxic chemicals on enzymes, biochemical effects of – As, Cd, Pb, Hg, CO, NO_x, SO_2, Ozone, PAN, cyanide, pesticides, carcinogens, Bio-Warfare agents, environment and public health. Air pollution – air pollutants (CO, NO_x, hydrocarbons and photochemical smog, CFCs, SO_2, acid rain, particulates, radioactive substances, tropospheric chemistry), Air quality standards – sampling, monitoring, some air pollutant accidents (TCDD Accident at Seveso, Italy – July 1976, The Bhopal Disaster – December 3, 1984, Chernobyl Disaster – April 28, 1986). Water pollution – Aquatic environment, water pollutants, eutrophication, water quality parameters and standards, trace elements in water, monitoring techniques and methodology – (pH, specific conductance, DO, NH_3, nitrate and nitrites, chloride, fluoride, cyanide, sulphide, sulphate, phosphate, total hardness, phenols, oil spills, pesticides, surfactants, microorganisms, COD, BOD). Determination of DO, COD and BOD. Treatment of water pollutants – primary, secondary and tertiary processes.

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3. **Principles of Inorganic Chemistry** - B.R. Puri, L.R. Sharma and K.C. Kalia, Mile Stone Publishers, Delhi, 2010.

4. **Principles of Bioinorganic Chemistry**, Stephen J. Lippard and Jeremy Berg, Panima Publishing Corporation, New Delhi, India, 2005.

5. **Bioinorganic Chemistry,** Bertini, Gray, Lippard and Valentine**,** Viva Books, Pvt., Ltd. 2004.

6. **Bioinorganic Chemistry**-Asim K. Das, 2010 Reprint, Books and Allied (P) Ltd, Kolkota.

7. New Directions in Solid State Chemistry, C.N.R. Rao, J. Gopalakrishna, Cambridge University Press, 1997**.**

8. **Introduction to nanoscience,** Gabor L. Hornyak, Joydeep Dutta, Harry F. Tibbals, Anil K. Rao, CRC Press, 2008.

9. **Nanotechnology: Importance and applications,** M.H. Fulekar, IK Internation al, 2010. 10. **Supramolecular chemistry- Concepts and Perspectives**, J.M. Lehn, Wiley-VCH, 1995.

10. **Supramolecular Chemistry,** P.D. Beer, P.A. Gale, D.K. Smith, Oxford University Press, 1999.

11. **Supramolecular Chemistry,** J.W. Steed, J.L. Atwood, Wiley, 2000. .

12. **Biophysical, Bioorganic and Bioinorganic Chemistry**, Asim K. Das, Mahua Das, Ankita Das, Ruba Sen Books and Allied (P) Ltd, 2nd edition, 2021.

13. **Environmental Chemistry,** A.K. De, 6th Edition, New Age International Publishers, New Delhi, India, 2008.

14. **Environmental Pollution Analysis,** S.M. Khopkar, Wiley International Publishers, 1993.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Bioligands such as amino acids, proteins, nucleic acids, and their metal-binding.*
2. *Biological nitrogen fixation by nitrogenase and N_2 binding mechanism.*
3. *Essential and toxic element concentrations affect biological growth significantly. Iron deficiency leads to anemia, which can be treated with supplementation and diet.*
4. *Concepts of environmental chemistry includes studying earth's segments and natural cycles. Earth's radiation balance and atmospheric reactions involve oxygen and ozone chemistry.*
5. *Water treatment by primary, secondary, and tertiary processes. Target specific pollutants to ensure water safety and quality.*

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ChSCT-4.3: ORGANIC CHEMISTRY – IV

Total: 64 hrs.

UNIT-I: GREEN CHEMISTRY **16hrs.**

Introduction, pillars of green chemistry – catalyzed reactions, replacement of organic solvents, starting materials from renewable resources, atom economy, biodegradable household and bulk chemicals. Plausible routes - to increase the atom economy, to reduce toxicity of reactions and to lower the production cost. Synthesis of styrene, adipic acid, catechol, 3-dehydroshikimic acid, and methyl methacrylate.

Aqueous Phase Reactions: Introduction, Claisen Rearrangement, Wittig-Homer Reaction, Michael reaction, aldol Condensation, Knoevenagel Reaction, Pinacol Coupling, Benzoin Condensation, Claisen-Schmidt Condensation, Heck reaction, Strecker synthesis.

Microwave-induced green synthesis: Microwave assisted reactions in water - Hofmann elimination, hydrolysis, oxidation of toluene, alcohols and hydrolysis of methyl benzoate to benzoic acid.

CHEMISTRY OF NATURAL PRODUCTS – I

UNIT-II: Carbohydrates and Lipids **16 hrs.**

Carbohydrates: Classification of carbohydrates, D, L-notations, configuration and conformations of carbohydrates. Redox reactions of monosaccharides, osazone formation, chain elongation (Kiliani-Fischer synthesis), chain shortening (Ruff degradation), cyclic structure of monosaccharides (hemiacetal formation), stability of glucose, acylation and alkylation of monosaccharides, formation of glycosides, anomeric effect, reducing and non-reducing sugars. Disaccharides-structural elucidation of sucrose, cellobiose, maltose and lactose. Polysaccharides-structural elucidation of cellulose, starch (amylose and amylopectin) and glycogen.

Lipids: Introduction, simple lipids (fats, oils, waxes), compound lipids, phospholipids (Lecithins, Cephalins, Plasmalogens, Sphingomyelins), glycolipids, galactolipids. Triglycerides (structure, properties and functions), reactions of triglycerides (hydrogenation, hydrolysis and auto-oxidations).

UNIT-III: Amino acids, Proteins and Nucleic acids **16 hrs.**

Amino acids: Classification and nomenclature of amino acids, general properties and reactions of amino acids, configuration of amino acids, isoelectric point, separation of amino acids via electrophoresis. General methods of synthesis of amino acids – amination of D-halo acids, Gabriel's phthalimide synthesis, Strecker synthesis, malonic ester synthesis, Darapsky synthesis and azlactone synthesis.

Proteins: Structure and nomenclature of peptides and proteins, automated solid phase peptide synthesis (Bruce-Merrifield synthesis), cleavage of disulphide linkages, determination of amino acid composition, sequencing of peptides from N-terminus (Edman degradation) and C-terminus, structural determination of proteins (primary, secondary and tertiary structures).

Nucleic acids: Classification of nucleic acids, structure of nucleosides and nucleotides

containing pyrimidine and purine bases, sequence of nucleic acids, Crick-Watson model of DNA, structure of RNA (m-RNA, t-RNA and r-RNA), genetic code – salient features.

CHEMISTRY OF NATURAL PRODUCTS- II

UNIT-IV: Alkaloids, terpenoids, flavonides and steroids **16 hrs**

Alkaloids- Definition, nomenclature, occurrence and classification based on nitrogen heterocyclic ring and general methods of structure elucidation. Structure and synthesis of papaverine, reserpine, ephedrine, nicotine, atropine, quinine and morphine (one method each).

Terpenoids-Classification, nomenclature, occurrence, general methods of structure determination of terpenoids. Synthesis of α-citral, α-terpineol, menthol, zingiberene and santonin (one method each).

Flavonoids-Classification, nomenclature, occurrence, general methods of structure determination and synthesis of apigenin, luteolin, quercetin and myrcetin (one method each).

Steroids- Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon. Stereochemistry and structural elucidation of cholesterol, ergosterol, stigmasterol, androsterone, testosterone, progesterone and aldosterone.

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2. **Organic Chemistry**, G. Marc Loudon, 4th Edition, Oxford University Press, UK, 2000.
3. **Organic Chemistry**, R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.
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9. **Organic Chemistry of Natural products**, Gurudeep R. Chatwal, (Edited by M. Arora), Vol. 2, Himalaya Publishing House, Mumbai, India, 2008.
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11. **Organic Chemistry – Natural Products,** O.P. Agarwal, Vol. II, GOEL Publishing House, Meerut, India, 2004.

12. **Natural products: Chemistry and Biological Significance**, J. Mann; R.S. Davidson; J. B. Hobbs, D.V. Banthrope ; J.B. Harborne, Longman publication.
13. **Introduction to Flavonoids**, B.A. Bohm, Harwood Academic Publishers
14. **Chemistry of natural products,** S.V. Bhat; B.A.Nagasampagi; M. Sivakumar, Narosa publications.
15. **Classics in Total Synthesis of Natural Products,** K.C. Nicolaou, VCH publisher, Vol. I, 1996
16. **Classics in Total Synthesis of Natural Products,** K.C. Nicolaou, VCH publisher, Vol. II, 2003.
17. **Organic Chemistry,** 2nd Edition, Nick Greeves), Stuart Warren, Jonathan Clayden.
18. **Organic Chemistry**, David Klein, Fourth edition, Wiley, 2021.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Basic principles of green chemistry, renewable resources, atom economy, and biodegradable chemicals.*
2. *Microwave-induced green synthesis reactions in water such as Hofmann elimination, hydrolysis, and oxidation.*
3. *Classification, structure, conformations, and reactions of carbohydrates and lipids.*
4. *Classification, synthesis of amino acids, structure of proteins and nucleic acids.*
5. *Classification, occurrence, structure, and synthesis of specific alkaloids, terpenoids, flavonoids and steroids.*

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ChSCT-4.4: PHYSICAL CHEMISTRY – IV

Total: 64 hrs.

UNIT-I: CHEMISTRY OF NANOMATERIALS **16 hrs.**

Introduction: Fundamentals and importance, metal nanoclusters, magic numbers, theoretical modeling of nanoparticles, geometric structure, electronic structure, reactivity, fluctuations, magnetic clusters, bulk to nanotransitions. Semi conducting nanoparticles-optical properties, photofragmentation, coulombic explosion.

Carbon nano particles: Introduction, carbon molecules, nature of the carbon bond, new carbon structures. Carbon clusters: small carbon clusters, C_{60}; discovery, structure, crystal, alkali doping, super conductivity, fullerenes, other bulky balls. Carbon nano-tubes: fabrication, structure, electrical, vibrational and mechanical properties. Applications of nanomaterials.

Methods of preparation: Laser evaporation, plasma arcing, chemical vapour deposition, sol-gel, electrodeposition, ball milling, chemical methods, thermolysis and pulsed laser methods.

UNIT–II: METAL FINISHING **16 hrs.**

Metal finishing: Electrode potential-standard potential, EMF series and its applications, deposition potential-deposition from simple salt solution and solution mixtures, polarization and over voltage, effect of polarization on electrodeposition, limiting current density, hydrogen over voltage. Principles of electroplating. Role of anodes in electroplating. Pre-plating process and surface preparation. Hull cell experiment, measurement of covering power and throwing power (Haring-Blum cell experiment). Electroplating practice for metals and alloys (Cu, Ni, Zn, brass and bronze).

Specifications and testing of electroplates - Introduction, thickness-destructive and non-destructive testing methods. Adhesion-bend test, burnishing test, file test, grinding test, heat test and peel test. Corrosion resistance-salt spray test, acetic acid salt spray test, copper accelerated acetic acid salt spray test, corrodekote test and sulphur dioxide test. Porosity-ferroxyl test, electrographic test and hot water test. Hardness test, immersion (Galvanic) plating and electroless plating.

UNIT-III: CORROSION AND PHASE EQUILIBRIA **16 hrs.**

Corrosion and its control: Concepts of dry corrosion and wet corrosion. Electrochemical aspects of corrosion. Types of corrosion - uniform, Galvanic, intergranular, selective leaching, crevice, pitting, erosion-corrosion, stress and microbiological corrosion.

EMF & Galvanic series and their limitations. Corrosion and passivation of metals – Pourbaix and Evans diagrams – prevention of corrosion. Measurement of corrosion rate - weight loss and electrochemical methods. Protection against corrosion - design improvement, anodic-cathodic protection, inhibitors and coating.

Phase equilibria: Explanation and illustration of phase, component and degree of freedom, thermodynamic derivation of phase rule, applications of phase rule to one-component systems (water and sulphur systems). Two-component systems (potassium iodide-water system, phenol-water and ferric chloride-water system) and three-component systems (acetic acid-chloroform-water and ammonium chloride-ammonium sulphate-water system).

UNIT-IV: ELECTRO-ORGANIC SYNTHESIS **16 hrs.**

Fundamentals, generalized electrochemical reaction, reaction variables in electro synthesis, setting up the electrolysis cell – basic laboratory apparatus, two-electrode cells, three-electrode cells. Electrode material, cell geometry. Selection of electrode potential,

divided and undivided cells, preparation of solution for electrolysis – solvent and supporting electrolyte, temperature effects.

Electro-organic reactions: Electrooxidation and reductions of hydrocarbons, nitro compounds, sulphur and nitrogen heterocyclic compounds, halogen compounds and carboxylic acids (Kolbe's synthesis). Some preparative examples - reductive intermolecular carbon-nitrogen bond formation, carboxylic acids from primary alcohols, cyanation of N,N-propylpyrrolidine, preparation of 3,6-dichloropicolinic acid from 3,4,5,6-tetrachloropicolinic acid.

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2. **Nanotechnology (Basic Science and Emerging Technologies)**, Mick Wilson, Kamali Kannangara Geoff Smith, Michelle Simmons, and Burkhard Raguse, First Indian Edition, Overseas Press India Private Limited, 2005.
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13. **G.W. Castellan, Physical Chemistry**, 3rd Ed., Narosa Publishing House, New Delhi, 1983.
14. **S. Glasstone, Thermodynamics for Chemists,** East-West Press, New Delhi, 1964.

Course Outcomes:

After the successful completion of this course, the student will be able to understand the following:

1. *Fundamentals, structure, preparation and applications of nanoparticles.*
2. *Basic concept of electrode potential, principles of electroplating and destructive testing methods.*

3. *Types of corrosion, galvanic series merits/demerits and methods of prevention of corrosion.*
4. *Phase rule and its applications to different component systems.*
5. *Fundamentals and reaction variables of electrosynthesis.*
6. *Electro-organic redox reactions of few organic compounds.*

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