CHOICE-BASED CREDIT SYSTEM (CBCS)

Course Structure & Syllabus

for

M. Sc. Chemistry

(To be implemented from Session 2021-2022)

Department of Chemistry

School of Physical Sciences
Guru Ghasidas Vishwavidyalaya
Bilaspur-495 009

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CBCS- Course structure for M. Sc. (Chemistry)

(To be implemented from Session 2021-2022)

SEMESTER -I								
Course Structure	**Course Code**	**Title**	**T/L**	**CCA**	**ESE**	**Total Marks**	**Credit**	**Final credit**
CC-1	CYPATT1	Analytical Chemistry I	T-3	40	60	100	3	5
	CYPALT1	Analytical Chemistry Practical I	L-4	40	60	100	2	
CC-2	CYPATT2	Inorganic Chemistry I	T-3	40	60	100	3	5
	CYPALT2	Inorganic Chemistry Practical I	L-4	40	60	100	2	
CC-3	CYPATT3	Organic Chemistry I	T-3	40	60	100	3	5
	CYPALT3	Organic Chemistry Practical I	L-4	40	60	100	2	
CC-4	CYPATT4	Physical Chemistry I	T-3	40	60	100	3	5
	CYPALT4	Physical Chemistry Practical I	L-4	40	60	100	2	
OE	CYPATO1	Polymer Chemistry	T-3	40	60	100	3	5
	CYPALO1	Polymer Chemistry- Practical I	L-4	40	60	100	2	
VAC/ Certificate Course/ Optional	CYPATC1	Refer the List of Value-Added Course (p. 5)	T-2	40	60	100	2	Additional Credit Course
	CYPALC1		L-2	40	60	100	1	
					Total Credit			**25**
Semester-II								
CC-5	CYPBTT1	Analytical Chemistry II	T-3	40	60	100	3	5
	CYPBLT1	Analytical Chemistry Practical-II	L-4	40	60	100	2	
CC-6	CYPBTT2	Inorganic Chemistry II	T-3	40	60	100	3	5
	CYPBLT2	Inorganic Chemistry Practical-II	L-4	40	60	100	2	
CC-7	CYPBTT3	Organic Chemistry II	T-3	40	60	100	3	5
	CYPBLT3	Organic Chemistry Practical-II	L-4	40	60	100	2	
CC-8	CYPBTT4	Physical Chemistry II	T-3	40	60	100	3	5
	CYPBLT4	Physical Chemistry Practical-II	L-4	40	60	100	2	
CC-9	CYPBTT5	Molecular Spectroscopy	T – 4+1*	40	60	100	5	5
DSE-1	CYPBTD1	Instrumental Analytical Techniques	T – 4+1*	40	60	100	5	5
	CYPBTD2	Bio-inorganic Chemistry	T – 4+1*	40	60	100	5	
	CYPBTD3	Chemistry of Heterocycles	T – 4+1*	40	60	100	5	
	CYPBTD4	Solid State Chemistry	T – 4+1*	40	60	100	5	
	Remarks: *Any one course from DSE-1 will be offered to each student by the Department.*							
VAC/ Certificate Course/ Optional	CYPATC1	Refer the List of Value-Added Course (p. 5)	T-2	40	60	100	2	Additional Credit Course
	CYPALC1		L-2	40	60	100	1	
					Total Credit			**30**
Semester-III								
CC-10	CYPCTT1	Computer Applications in Chemistry	T – 4+1*	40	60	100	5	5
RM	CYPCTA1	Research Methodology	T-2	40	60	100	2	2

OE-2	CYPCTO2	Medicinal Chemistry	T-3	40	60	100	3	5
	CYPCLO2	Medicinal Chemistry Practical	L-4	40	60	100	2	
	CYPDTO3	Industrial Chemistry	T-3	40	60	100	3	
	CYPDLO3	Industrial Chemistry Practical	L-4	40	60	100	2	
	Remarks: *Any one course each from OE will be offered by the Department.*							
DSE-2	CYPCTD1	Principles of Analytical Chemistry	T-3	40	60	100	3	5
	CYPCLD1	Analytical Chemistry Practical III	L-4	40	60	100	2	
	CYPCTD2	Organometallic Chemistry of Transition Metals	T-3	40	60	100	3	
	CYPCLD2	Inorganic Chemistry Practical III	L-4	40	60	100	2	
	CYPCTD3	Stereochemistry, Reactions and Rearrangements	T-3	40	60	100	3	
	CYPCLD3	Organic Chemistry Practical III	L-4	40	60	100	2	
	CYPCTD4	Electrochemistry	T-3	40	60	100	3	
	CYPCLD4	Physical Chemistry Practical III	L-4	40	60	100	2	
	Remarks: *Any one course from DSE-2 will be offered to each student by the Department.*							
DSE-3	CYPCTD5	Chemical Analysis	T-3	40	60	100	3	5
	CYPCLD5	Analytical Chemistry Practical IV	L-4	40	60	100	2	
	CYPCTD6	Inorganic Rings, Chains, and Clusters	T-3	40	60	100	3	
	CYPCLD6	Inorganic Chemistry Practical IV	L-4	40	60	100	2	
	CYPCTD7	Chemistry of Natural Products	T-3	40	60	100	3	
	CYPCLD7	Organic Chemistry Practical IV	L-4	40	60	100	2	
	CYPCTD8	Quantum Chemistry	T-3	40	60	100	3	
	CYPCLD8	Physical Chemistry Practical IV	L-4	40	60	100	2	
	Remarks: *Any one course from DSE-3 will be offered to each student by the Department*							
VAC/ Certificate Course/ Optional	CYPCTC1	Refer the List of Value-Added Course (p.5)	T-2	40	60	100	2	Additional Credit Course
	CYPCLC1		L-2	40	60	100	1	
					Total Credit			**22**
Semester-IV								
CC-11	CYPDTT6	Biological Chemistry	T-3	40	60	100	3	5
	CYPDTL6	Biological Chemistry Practical	L-4	20	30	50	2	
	Remarks: *Any one course each from OE-2 will be offered by the Department.*							
DSE-4	CYPDTD1	Advanced Separation Techniques	T – 4+1*	40	60	100	5	5
	CYPDTD2	Structural Methods in Inorganic Chemistry	T – 4+1*	40	60	100	5	
	CYPDTD3	Organic Spectroscopy for Structural Elucidation	T – 4+1*	40	60	100	5	
	CYPDTD4	Statistical Mechanics	T – 4+1*	40	60	100	5	
	Remarks: *Any one course from DSE-4 will be offered to each student by the Department*							
	CYPDTD5	Electroanalytical Methods	T – 4+1*	40	60	100	5	
	CYPDTD6	Special Topics in Inorganic Chemistry	T – 4+1*	40	60	100	5	

DSE-5	CYPDTD7	Reagents and Reactions in Organic Synthesis	T – 4+1*	40	60	100	5	5
	CYPDTD8	Chemical Kinetics	T – 4+1*	40	60	100	5	
	Remarks: *Any one course from DSE-5 will be offered to each student by the Department*							
DSE-6	CYPDTD9	Environmental Chemistry	T – 4+1*	40	60	100	5	5
D	CYPDDD1	Dissertation/field work/ internship/project/ Industry visit	D-12	40	60	100	6	6
VAC/ Certificate Course/ Optional	CYPATC1	Refer the List of Value-Added Course (p. 5)	T-2	40	60	100	2	Additional Credit Course
	CYPALC1		L-2	40	60	100	1	
					Total			**26**
MOOC's#								
Total Credit								**Credit: 103**

CC = Core courseDSE = Discipline specific Elective OE = Open Elective T= Theory L=Lab
Course Structure:

List of Value-Added Course (Certificate Course)	
1	Lab Safety Management (Prof. G. K. Patra)
2	Green Water Technology (Dr. S. K. Singh & Dr. U. P. Azad)
3	Agrochemicals Formulation (Dr. Charu Arora)
4	Cement Chemistry (Dr. S. S. Thakur & Prof. G. K. Patra)
5	Chemistry of Smart Materials and Technology (Dr. Arti Srivastava & Dr. Neeraj Kumari)
6	Food Adulteration and Testing (Dr. V. K. Rai and Dr. Manorama Singh)

#MOOC's courses may be offered at least one time during entire PG programme for the any of Core Course, Generic elective, Discipline specific elective, AEC course, Skill enhancement course available on MOOC's platform time to time. If any such course related to your subject is not available on MOOC's platform, department may continue with regular courses.

T – 4+1*refer to 4 hours Lecture and 1 hour Tutorial

SEMESTER–I

CC-1: CYPATT1-Analytical Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING: *Introduction, scope and objectives of analytical chemistry, selection of methods, tools of analytical chemistry, different analytical chemometrics as t-test, F-test, Q-test etc, general treatment of equilibria in aqueous medium, theory of redox indicators, principles of chromatography, classification, GC, HPLC.*

1. **Introduction:** Scope & objectives, Analytical chemistry and chemical analysis, Classification of analytical methods, Method selection, Sample processing, Steps in a quantitative analysis, Quantitative range (bispartite classification), Data organization, Analytical validations, Limit of detection and limit of quantitation, The tools of analytical chemistry and good lab practices.

2. **Analytical chemometrics:** Useful statistical test: test of significance, the F test, the student 't' test, the chi-test, the correlation coefficient, confidence limit of the mean, comparison of two standard values, comparison of standard deviation with average deviation, comparison of mean with true values, significant figures, regression analysis (least square method for linear and non-linear plots), statistics of sampling and detection limit evaluation. Chemometrics for optimization, modeling and parameter estimation, factor analysis, resolution and pattern recognition.

3. **Treatment of Equilibria:** Solvents and solutions, leveling of aqueous and non- aqueous solvent effects, general treatment of equilibria in aqueous medium involving monoprotic weak acid and weak base, and salts of weak acids and weak bases. Activity and concentration, Effect of electrolytes on chemical equilibria, Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, Theory of redox indicators, precipitation titrations.

4. **Chromatographic Separation:** Principle of chromatography, classification of chromatography, planar chromatography (paper and thin layer chromatography) and column chromatography (Gas chromatography, High-performance liquid chromatography).

OUTCOMES: *Students will learn how to do statistical analysis in analytical chemistry for different data analysis, solving problems related to pH and theory of redox indicators, Theoretical approach towards different types of chromatographic separations.*

Books Recommended:

1. R. L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
2. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.
3. D. A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Analytical Chemistry - An Introduction, 7th Edition (2000), Saunders College Publishing, Philadelphia, London.
4. J. H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), Saunders Holt, London.

CC-1: CYPALT1-Analytical Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING: *Understanding of term standard solution, titration, back titration, equivalence point, end point, primary and secondary standard, solves volumetric calculations based on performing different types of experiments.*

1. Determination of accuracy, precision, standard deviation, coefficient of variation, and least square fitting of certain set of experimental data in an analysis
2. Composition of two sets of results in terms of significance (Precision and accuracy) by (i) student's t-test, (ii) F-test
3. Quantitative determination of iron in soil samples by Redox titration method
4. Determination of hardness by EDTA titrations method using Eriochrome Black T
5. Determination of chloride by Argentometric method
6. Determination of composition of the metal complexes by Jobs continuous variation and mole ratio method
7. Spectrophotometric determination of iron using thiocyanate method
8. Determination of buffer capacity by pH metry.

Note: *Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: On successful completion of these semesters, students will be able to know:

- The principles and applications of instrumental methods of analysis, including chemical separation methods etc.
- formulating and solving problems in the laboratory
- how to communicate scientific information clearly and accurately, both in oral and in written forms
- the composition of written laboratory reports that summarize experimental procedures and the accurately present and interpret data
- statistical methods of data analysis including error distributions, hypothesis testing, confidence intervals, the method of maximum likelihood or least-squares analysis.

CC-2: CYPATT2-Inorganic Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING:

1. The students should be able to describe boding in coordination complexes.
2. The students should be able to explain electronic spectra of Transition Metal Complexes.
3. The students should be able to explain coordination, spectral and magnetic properties of lanthanides and actinides.
4. The students should be able to explain the use of terms Hard and Soft in relation to metal ions and ligands and discuss the stability of complexes in terms of hard and soft interactions.

1. **Metal-Ligand Bonding in Transition Metal Complexes**: Crystal field splitting diagrams in complexes of low symmetry; Spectrochemical and Nephelauxetic series; thermodynamic and structural effects; site selection in spinels, Jahn-Teller distortions; experimental evidence for metal-ligand orbital overlap; ligand field theory, molecular orbital theory of octahedral complexes.

2. **Electronic spectra of Transition Metal Complexes**: Spectroscopic ground states; Orgel energy level and Tanabe-Sugano diagrams for transition metal complexes; Charge transfer spectra; electronic spectra of octahedral and tetrahedral Co(II) and Ni(II) complexes and calculation of ligand-field parameters.

3. **Lanthanides and Actinides**: contraction, coordination, optical spectra and magnetic properties.

4. **HSAB Theory:** Classification of acids and bases as hard and soft; HSAB principle, theoretical basis of hardness and softness; Lewis-acid base reactivity approximation; donor and acceptor numbers, E and C equation; applications of HSAB concept.

5. **Uses of Organic reagents in Inorganic Analysis:** Cupferron, DMG, dithiozone, aluminon, oxine, dithiooxamide, α-benzoinoxime, αnitro-(3-naphthol, α-nitroso-3-naphthol, diphenyl carbazone, diphenyl carbazide, anthranilic acid, tannin, pyragallol, benzidine. salicylaldoxime, o-phenanthroline.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Boding in coordination complexes.
2. Spectral and magnetic properties of coordination compounds.
3. Coordination, spectral and magnetic properties of lanthanides and actinides.
4. Stability of complexes in terms of hard and soft interactions.

Books Recommended:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4th Edn. (1993), Addison-Wesley Pub. Co., New York.
3. R. S. Drago, Physical Methods in Inorganic Chemistry, International Edn. (1971), Affiliated East-West Press, New Delhi.
4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, (2006).
5. Vogel's Text book of Quantitative Inorganic Analysis, ELBS Press.

CC-2: CYPALT2-Inorganic Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Quantitative separation and determination of the following pairs of metal ions using gravimetric and volumetric methods:
   (i) Ag+ (gravimetrically) and Cu^{2+}(Volumetrically)
   (ii) Cu^{2+} (gravimetrically) and Zn^{2+}(Volumetrically)
   (iii) Fe^{3+} (gravimetrically) and Ca^{2+}(Volumetrically)
   (iv) Mg^{2+} (gravimetrically) and Ca^{2+}(Volumetrically)
   (v) Cu-EDTA (Volumetrically) and Cu-KCNS(Gravimetrically).
   (vi) Ni- EDTA (Volumetrically) Ni- DMG (Gravimetrically.)

2. Separation of a mixture of cations/anions by paper chromatographic technique using aqueous/non-aqueous media.
   (i) Pb^{2+} and Ag^{+} (aqueous and non-aqueous media)
   (ii) Co^{2+} and Cu^{2+} (non-aqueous medium)
   (iii) Cl^{-} and I^{-} (aqueous-acetone medium)
   (iv) Br– and I^{-} (aqueous-acetone medium)

Note: *Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: On successful completion of these semesters, students will be able to know:

- The principles and applications of qualitative and quantitative analysis.
- Learning paper chromatographic techniques for the identification and separations of inorganic cations/anions.
- Collection, analysis and representation of data in a scientific manner.

CC-3: CYPATT3-Organic Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING: Students will learn aromaticity, Effects of Structure on Reactivity, Mechanism and Stereochemistry of S_N1, S_N2, S_Ni and S_N2' reactions, The E1, E2 and E1cB mechanisms, Orientation of the double bond, Electrophilic, free-radical and nucleophilic mechanisms-Mechanistic and Stereochemical aspects. Orientation and reactivity.

1. **Aromaticity & Effects of Structure on Reactivity:** Benzenoid and non-benzenoid systems, anti-aromaticity, Homoaromaticity and NMR based concept of aromaticity; Linear free energy relationships (LFER), the Hammett equation - Substituent and reaction constants; the Taft treatment of polar and Steric effects in aliphatic compounds.

2. **Nucleophilic Substitution at Saturated Carbon:** Mechanism and Stereochemistry of SN1, SN2, SNi and SN2′ reactions. The reactivity effects of substrate structure, solvent effects, competition between SN1 and SN2 mechanisms.

3. **Neighboring Group Participation:** Evidences of N.G.P.; the Phenonium ion, participation by π and σ bonds, Anchimeric assistance. Classical vs. non-classical carbonium ions–the present status.

4. **Elimination reactions:** The E1, E2 and E1cB mechanisms, Orientation of the double bond. Hofmann versus Saytzeff elimination, Pyrolytic syn-elimination, Competition between substitution and elimination reactions.

5. **Addition to Carbon–Carbon Multiple Bonds:** Electrophilic, free-radical and nucleophilic mechanisms-Mechanistic and Stereochemical aspects. Orientation and reactivity. Hydroboration and Michael reaction.

OUTCOMES: After successful completion of the course, students will be enriched in knowledge to apply in their future endeavors. Students will be much familiar and acquainted with concept of aromaticity and its effect on structure, stability and reactivity. Students will gain the knowledge of Linear free energy relationships, polar and Steric effects in aliphatic compounds. Students will be well-versed with the basic as well as advanced concept of Organic reaction. Understand the basic concept of organic chemistry at advance level to apply in practical knowledge. Aromaticity of molecules and its effect on reactivity and stability. Relation between structure, reactivity

and energy of molecule as well as reaction dynamics. Basic as well as advanced knowledge of different mechanisms of addition reaction, substitution reaction and elimination reaction. Reactivity effects of substrate structure and solvent effects in SN1, SN2, E1 and E2 mechanism to unlock the basic problems of organic chemistry. To apply these basic concepts in solving the complex organic problems based on fundamentals.

Books recommended:

1. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
2. Peter Sykes, A Guide book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. S.M. Mukherjee and S.P. Singh, Reaction Mechanism in Organic Chemistry, Ist Edition (1990), Macmillan India Ltd., New Delhi.
4. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition)
5. R.T. Morrison and R.N. Boyd, Organic Chemistry, 6th Edition (2003), Prentice- Hall of India, New Delhi.
6. P.S. Kalsi, Organic Reactions and Their Mechanisms, Ist Edition (1996), New Age International Pub., New Delhi.

CC-3: CYPALT3-Organic Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

Separation of binary mixtures (Solid-Solid) of organic compounds and identification of individual components (physical characterization, elemental analysis, functional group (s) detection, derivative preparation and melting point determination.

OUTCOMES: On completion of this module, the learner will be able to independently identify the presence of different components/molecules in the unknown organic mixture, detection of elements, functional groups, prepare derivatives of organic molecules

CC-4: CYPATT4-Physical Chemistry-I (Credit-3)

OBJECTIVES AND LEARNING: To understand the ion–ion interaction and different ionic atmosphere, kinetics of complex and explosion reactions, the phenomena of chemical equilibrium in a microscopic world of a chemical reaction, to understand the consequences of Nernst heat theorem, the need of third law of thermodynamics and its applications, the kinetics of adsorption of particles on solid surfaces.

Electrochemistry: Activity Coefficient and Ionic Migration in Electrolyte Solutions: Quantitative treatment of Debye-Hückel theory of ion-ion interaction and activity coefficient, applicability and limitations of Debye-Hückel limiting law, its modification for finite-sized ions, effect of ion-solvent interaction on activity coefficient. Debye-Hückel-Onsagar (D-H-O) theory of conductance of electrolyte solution, its applicability and limitations, Pair-wise association of ions (Bjerrum and Fuoss treatment), Modification of D-H-O theory to account for ion-pair formation, Determination of association constant (KA) from conductance data.

Chemical Kinetics: Mechanism of Composite Reactions - types of composite mechanisms, rate equations for composite mechanisms, simultaneous and consecutive reactions, steady state

treatment, rate-determining steps, microscopic reversibility and detailed balance, dynamic chain (H2-Br2 reaction, decomposition of ethane and acetaldehyde) and oscillatory reactions (Belousov-Zhabotinskii reaction), branching chain: Hydrogen oxygen reaction (H2O2) reaction.

Surface Chemistry and Catalysis: Bimolecular surface reactions - reaction between a gas molecule and an adsorbed molecule, reaction between two adsorbed molecules, inhibition and activation energy of such reactions, BET and Langmuir adsorption isotherm.

Catalytic activity at surfaces (volcano curve), transition state theory of surface reactions: rates of chemisorption and desorption, unimolecular and bimolecular surface reaction, comparison of homogeneous and heterogeneous reaction rates, surface heterogeneity, lateral interaction.

Thermodynamics: Properties of non-ideal solutions-deviations (negative and positive) from ideal behaviour, excess functions for non-ideal solutions, calculations of partial molar quantities, determination of partial molar volume and partial molar enthalpy.

Third Law of thermodynamics: Nernst heat theorem, variation of entropy with temperature, determination of absolute entropy of liquids and gases, residual entropy.

OUTCOMES:

- Upon course completion, the student will be able to define central parts of electrochemical cells and electrochemical environment around the electrode and they can apply the famous Debye Huckel and Onsager equation for calculation of strength of electrochemical atmosphere with the change of variables.
- Students will be able to interpret the behavior of interfaces, the phenomena of physisorption and chemisorptions, kinetic applications of different theories and their main industrial applications.
- Students will be able to apply thermodynamics and kinetics knowledge to equilibrium systems in the solution of practical cases, proposing different strategies, evaluating possible options and providing a reasoned analysis of the results, working both individually and cooperatively.

Books Recommended:

1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy, Second Edition, Plenum Press, New York (1998).
2. Chemical Kinetics, K. J. Laidler,Third Edition (1987), Harper & Row, New York.
3. Physical Chemistry, P. W. Atkins, 7th Edition, Oxford University Press, New York (2002)
4. Physical Chemistry, P. W. Atkins, 7th Edition, Oxford University Press, New York (2002).
5. Physical Chemistry, I.N. Levine, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
6. Kinetics and Mechanism of Chemical Transformations, J. Raja Ram and J.C. Kuriacose, MacMillan Indian Ltd., New Delhi (1993).

CC-4: CYPALT4-Physical Chemistry Practical-I (Credit-2)

OBJECTIVES AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes:

1. Saponification of ethyl acetate with sodium hydroxide by chemical method.
2. Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis.
3. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
4. Distribution coefficient of I2 between two immiscible solvents.

5. Conductometric titration of a weak acid with strong base.
6. Conductometric titration of a mixture of weak and strong acids.
7. Potentiometric titration of a strong acid with strong base using quinhydrone electrode.
8. Conductometric titration of KCl with AgNO3.
9. Molecular weight of a non-electrolyte by cryoscopy method.
10. Determination of Molecular weight of a non-volatile substance (non-electrolyte) by Landberger method.

Note:*Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES:

- Upon course completion, the student will be able to apply all these experiment in relevant industry and further in higher studies for the outcome.
- To interpret the experimental results obtained by conductometer and potentiometer.
- Students will be able to conduct the Chemical kinetics experiment on various important reactions.
- Students will be able to describe the principles behind the experiment performed in the laboratory.

1: CYPATO2-Polymer Chemistry (Credit-3)

OBJECTIVE AND LEARNING:

- Learning scientific Mechanism of step-growth and chain growth polymerization.
- To understand the nature and properties of polymers.
- To predict Glass transition temperature and Degradation of polymers.
- Defining The Flory-Huggins Theory of Polymer solutions.

1. **Introduction:** Introduction, Classification of Polymers, Intermolecular forces in Polymers.

2. **Mechanism and kinetics of step-growth and chain growth polymerization:** radical, cationic, anionic and condensation polymerization. Copolymerization, Reactivity Ratios, Thermodynamic Aspects of Polymerization. Mechanism of Living Radical Polymerizations: Nitroxide mediated polymerization (NMP), Metal-catalyzed Living Radical Polymerization, Coordination polymerization, Ring opening polymerization.

3. **Polymer solutions:** Thermodynamics of polymer dissolution, The Flory-Huggins Theory of Polymer solutions, Nature of polymer macromolecules in solution, Size and shape of macromolecules in solution.

4. **Polymer structure and Physical properties:** Microstructure of polymer chains, crystallinity in polymers, Glass transition temperature, rheological properties. Degradation of polymers. Polymer reactions. Polymer Processing.

5. **Experimental methods:** polymer fractionation, molecular weight determination: Molecular mass – number and mass average molecular mass, determination of molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.

OUTCOMES: After studying this course, you should be able to:

- Summarize historical evolution of the polymers.
- Identify the repeat units of particular polymers and specify the isomeric structures which can exist for those repeat units.
- Evaluate the Polymer structure and Physical properties.
- Determine the molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.
- Recognize monomers and polymers.

Books Recommended:

1. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.
2. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.
3. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore
4. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences, Narosa Publishing House, New Delhi (2002)
5. V.R. Gowarikar, N.V. Vishwanathan, J. Shreedhar, Polymer Sciences, Wiley Eastern, New Delhi (1986).

OE-1: CYPALO2-Polymer Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING:

- Learning scientific Mechanism of step-growth and chain growth polymerization.
- To understand the nature and properties of polymers.
- To predict Glass transition temperature and Degradation of polymers.
- Defining The Flory-Huggins Theory of Polymer solutions.

1. Purification of monomer
2. Polymer synthesis:
   A. Synthesis of homopolymer and their copolymers by Free radical polymerizationin aqueous solution.
   B. Polymerization of vinyl monomer in nonaqueous media.
   C. Preparation of urea-formaldehyde resin
   D. Preparation of hydrogel
   E. Preparation of Nylon 6,6
3. Polymer molecular weight Determination:
   A. Determination of molecular weight by viscometry:
   B. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
4. Characterization Techniques:
   A. FTlR studies of Polymers
   B. XRD analysis
   C. Polymerization kinetics by UV analysis

OUTCOMES: After studying this course, you should be able to:

- Summarize historical evolution of the polymers.
- Identify the repeat units of particular polymers and specify the isomeric structures which can exist for those repeat units.
- Evaluate the Polymer structure and Physical properties.
- Determine the molecular mass by Osmometry, viscosity, light scattering and size exclusion chromatography.
- Recognize monomers and polymers.

Reference Books:

1. Harry R. All.cock, Frederick W. Lampe and James E. MarhContemChemistry, 3ro ed. Prentice-Hall (2003)
3. Fred W. Billmeyer, Textbook of Polymer Science,-3rd edition, WileyJnterscience (1984).
4. Joel R. Fried, Polymer Science and Technology' 2nded' Prentice-Hall (2003).
5. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
6. Seymour/Carraher's Polymer Chemistry, 9th ed. by Charles E, Carraher, Jr. (2013).

SEMESTER–II

CC-5: CYPBTT1-Analytical Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING: Theory, instrumentation and applications of X-rays (emission, absorption, diffraction and fluorescence), Atomic absorption spectroscopy, Atomic emission spectrometry, UV-visible molecular absorption spectrometry, Jobs method of continuous variation, mole ratio, and slope ratio analysis, Molecular luminescence (fluorescence, phosphorescence, chemiluminescence).

1. **Basics of Polarography:** Origin of polarography, Current-voltage relationship, Theory of polarographic waves (DC and sampled DC (tast) polarograms), Instrumentation, interpretation of polarographic curve, Limiting current, residual and charging current, diffusion current, migration current. Supporting electrolytes. Effect of supporting electrolyte on the limiting current, Half wave potential and its significance, Qualitative and quantitative applications.

2. **Spectroscopic Techniques:** Theory, Instrumentation and applications of X-rays (emission, absorption, diffraction and fluorescence methods), Atomic absorption Spectroscopy, Atomic fluorescence spectrometry, Atomic emission spectrometry.

3. **Spectrophotometry:** UV-visible molecular absorption spectrometry, Principle and applications, determination of stoichiometry of complexes (Job's method of continuous variation, mole ratio and slope ratio analysis). Molecular luminescence spectrometry (fluorescence, phosphorescence, chemiluminescence).

4. **Thermal Analysis:** Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods.

5. **Automation in the Laboratory:** Principles of automation, Process control through automated instruments, Autoanalyzers (single channel and multi-channel), Basic sequences of multi-fold operational analyzers in segmented and non-segmented flows.

OUTCOMES:

- Having successfully completed this module, you will be able to:
- understand the underlying theoretical basis of analytical techniques including titration and gravimetric analysis, spectroscopic methods including UV-visible, Fluorescence, and atomic absorption, chromatography, and electroanalysis;
- be able to select the appropriate analytical methods to evaluate a sample;
- critically evaluate data from a variety of analytical chemistry techniques and apply knowledge of the statistical analysis of data;
- have developed the skills required to work as a member of a group;
- be aware of current developments in the field of analytical chemistry.

Books Recommended:

1. Willard, Merrit, Dean, Settle, Instrumental Methods of Analysis, 7th Ediion, CBS Publishers & Distributors PVT Ltd.
2. D.A. Skoog, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College Publishing, Philadelphia, London.

3. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
4. J.H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), Saunders Holt, London.
5. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.

CC-5: CYPBLT1- Analytical Chemistry Practical-II (Credit-2)

OBJECTIVE AND LEARNING: Understanding of term standard solution, titration, back titration, equivalence point, end point, primary and secondary standard, solves volumetric calculations based on performing different types of experiments.

1. Determination of biological oxygen demand (BOD) and dissolved oxygen (DO) in water samples
2. Determination of chemical oxygen demand (COD) in waste water samples
3. Determination of total phosphorous and total dissolved solid in drinking water
4. Gas chromatography: Quantitative determination of organic compounds
5. Thin layer chromatography: Separation of amino acids
6. Iodometric titration: Determination unsaturation (iodine number)
7. Potentiometric titration: Determination of concentration of halide ion(s) in given solution
8. Determination of trace metal impurities present in water sample by voltammetric method

Note: *Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: On successful completion of these semesters, students will be able to know:
(a) The principles and applications of instrumental methods of analysis, including chemical separation methods etc. (b) formulating and solving problems in the laboratory (c) how to communicate scientific information clearly and accurately, both in oral and in written forms (d) the composition of written laboratory reports that summarize experimental procedures and the accurately present and interpret data (e) statistical methods of data analysis including error distributions, hypothesis testing, confidence intervals, the method of maximum likelihood or least-squares analysis.

CC-6: CYPBTT2-Inorganic Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING:

1. The students should be able to describe reactivity, electron transfer and mechanism in coordination and organometallic compounds.
2. The students should be able to explain bonding, synthesis and reactivity of transition metal complexes with pi donor ligands.
3. The students should be able to explain Wade's rule and the capping rule.
4. The students should be able to describe supramolecular interactions.
5. The students should know basic principle of Optical Rotatory Dispersion and Circular Dichroism.

1. **Kinetics and Mechanism of Substitution Reactions:** Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms of VBT and CFT; rates of reactions; acid hydrolysis, base hydrolysis and anation reactions.

2. **Electron Transfer Reactions:** Mechanism and rate laws; various types of electron transfer reactions, Marcus-Husch theory, correlation between thermal and optical electron transfer reactions.

3. **Supramolecular Chemistry:** Definition, supramolecular host-guest compounds, macrocyclic effect, nature of suparmolecular interactions, molecular machine, biomodelling.

4. **Optical Rotatory Dispersion and Circular Dichroism:** Basic Principles of ORD and CD techniques. ORD and Cotton effect, Faraday and Kerr effects; Applications in determining absolute configuration of metal complexes.

5. **Symmetry Point groups:** determination of point group of a molecule. Representations. The great orthogonality theorem. Character table. Construction of character tables for c2v and c3v groups.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Reactivity, electron transfer and mechanism in coordination and organometallic compounds.
2. Boding ad reactivity of transition metal complexes with CO, NO and hydrides.
3. Supramolecular interaction and their application in host guest interaction and molecular machine.
4. Basic principle of optical rotatory dispersion and circular dichroism.

Books Recommended:

1. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn (1967), Wiley Eastern Ltd., New Delhi.
2. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd Edn. (1999), ELBS, London.
3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons, New York (1999).
4. D.N. Sathyanarayana, Electronic Absorption Spectroscopy and Related Techniques, University Press (India) Ltd., Hyderabad (2001).
5. J.-M. Lehn; Supramolecular Chemistry-Concepts and Perspectives, Wiley-VCH, (1995).
6. P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry, Oxford University Press, (1999).
7. J. W. Steed and J. L. Atwood; Supramolecular Chemistry, Wiley, (2000).
8. Introductory Quantum Chemistry, A.K. Chandra, 4th Edition (1994), Tata Mcgraw Hill, New Delhi.
9. Atomic & Molecular Symmetry Groups and Chemistry, S.C. Rakshit, Aug 2021, CRC Press
10. Chemical Applications of Group Theory, 3ed, F. A. Cotton, Willey

CC-6: CYPBLT2- Inorganic Chemistry Practical-II (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

- Inorganic preparation of Mono Nuclear Metal Complexes.
- Preparation of coordination complexes and their characterization by magnetic susceptibility measurements and IR, UV / Vis, ^{1}H NMR spectroscopic techniques.

a) Tetrammine cupric sulphate $[Cu(NH_3)_4]SO_4 \cdot H_2O$.
b) *tris* (thiourea) cuprous sulphate $[Cu(NH_2CSNH_2)_3]_2\ SO_4 \cdot H_2O$

c) *tris* (thiourea) cuprous chloride $[Cu(NH_2CSNH_2)_3]Cl$.
d) Hexa ammine nickel(II) chloride $[Ni(NH_3)_6]\ Cl_2$.
e) Hexathiourea–plumbus nitrate $[Pb(NH_2CSNH_2)_6]\ (NO_3)_2$.
f) Potassium trioxalato chromate $K_3\ [Cr(C_2O_4)_3]$.
g) Potassium trioxalato aluminate $K_3\ [Al(C_2O_4)_3]$.
h) sodium trioxalateferrrate(III) $Na_3\ [Fe(C_2O_4)_3]\ 9H_2O$.
i) Hexamminecobalt(III) chloride $[Co(NH_3)_6]\ Cl_3$.
j) Pentathioureadicuprous nitrate $[Cu(NH_2CSNH_2)_5]\ (NO_3)_2$.

Note: *Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES:

- Knowing about IR, electronic spectra and magnetic susceptibility of various transition metal complexes.
- Calculation of ligand field parameters based on electronic spectra of various transition metal complexes.
- Student will have idea about instrumentation methods of structural determination.

CC-7: CYPBTT3-Organic Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING: To make student aware the advance level of basic organic chemistry to apply in different reaction mechanisms and organic transformations.

1. **Electrophilic Aromatic Substitution & Nucleophilic Substitution:** The Arenium ion mechanism, orientation and reactivity in monosubstituted benzene rings. Ipso substitution. Electrophilic aromatic substitution of naphthalene, phenanthrene and antharcene.

2. **Aromatic Nucleophilic Substitution:** The Aromatic SN1, SN2 and Benzyne mechanisms. Reactivity – effect of substrate structure, leaving group, and attacking nucleophile. Nucleophilic aromatic substitution of naphthalene, phenanthrene and antharcene.

3. **Pericyclic Reactions:** Orbital symmetry and correlation diagram, Woodward-Hoffmann rules; cycloaddition [2+2] and [4+2], and electrocylic reactions. Prototropic and Sigmatropic rearrangements, Cope, Claisen and Ene reactions, Cheletropic reactions; 1,3-Dipolar cycloaddition.

4. **Photochemistry–I:** Introduction and Basic Principles of Photochemistry, Photochemical energy, Jablonski diagram, photo-sensitization and quenching.

5. **Photochemistry–II:** Photochemistry of olefins Isomerization, Di-□-methane rearrangement and cycloadditions; Photochemistry of aromatic compounds; Photochemistry of carbonyl compounds: Norrish type-I and Norrish type-II cleavage; Intramolecular and intermolecular hydrogen abstraction; Photocyclo-addition of ketones with unsaturated compounds: Paterno-Buchi reaction, photodimerisation of α,β-unsaturated ketones, rearrangement of enones and dienones, Photo-Fries.

OUTCOMES: After successful completion of the course, students will learn the advanced organic chemistry concepts that will be applied in solving their future chemistry problems. They will learn about Arenium ion mechanism, orientation and reactivity. participation by π and σ bonds, Anchimeric assistance. Classical versus non-classical carbonium ions. Woodward-Hoffmann rules; cycloaddition [2+2] and [4+2], and electrocylic reactions. Prototropic and Sigmatropic rearrangements, Ene reactions and Cheletropic reactions; 1,3-Dipolar cycloaddition. Photochemical energy, Jablonski diagram, photosensitisation and quenching, Isomerization, Di-π-methane rearrangement and cycloadditions; Norrish type-I and Norrish type-II cleavage; Paterno-Buchi reaction, photodimerisation of α,β-unsaturated ketones, rearrangement of enones and dienones, Photo-Fries rearrangement.

Books recommended:

1. M.B. Smith & Jerry March, March's Advanced Organic Chemistry, 5th Edition (2001), John Wiley & Sons, New York.
2. Peter Sykes, A Guide Book to Mechanism in Organic Chemistry, 6th Edition (1997), Orient Longman Ltd., New Delhi.
3. S.M. Mukherjee and S.P. Singh, Reaction Mechanism in Organic Chemistry, Ist Edition (1990), Macmillan India Ltd., New Delhi.
4. T.H. Lowry and K.S. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edition (1998), Addison – Wesley Longman Inc. (IS Edition).
5. R.T. Morrison and R.N.Boyd, Organic Chemistry, 6th Edition (2003), Prentice- Hall of India, New Delhi.
6. P. S. Kalsi, Organic Reactions and Their Mechanisms, Ist Edition (1996), New Age International Pub., New Delhi.
7. S. M. Mukherjee and S. P. Singh, Pericyclic Reactions, MacMillan India, New Delhi.
8. I. Fleming, Pericyclic Reactions (1999), Oxford University Press, Oxford.
9. I. Fleming, Frontier Orbitals and Organic Chemical Reactions (1976), Wiley, New York.
10. T. L. Gilchrist and R. C. Storr, Organic Reactions and Orbital Symmetry, 2nd Edn., Cambridge University Press, 1979.
11. R.B. Woodward and R. Hoffman, The Conservation of Orbital Symmetry, Verlag Chemie GmbH, 1970.
12. T.H. Lowry and K.C. Richardson, Mechanism and Theory in Organic Chemistry, 3rd Edn., Harper and Row, 1998.
13. J. Singh and J. Singh, Photochemistry and Pericyclic Reactions, 2nd Edn., New Age International (P) Ltd., 2005
14. John D. Coyle, Introduction to Organic Photochemistry, John Wiley and Sons, New York (1986).
15. C. H. Depuy and O. L. Chapman, Molecular Reactions and Photochemistry, 2nd Edition (1988), Prentice-Hall of India (P) Ltd., New Delhi.
16. F. A. Carey and R. J. Sundberg, Photochemistry in Advanced Organic Chemistry, Chapter 13, Part A, 3rd Edition (1990), Plenum Press, New York.
17. N. J. Turro, Modern Molecular Photochemistry, University Science Books, Sausalito (1991).

CC-7: CYPBLT3-Organic Chemistry Practical-II (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Synthesis of organic compounds involving important chemical reactions such as aldol condensation, nitration, bromination, diazotization, coupling reactions, molecular rearrangements etc.
2. Isolation of some natural products (Caesin from milk, lycopene from tomatoes, Nicotine from tobacco leaves etc.).

Note: *Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: On completion of this module, the learner will be able to:

- Independently synthesize important organic molecules

- Purify synthesized molecules
- Calculate the percentage of yield of the products
- Able to identify the outcome of products by spectroscopic techniques.

CC-8: CYPBTT4-Physical Chemistry – II (Credit-3)

OBJECTIVES AND LEARNING: To learn the basic concept of Corrosion and micelles and their uses, radio chemistry and transport phenomenon like viscosity, diffusion etc in gaseous state, learn the micelles.

1. **Corrosion:** Scope and economics of corrosion, causes and types of corrosion, electrochemical theories of corrosion, kinetics of corrosion (corrosion current and corrosion potential). Corrosion measurements (weight loss, OCP measurement, and polarization methods), units of corrosion rate, passivity and its breakdown. Corrosion prevention (electrochemical, inhibitor, and coating methods).

2. **Transport Phenomena:** General transport equation: Thermal condutivity, Viscosity and Diffusion. Intermolecular Forces: Long range forces. Lennard Jones potential.
Physical transformation of Pure substances: stability of Phases, Phase boundaries, three typical phase diagram, thermodynamic criteria of equilibrium, the dependence of the stability on the conditions, location of phase boundaries, the Ehrenfest classification of phase transition.

3. **Chemical thermodynamics:** Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; thermodynamics of ideal and non-ideal gases, and solutions.

4. **Micelles Surface-active agents and their classification, Hydrophile-Lipophile Balance:** HLB parameter, Shape and Structure of micelles, micro-emulsions, reverse micelles, micellization, Critical miceller concentration (cmc), phase separation and mass action models, factors affecting cmc of surfactants, thermodynamics of micellization, micelle temperature range: MTR or Krafft Point.

5. **Radiochemistry:** Radiation detection & measurements--Proportional, Geiger-Muller and Scintillation counters, semiconductor detectors. Radiochemical principles in the use of tracers. Applications of radioisotopes as tracers: activation analysis, isotope dilution technique, age determination, medical applications.Radiation Chemistry: Elements of radiation chemistry, units for measuring radiation absorbed.

OUTCOMES:

- The course contains background for understanding various corrosion processes, protection methods and materials selection with practical examples. Based on physical chemical theory, the student shall be able to evaluate if corrosion can occur under specific operating conditions in a given equipment or construction. In cases where corrosion can occur, the student shall be able to determine the probable corrosion type, estimate the corrosion rate and propose the most reasonable protection method with regard to safety, price and environmental considerations.

- Students will be able to understand the physicochemical fundamentals that allow for the interpretation of transport phenomena in physical and chemical processes, phase equilibria and interface behaviour and adsorption phenomena.
- Students will be able to restate definition of system, surrounding, closed and open system, extensive and intensive properties. Student will be able to determine the reversibility or irreversibility of a thermodynamic process.
- Students will be able to Introduce about the Micelle, Critical Micelle Concentration and Micellization and its thermodynamics. Students will be able to Determination of CMC of any Surfactant.
- Students will be able to explain the concepts of Radiation Chemistry. Applications of Radioisotopes in different field is very useful for the students.

Books Recommended:

1. Modern Electrochemistry, Vol. 2 A & B, J.O'M. Bockris and A. K. N. Reddy, Second Edition, Plenum Press, New York (1998).
2. Electrochemical Methods: Fundamentals and Applications; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.
3. Physical Chemistry, P. W. Atkins, 7th Edition, Oxford University Press, New York (2002).
4. Physical Chemistry, N. Levine, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.
5. "Physical Chemistry", K. J. Laidler and J. M. Meiser, 3rd Edition (International Ed.) Houghton Mifflin Co., New York.
6. "Physical Chemistry", R. S. Berry, S. A. Rice and J. Ross, 2nd Edition, Oxford University Press, Oxford (2000).
7. Y. Moroi, Micelles: Theoretical and Applied Aspects, Plenum Press, New York (1992).
8. F.W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley-Interscience, New York.
9. B. G. Harvey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, Inc. (1969).
10. H.J. Arnikar, Essentials of Nuclear Chemistry, 4th Edition (1995), Wiley-Eastern Ltd., New Delhi.
11. G. Fridlander, J.W. Kennedy, E. S. Macias, and J. M. Miller, Nuclear & Radiochemistry, 3rd Edition (1981), John Wiley, New York.

CC-8: CYPBLT4-Physical Chemistry Practical – II (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Rate constant of acid catalyzed hydrolysis of sucrose by polarimetric method.
2. Rate constant of acid catalyzed hydrolysis of sucrose by chemical method.
3. Rate constant of $FeCl_3$-catalyzed H_2O_2 decomposition by gasometric method.
4. Degree of hydrolysis of urea hydrochloride by kinetics method.
5. Equilibrium constant of $KI + I_2 \rightleftharpoons KI_3$ by distribution method.
6. Phase diagram of a binary organic system (Naphthalene and Diphenyl).
7. Determination of solubility and solubility product of sparingly soluble salt conductometrically.
8. Potentiometric titration of a redox system (ferrous ammonium sulfate with $K_2Cr_2O_7$).
9. Adsorption of acetic acid on charcoal to verify Freundlich adsorption isotherm.
10. Determination of the velocity constant of hydrolysis of an ester/ionic reaction in miceller media.

OUTCOMES:

- Upon course completion, the student will be able to apply the experiment based on adsorption, phase diagram and molecular weight in relevant industry and further in higher studies for the outcome.
- To interpret the experimental results obtained by conductometer and Polarimeter.
- Students will be able to conduct the Chemical kinetics experiment on various important reactions.
- Students will be able to describe the principles behind the experiment performed in the laboratory.

CC-9: CYPBTT5-Molecular Spectroscopy (Credit-5)

OBJECTIVES AND LEARNING: This module will provide theory, instrumentation and applications of different spectroscopic techniques.

1. **Unifying Principles:** Electromagnetic radiation, interaction of electromagnetic radiation with matter, absorption, emission, transmission, reflection, refraction, dispersion, polarization, and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, result of the time-dependent perturbation theory, transition moment selection rules, intensity of spectral line. Born-Oppenheimer approximation, rotational, vibrational, and electronic energy levels. Fourier Transform Spectroscopy.

2. **Rotation and Vibration of Diatomic Molecules:** Vibration-rotational spectra of diatomics; P,Q,R branches, normal modes of vibration, overtones, hot bands Raman spectroscopy: Origin; rotational and vibrational Raman spectra of diatomics, Anharmonicity, Selection Vibration of polyatomic molecules–normal coordinates. Polarization of Raman lines. Fingerprint region and applications.

3. **Electronic Spectroscopy:** Electronic spectra of diatomic molecules, Franck-Condon principle, Vibronic transitions, $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transition. Dissociation and pre-dissociation. Rotational fine structure.

4. **Nuclear Magnetic Resonance:** Review of angular momentum. Basic principles and relaxation times. Magnetic resonance spectrum of hydrogen. First-order hyperfine energies. NMR in liquids: Chemical shifts and spin-spin couplings First order Spectra: A3X, AX and AMX systems. Solid state NMR spectroscopy, Introduction of 2D NMR spectroscopy, Basic principle and Applications of COSY, NOE and HMBC.

5. **Photoelectron Spectroscopy (PES):** Photo excitation and photo ionization, core level photo ionization (XPS, ESCA.) and valence level (UPS) experiments, detection of atoms in molecules, chemical shift.

OUTCOMES: Student will get the knowledge of principles and different spectral techniques and how to do apply using these spectroscopic analyses in their experimental work.

Book Recommended:

1. J. M. Hollas, Modern Spectroscopy, 4th edition (2004) John Wiley & Sons, Ltd., Chichester.
2. C. N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th edition (1994), Tata McGraw Hill, New Delhi.
3. A Carrington and A. D. Mc Lachlan, Introduction to Magnetic Resonance, Chapman and Hall, London (1979).
4. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, Addison Wesley, Longman Ltd, London (1986).

DSE-1: CYPBTD1- Instrumental Analytical Techniques (Credit-5)

OBJECTIVE AND LEARNING: This module will provide theory, instrumentation and applications of different analytical instrumental techniques of Fourier Transform Infra-Red (FTIR), Raman, Nuclear Magnetic Resonance (NMR), Electron Spin Resonance (ESR), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Inductively coupled plasma emission spectroscopy (ICPE).

1. **Infrared Spectroscopy:** Infrared instruments, typical applications of infrared spectroscopy (qualitative and quantitative).

2. **Raman Spectroscopy:** Raman spectroscopy, Instrumentation, Analytical applications of Raman spectroscopy.

3. **Nuclear Magnetic Resonance Spectroscopy:** Theory of nuclear magnetic resonance, Environmental effects on NMR spectrometers, Applications of proton NMR, C13 NMR, Two dimensional Fourier-transform NMR, Magnetic resonance imaging (MRI), Quantitative applications of NMR: Drug Analysis, Molecular Weight determination.

4. **Electron Spin Resonance Spectroscopy:** Theory, Instrumentation and Important analytical applications.

5. **Electron Spectroscopy:** Theory, Instrumentation and applications of Electron spectroscopy (ESCA and Auger), Scanning electron microscopy (SEM), Scanning tunnelling microscopy (STM) and Atomic force microscopy (AFM).

6. **Plasma Emission Spectroscopy:** Theory, Instrumentation and Analytical applications of inductively coupled plasma emission spectroscopy (ICPE).

7. **Applications in analysis of special materials:** Analysis of dairy products, food additives, petrochemicals (including liquid and gaseous fuels), drugs and pharmaceuticals and fertilizers.

OUTCOMES: Student will get the knowledge of principles and instrumentation of different analytical techniques and how to do the analysis using FTIR, Raman, NMR, ESR, SEM, TEM and ICPE.

Books Recommended:

1. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Harcourt Brace & Company, Florida.

2. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
3. J.M. Hollas, Modern Spectroscopy, 3rd Edition (1996), John Wiley, New York.
4. H.A. Strobel, Chemical Instrumentation – A Systematic Approach, 2nd Edition (1973), Addison Wesley, Mass.
5. D.C. Garratt, the Quantitative Analysis of Drugs, 2nd Edition (1992), Chapman and Hall Ltd., London.
6. W. Horwitz (Editor), Official Methods of Analysis, 11th Edition (1970), Association of Official Analytical Chemists, Washington DC.

DSE-1: CYPBTD2- Bio-inorganic Chemistry (Credit-5)

OBJECTIVE AND LEARNING: Objective of this course is

1. The students should be able to describe role of alkaline earth metal ions in biological systems.
2. The students should know structure and function of iron, copper and molybdenum in biological systems.
3. The students should be able to explain structure and reactivity of Urease, Hydrogenase, and Cyanocobalamine.
4. The students should be able to know interaction of metal with DNA and chemotherapeutic agents.
5. The students should be able to knowStructure and role ofIron storage and transport proteins.

1. **Role of alkaline earth metal ions in biological systems:** (i) Catalysis of phosphate transfer by Mg2+ ion, (ii) Ubiquitous regulatory role of Ca2+ -muscle contraction.

2. **Iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity:** (i) Anti-oxidative functions: cytochrome P-450, catalases and peroxidases, (ii) Nitrate and nitrite reduction: NO3 and NO2 reductase, (iii) Electron transfer: cytochromes; blue copper proteins and iron-sulfur proteins and their Synthetic models, (iv) Nitrogen fixation through metal complexation, nitrogenase, (v) Photosynthesis (PS-I and PS-II).

3. **Metalloenzymes:** Urease, Hydrogenase, and Cyanocobalamine. Superoxide Dismutase, Carbonic anhydrase, Carboxypeptidase.

4. **DNA and its interaction with metal complexes:** Protein structure, Ramachandran - plot, protein folding: DNA/RNA structures, various forms (a, b, c, z) of DNA, and DNA binding protein-zinc-finger protein, DNA probe and chemotherapeutic agents.

5. **Iron storage and transport proteins:**Hemoglobin, Myoglobin, Hemerythrin and hemocyanin, Ferritin, Siderophores, Transferritin and Hemosiderin

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Role of alkaline earth metal ions in biological systems.
2. Structure and function of iron, copper and molybdenum in biological systems.
3. Structure and reactivity of Urease, Hydrogenase, and Cyanocobalamine.
4. Interaction of metal with DNA and chemotherapeutic agents.
5. Structure and role of iron storage and transport proteins.

Books recommended:

1. M. N. Hughes, Inorganic Chemistry of Biological Processes, 2nd Ed. (1981), John-Wiley & Sons, New York.
2. W. Kaim and B. Schwederski, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide, Wiley, New York (1995).
3. S. J. Lippard and J. M. Berg, Principles of Bioinorganic Chemistry, University Science Books, (1994).
4. I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, Bioinorganic Chemistry, Viva Books Pvt. Ltd., New Delhi (1998).

DSE-1: CYPBTD3-Chemistry of Heterocycles (Credit-4)

OBJECTIVE AND LEARNING: Student will learn the synthesis and application of heterocycles as half of the drugs and natural products saving life contains heterocycles.

1. **Introduction:** Definition of heteroatom, Aromatic and non-aromatic heterocyclic compounds, Classification and nomenclature of heterocyclic compounds, important reactions with heterocyclic compounds i.e., oxidation, reduction and tertiary effect of Nitrogen in heterocyclic compound.

2. **Non-Aromatic Small Ring (Three/Four-Membered) Heterocycles:** Different types of strains, interactions and conformational aspects of non-aromatic heterocycles. Synthesis, reactivity and importance of the following ring systems: Aziridines, Oxiranes, Thiiranes, Oxaziridines, Azetidines, Oxetanes and Thietanes.

3. **Five Membered Heterocyclics with Two Hetero Atoms**: Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyrazole, Imidazole, Oxazole, Thiazole, Isoxazole, Isothiazole,

4. **Six Membered Heterocyclics with Two Hetero Atoms**: Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyridazine, Pyrimidine. Pyrazine, Oxazine, thiazine: Fused heterocycle: Benzimidazole, benzoxazole and benzthiazole.

5. **Use of Heterocycles in Life:** Structure determination, synthesis and applications of Thiamine (B1), Pyridoxine, Ascorbic acid and Biotin (H).

OUTCOMES: After learning the course, students will be able to design, synthesis and apply the studies about heterocycles in their future academic industry career.

Book Recommended:

1. I.L. Finar, Organic Chemistry, Vol. II, 5th Edition (1975 Longman Ltd., New Delhi.
2. T.L. Gilchrist, Heterocyclic Chemistry, 3rd Edition (1997) Addison-Wesley Longman Ltd., England
3. R.K. Bansal, Heterocyclic Chemistry: Syntheses,Reactions and Mechanisms, 3rd Edition (1999), New Age International, Publisher, New Delhi.
4. A.R. Katritzky and A.F. Pozharskii, Handbook of Heterocyclic Chemistry, 2nd Edition (2000), Pergamon Press, Oxford.
5. Advances in Heterocyclic Chemistry, A.R. Katritzky (Editor), Academic Press, New York.
6. Heterocyclic Compounds, A. Weissberger (Editor), Interscience, New York.

7. T. Gilchrist: Heterocyclic Chemistry R. M. Acheson: An Introduction to the Chemistry of Heterocyclic Compounds
8. J. A. Joule & K. Mills: Heterocyclic Chemistry
9. A. Paquette: Principles of Modern Heterocyclic Chemistry
10. J, A. Joule & Smith: Heterocyclic Chemistry.

DSE-1: CYPBTD4-Solid State Chemistry (Credit-5)

OBJECTIVE AND LEARNING: To identify and apply the concepts involved in the syntheses, structure and physical properties of crystalline inorganic solid, XRD of Solids, band theory and magnetic properties of solids.

1. **Solid State Reactions:** General Principles, Experimental procedure, Co-precipitation as precursor to solid-state reactions, Kinetics of solid-state reactions, Crystallization of solutions, melts, glasses and gels. Growth of single crystals: Czochralski, Bridgman and Stockbarger methods. Zone Melting.

2. **X-ray Diffraction & Crystal Structure:** Diffraction of X-rays by crystals: Bragg's law, Definitions related to crystal structure, crystallographic direction and crystallographic phases. X-ray diffraction experiments: The powder method and the single crystal method. Reciprocal lattice. Structure factor and its relation to intensity and Electron density. The phase problem. Description of procedure for an X-ray structure analysis.

3. **Phase Transitions:** Thermodynamic and Burger's classification of phase transition, Kinetics of phase transition- nucleation and growth, T-T-T diagrams, Factors influencing kinetics of phase transition, Martensitic and order-disorder transitions.

4. **Electronic Properties and Band Theory:** Electronic structure of solids- band theory, Refinement of simple band theory- k-space and Brillouin Zones, Band structure of metals, insulators and semiconductors, Intrinsic and extrinsic semiconductors, Doped semiconductors, p-n junctions. Superconductors Meissner effects.

5. **Magnetic Properties:** Behavior of substances in a magnetic field, effect of temperature: Curie and Curie-Weiss law, origin of magnetic moment, ferromagnetic, antiferromagnetic and ferromagnetic ordering, super exchange, magnetic domains, hysteresis.

OUTCOMES: After finishing this course the students will be able to
Grasp the basis of ensemble approach in statistical mechanics to a range of situations.Explain the fundamentals of thermodynamics, carnot cycle, statistics and distributions.Explain the fundamental differences between classical and quantum statistics and learn about quantum statistical x laws.Analyze important examples of ideal Bose systems and Fermi systems.

Books Recommended:

1. A.R. West, Solid State Chemistry and its Applications, John Wiley and Sons, Singapore (1984).
2. L.V. Azaroff, Introduction to Solids, Tata McGraw-Hill, New Delhi (1977).
3. L. Smart and E Moore, Solid State Chemistry, Chapman & Hall, Madras (1992).
4. H. V. Keer, Principles of Solid State, Wiley Eastern (1993)

SEMESTER–III

CC-10: CYPCTT1-Computer Applications in Chemistry (Credit-5)

OBJECTIVES AND LEARNING: To get a brief knowledge of FORTRAN 77 and other numerical methods.

FORTRAN 77: Types of Constants and Variables in Fortran, Dimension, Data, Type, COMMON and EQUIVALENCE statements, Arithmetic and Logical IF, IF-THEN-ELSE Constructs, DO statement, Various types of I/O statements, Library functions, Statement functions, Function Subprograms and subroutine subprograms with suitable examples.

Numerical Methods: Roots of Polynomials, Solution of Linear simultaneous equations, matrix multiplication and inversion. Numerical integration. Statistical treatment of data, variance and correlations, Least square curve fitting.

OUTCOMES: Students will learn different programming languages which are required for helping in different molecular simulations.

Books Recommended

1. V. Rajaraman, Fortran 77, Prentice Hall (India), New Delhi.
2. K. V. Raman, Computers in Chemistry, Tata McGraw Hill (1993).
3. C. Xavier, Fortran 77 and Numerical Methods, New Age International Pvt. Ltd. Publishers, New Delhi
4. S. Lipschutz and A. Poe, Schaum's Outline Series – Theory and Problems of Programming with Fortran including structured Fortran, Mc Graw Hill Book Company, Singapore.

RM: CYPCTA1- Research Methodology (Credit-2)

OBJECTIVE AND LEARNING: To make the student aware about design and perform the research based-on their theoretical background in their PG study.

1. **Use of Information Technology resources:** The Internet and World Wide Web, Internet resources for Chemistry, Internet search engines, use of spreadsheets, word processors, data bases and other packages, finding and citing information. End-note software for references.

2. **Basic concept of Research Methodology:** Definition, objective and design of a research problem in Chemical sciences. Need and sources of Literature survey: journals, journal abbreviations, abstracts, reviews, monographs, text books, chemical abstracts and online source of literature search. Types of scientific communication: research papers, review.

3. **Concepts of Chemical safety:** Chemical safety and ethical handling of chemicals, safe working procedure and protective environment, emergency procedure and first aid, safe storage and use of hazardous chemicals, identification and procedure for working with substances that pose hazards, flammable or explosive hazards, identification and procedures for working with gases at pressures above or below atmosphere, and information about different symbols in chemistry and industry research laboratories.

4. **Advanced Spectral Techniques**: Applications of UV-Visible, IR, NMR and Mass spectroscopy for the structural elucidation of compounds in chemical research.

OUTCOMES: After completing this study, student will about the research methodology how to design their research work.

Reference Books:

1. Dr. C.R. Kothari, Research Methodology: Methods and Techniques, New Age International Publishers, 2nd Ed., New Delhi (2014.)
2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, Pearson Education; 2nd Ed., (2005).
3. M.D. Barbara Gastel and Robert A. Day, How to Write and Publish a Scientific Paper, Greenwood Publishing Group Inc, 8th Ed., 2016.
4. Tanmoy Chakraborty and Lalita Ledwani, Research Methodology in Chemical Sciences: Experimental and Theoretical Approach, Apple Academic Press; 1st Ed., 2016.

OE-2: CYPCTO1- Medicinal Chemistry (Credit-3)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Various chemical and structural aspects of medical drugs
2. Several Biological activity parameters and Drug metabolism
3. Conventional and modern methods for drugs synthesis

1. **Structure and activity:** Relationship between chemical structure and biological activity (SAR). Receptor Site Theory. Approaches to drug design. Introduction to combinatorial synthesis in drug discovery.

2. **Few Important Drugs:**
   - (a) Antibiotics and antibacterials:
     - (i) Introduction
     - (ii) Antibiotic β-Lactam type - Penicillins, Cephalosporins
     - (iii) Anticancer - Dactinomycin (Actinomycin D), Methoxytrexate
     - (iv) Antibacterial – Ciprofloxacin, Norfloxacin
     - (v) Antiviral – Acyclovir
   - (a) Antimalarials: Chemotherapy of malaria. SAR. Chloroquine, Chloroguanide and Mefloquine
   - (b) Non-steroidal and Anti-inflammatory Drugs: Diclofenac Sodium, Ibuprofen and Netopam.
   - (c) Antihistaminic and antiasthmatic agents: Terfenadine, Cinnarizine, Salbutamol and Beclomethasone dipropionate.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. The basics of medicinal chemistry and biophysical properties of various drugs.
2. Concept of rational drug design and their related applications

Books Recommended:

1. Burger, Medicinal Chemistry, Vol. I-III, (1995) Wiley Interscience Publications, New York.
2. W. O. Foye, Principles of Medicinal Chemistry, 3rd Edition (1989), Lea & Febiger/ Varghese Publishing House, Bombay.
3. D. Lednicer and L. A. Mitscher, The Organic Chemistry of Drug Synthesis, Vol. I-III, Wiley Interscience.

4. A. Kar, Medicinal Chemistry, (1993) Wiley Eastern Ltd., New Delhi.
5. N. K. Terrett, Combinatorial Chemistry, (1998) Oxford Univ. Press, Oxford

OE-2: CYPCLO1- Medicinal Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the practical classes about conventional and modern methods for drugs synthesis

1. Preparation and characterization of following drugs and intermediates
   (a) Sulphanilamide, (b) 7-Hydroxy, 4-methyl coumarin
   (c) Chlorobutanol, (d)Triphenyl imidazole
   (e)Tolbutamide, (f) Hexamine, (g) Aspirin,
   (h) Ibuprofen,(i) Atropine,(j) Chlorpromazine.

2. Resolution of racemic drug to single enantiomer by chemical methods

OUTCOMES: After completion of the course, the learner can be able to understand:
1. Independently synthesize important organic drug molecules
2. Separate and purify synthesized drug molecules.

OE-2: CYPCTO2-Industrial Chemistry (Credit-3)

OBJECTIVE AND LEARNING: To get the detailed knowledge about different process used for the purification of contaminated and hard water. To know the basic constituents of glass, and its types, classification of fertilizers, different types of solid and liquid fuels, dyes and fibers.

1 **Water and Its Treatment:** Sources of water, chlorinated and nonchlorinated water, chemical method of sterilization: precipitation method, Aeration, ozonisation, chlorination, chloramines process, potassium permanganate method, Physical method of sterilization: Boiling, exposure to sunlight, hard and soft water, Types of hardness, temporary and permanent hardness, water softening, cold and hot lime soda process, zeolite process, ion exchange process, removal of iron, silica, and dissolved oxygen from water for industrial purposes, water for boiler uses, water analysis.

2 **Glass and Rubbers:** Glass: physical and chemical properties of glass, constituents in glasses, raw materials, manufacturing of glasses, optical glass, borosilicate glass, lead glass, colored glass, opal glass, safety glass, fiber glass.Natural and Synthetic Rubber: classification of rubber, natural and synthetic rubber.

3. **Chemical Fertilizers:** Classification of fertilization, nitrogeneous fertilizers, method of production and its action- ammonium nitrate, ammonium sulphate, urea, calcium cyanamide, ammonium chloride, phosphate rock, normal super phosphate, triple super phosphate.

4. **Solid and liquid fuels:** Definition and Classification of coal, Proximate and ultimate analysis, Determination of calorific value of solid fuel, Flue gas analysis, Classification

of petroleum, composition of petroleum, mining of petroleum, refining of petroleum, octane rating, octane number and antiknock compound, cetane number, production of gases, crude naptha, benzene, kerosene oil, fuel oil, lubricating oil, paraffin wax and black tarry after refining. Cracking: thermal cracking, hydrocracking, and fluid catalytic cracking.

5 **Fibers and Dyes:** Synthetic Fibers: Preparation of fibers- Nylons, Nylon-66, Nylon-6, Nylon-11, Nylon-610, Nylon-8, polyethylene terephthalate, orlon, saran, vinyon, taflon.Synthetic Dyes and Dyeing: Requisites of true dyes, sensation of color, witt's theory, chromophores, auxochromes: batho-, hypso-, hyper-, and hypochromic shifts; classification of dyes: acid dyes, basic dyes, adjective dyes, vat dyes, ingrain dyes, sulfur dyes, pigment.

OUTCOMES: At the end of the course student will be able to

1. Get fully industry-based knowledge.
2. Apply the knowledge for the analysis and purification of water.
3. Understand different types of glass and its production by using the raw material.
4. Understand composition of different types of fertilizers.
5. Understand various types of liquid and solid fuels and their analysis, different types of fibers and dyes and their synthesis.

Reference Books:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.

OE-2: CYPCLO2-Industrial Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING: To get the detailed knowledge about the removal of hardness of water by complexometric titration, estimation of the chemical and biological oxygen demands, estimation of nitrogen in fertilizers, determination of calorific value of solid fuel, estimation of chloride contents in a given water sample.

1. Determination of hardness of water by complexometry titration
2. Determination of BOD and COD of water sample
3. Determination of calorific value of solid fuel by Bomb Calorimeter.
4. Estimation of nitrogen in Urea
5. Synthesis of Dyes
6. Determination of flash and fire point of liquid fuel/ lubricant
7. Determination of Chloride content of water sample by Mohr's method
8. Estimation of iron from soap-bar (colorimetrically)

OUTCOMES: At the end of the course student will be able to

1. Remove the hardness of any given water sample.
2. Estimate the COD and BOD of given water sample.
3. Estimate the nitrogen contents in a given fertilizer sample.
4. Find the calorific value of the given solid fuel.

5. Calorimetrically estimate iron from soap bar.
6. Synthesize dyes using starting materials.

DSE-2: CYPCTD1- Principles of Analytical Chemistry (Credit-3)

OBJECTIVE AND LEARNING: The course will provide an:

- Introduction into the fundamentals of chemical analysis, including an understanding of some of the most important analytical techniques today (titration and gravimetric analysis, spectroscopic methods, separation techniques, electroanalysis etc.)
- Introduction into fundamentals of polarography, instrumentation and their application in qualitative and quantitative analysis.
- Different types of sensors and their applications.
- Determines systematic method for solving the multiple-equilibrium problems, pH calculation and their application in different systems, solves the problems related to pH calculation.

1. **Acid-Base Equilibria:** General concept of acid-base equilibria in water and in non-aqueous solvent, Definition of pH and pH scale (Sorenson and operational definitions), and its significance, Hammett acidity function, pH calculation for aqueous solutions of very weak acid and very weak base, salts of weak acid and weak bases, mixture of weak acid and its salts, mixture of weak base and its salts.

2. **Buffer Solutions:** Theory of buffer solution, dilution and salts effects on the pH of a buffer, Buffer index, Criteria and expression of maximum buffer capacity, Application of pH buffers, Preparation of buffer solutions of known ionic strength (Typical examples). Practical limitations in use of buffers, Metal ion buffers and their applications, Biological buffers and their applications.

3. **Photometric Titrations:** Basic principles, comparison with other titrimetric procedures, types of photometric titration curves, Instrumentation (Titration cell, Detectors, choice of analytical wavelength). Quantitative applications, Typical examples of one component and multicomponent analyses.

4. **Chemical Sensors:** Principles, types of chemical sensors based on the modes of transductions, Types of chemical sensor based on the chemically sensitive materials (solid electrolyte, gas, semiconductor), Humidity sensors, Biosensors, Electrochemical sensors (Potentiometric sensors, Ion-selective electrodes, Membrane electrodes, Amperometric sensors, Clark and Enzyme electrodes).

OUTCOMES: Student will learn theoretical approach to acid-base equilibria treatments in aqueous medium and calculation of pH, buffer system, construction and applications of different types of electrochemical, optical, mass sensor etc.

Books Recommended:

1. D.A. Skoog and D.M. West, Fundamental of Analytical Chemistry, International Edition, 7thEdition (1996), Saunders College Publishing, Philadelphia, Holt, London.
2. R.L. Pecsok, L.D. Shields, T. Cairns and L.C. McWilliam, Modern Methods of Chemical Analysis, 2nd (1976), John Wiley & Sons, New York.

3. D.A. Skoog, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College of Publishing, Philadelphia, London.
4. H.A. Strobel, Chemical Instrumentation: A Schematic Approach, 2nd Edition (1973), Addison Wesley, Reading, Mass.

References:

1. H.A. Laittnen and W.E. Harris, Chemical Analysis, 2nd International Student Edition (1960), McGraw Hill, New York.
2. R.G. Bates, Electrometric pH Determinations: Theory and Practice, 3rd Edition (1973), John Wiley & Sons, New York.
3. G.D. Moody and J.D.R. Thomas, Ion-selective Electrodes, London.
4. G.W. Ewing, Instrumental Methods of Chemical Analysis, 5th Edition (1978), McGraw Hill Book Co., New York.

DSE-2: CYPCLD1- Analytical Chemistry Practical-III (Credit-2)

OBJECTIVE AND LEARNING: Experiments of solvent extraction separation, estimation of biomolecules and metal ions in various real samples and packaged food samples.

1. Solvent Extraction: Determination of Fe (III) by chloride extraction in ether
2. Determination of Cd^{2+} ions concentration in given solution by voltammetrically (i) calibration (ii) standard addition
3. Determination of Na_2CO_3 content (%) of washing soda using a pH meter
4. Estimation of carbohydrate using Anthrone method
5. Estimation of acid values and iodine number in given oils/fats
6. Determination of buffer capacity of given acidic buffer.

Note: *Experiments may be added/deleted subject to availability of time and facilities*

OUTCOMES: The module will provide the hands-on different types of separation methods and analytical instruments to prepare, separate and quantify samples from various matrices.Apply the scientific process, including statistical analysis of data, conducting and presenting the data of chemical analysis.Able to develop methods for tracing and measuring new substances.

DSE-2: CYPCTD2- Organometallic Chemistry of Transition Metals (Credit – 3)

OBJECTIVE AND LEARNING: The objective of this course is

1. The students should be able to describe structure, synthesis and reactivity of organometallic compounds of O_2, N_2, CO, NO, Phosphine and carbenes.
2. The students should be able to explain catalytic reaction by transition metal compounds.
3. The students should be able to explain structure and characterization of metal hydrides.
4. The students should be able to know structure, synthesis and functionalization of porous materials.

1. **Metal Carbonyls:** Bonding, synthesis and reactivity of transition metal complexes with CO, NO, metal carbonyl hydrides and metal carbonyl clusters, Semibridging carbonyls; metal nitrosyl carbonyls; tertiary phosphines and arsines as ligands; carbenes and carbynes,

Dioxygen and Dinitrogen complexes of Transition metal, Fluxional organometallic compounds.

2. **Transition Metal Compounds in Catalysis:** Homogeneous and Heterogeneous catalysis, Types of catalysts, Catalysis by organometallic compounds: Hydrogenation of olefins, Wilkinson's catalyst, Tolman catalytic loop; synthesis gas, water-gas shift reaction; Hydroformylation (oxo process), Monsanto acetic acid process, Wacker process; synthetic gasoline: Fischer-Tropsch process and Mobile process, polymerization, oligomerization and metathesis reactions of alkenes and alkynes, Zieglar-Natta catalysis, photo dehydrogenation catalyst (platinum POP). Asymmetric Catalysis by organometallic complexes.

3. **Transition Metal Compounds with M-H bonds:** Metal hydrides (classical and non-classical). Agnostic interaction. Application of NMR in studying hydrido complexes.

4. **Porous materials Organic-inorganic hybrid materials:** Zeolites, AlPO, mesoporous materials, soft chemistry-based processes, functionalization of porous materials, MOF compounds, H_2/CO_2 gas storage and catalytic application, covalent organic Framework.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Structure, synthesis and reactivity of organometallic compounds of O_2, N_2, CO, NO, Phosphine and carbenes.
2. Catalysis by transition metal compounds.
3. Structure and characterization of metal hydrides.
4. Structure, synthesis and applications of porous materials.

Books Recommended:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn., (1999), John-Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4th Edn., (1993), Addison Wesley Pub. Co., New York.
3. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals, 1st Edn.(1988), John-Wiley & Sons, New York.
4. J. P. Collman, L. S. Hegedus, J. R. Norton and Richard G. Finke, Principles and Applications of Organotransition Metal Chemistry, 1st Edn.(1987), University Science Books, Mill Valley.
5. Ch. Elschenbroich and A. Salzer, Organometallics, VCH.
6. C. N. R. Rao, J. Gopalakrishnan, New Directions in Solid State Chemistry; Cambridge University Press: Cambridge (1997).
7. A. K. Cheetham, Solid State Chemistry:Compounds; Oxford University Press: Oxford, (1992).
8. J. N. Lalena and D. A. Cleary, Principles of Inorganic Materials Design; Wiley: New York, (2010).
9. Inorganic Chemistry, 5th Edition, Gary L. Miessler, St. Paul J. Fischer, Donald A. Tarr, Pearson publication.

DSE-2: CYPCLD2-Inorganic Chemistry Practical – III (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

I. Synthesis of inorganic complexes/compounds and their characterization by various physicochemical methods, viz. IR, UV, Visible, NMR spectroscopy, magnetic susceptibility etc. Selection can be made from the following or any other from the existing literature.

(i) *Cis* and *trans* isomers of $[Co(en)_2Cl_2]Cl$.
(ii) Ion-exchange separation of oxidation states of vanadium.
(iii) Synthesis, purification by sublimation and structural characterization of ferrocene.
(iv) Preparation of triphenyl phosphene PPh_3, and its transition metal complexes.
(v) Snnhesis of (*N,N'*)-bis(salicyldehyde)ethylenediamine Salen; and its cobalt complex [Co(Salen)].
(vi) Synthesis of metal acetylacetonates like Vanadyl / Alumunium acetylacetonate.
(vii) Synthesis and structural characterization of $[Ni(py)_4(NCS)_2]$.
(v) Single Crystal Growth of ligand and metal –complexes by various methods.

Note: *Experiments may be added/deleted subject to availability of time and facilities*

OUTCOMES: After completion of the course, the learner can be able to understand:

- About IR, electronic spectra and magnetic susceptibility of various transition metal complexes.
- Calculation of ligand field parameters based on electronic spectra of various transition metal complexes.
- Instrumentation methods of structural determination.

DSE-2: CYPCTD3- Stereochemistry, Reactions and Rearrangements (Credit – 3)

OBJECTIVE AND LEARNING: A detailed study of stereochemistry and conformations in organic molecules, asymmetric synthesis, various name reactions and rearrangements.

1. **Stereochemistry:** Molecular symmetry and chirality; Stereoisomerism; configuration and conformation; relative and absolute configuration; determination of relative configuration: Prelog's rule, Cram's rule (Felkin modification); Chiral auxiliaries, Optical Activity in absence of chiral carbon: biphenyls and Allenes and Atropisomerism.

2. **Asymmetric Synthesis:** Enantioselcetive synthesis with chiral non racemic reagents and catalysts: Hydroboration with chiral boranes (IpcBH2), (Ipc)2BH, Carbonyl group reduction with chiral complex hydride (BINAL-H, Chiral oxazaborolidines), Chiral organometal complex–(-)DAIB; 3-exo-dimethylamino isoborneol. Enantioselective hydrogenation with [Rh(DIPAMP)]+. Diastereoselective synthesis: Aldol reactions.

3. **Conformation:** Conformations of acyclic and cyclic system (5 and 6 member rings), fused (6/6); stability, reactivity and mechanism; reactions of 5/6-membered ring. Conformations of fused ring and bridged ring compounds

4. **Advanced Name Reactions:** Mukaiyama reaction, Julia olefination, McMurry reaction, Chichibabin reaction, Shapiro reaction, Baylis-Hillman reaction and Olefin metathesis

5. **Rearrangement Reactions:** Sommelet-Hauser rearrangement, Stevens rearrangement, Neber Rearrangement, Favorskii, rearrangements, Hofmann-Loffler-Freytag reaction, Barton reaction, Grob fragmentation reactions.

OUTCOMES: On Completion of this module, the learner will be able to calculate optical purity and enantiomeric excess. discuss the relative stability of conformational isomers of cyclohexanes and related compounds. draw all the stereoisomers of organic compounds, and recognise diastereomers, enantiomers, meso compounds and centers of symmetry. recognize and discuss the stereoisomers of chiral compounds that do not contain a stereogenic carbon centre and assign the configuration of the stereoisomers. explain and predict the stereochemical outcome of asymmetric organic reactions for examples, hydroboration by chiral boranes, reduction of ketones by chiral boron-based reagents, asymmetric hydrogenation by using chiral catalyst etc. and their mechanism.

Books Recommended:

1. M.B. Smith and J. March, March's Advanced Organic Chemistry-Reactions, Mechanisms and Structure, 5th Edition (2001), John Wiley & Sons, New York.
2. D. Nasipuri, Stereochemistry of Organic Compounds, 2nd Edition (1994), Wiley Eastern Ltd., New Delhi.
3. J. Aube and R. E. Gawley, Principles of Asymmetric Synthesis.
4. E.L. Eliel, S.H. Wilen and L.N. Mander, Stereochemistry of Organic Compounds, Wiley Interscience, New York (2004).
5. Paul de Mayo, Molecular Rearrangements, Vol.I& II, Interscience Publishers, New York (1963).
6. J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic chemistry, Oxford University press INC, New York, 2001.

DSE-2: CYPCLD3-Organic Chemistry Practical-III (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes

1. Organic Synthesis involving 2-3 steps (Synthesis, % Yield Calculation)
2. Characterization of synthesized organic compounds by melting point determination, and FT-IR, UV-Vis spectroscopic studies.

OUTCOMES: On Completion of this module, the learner will be able toidentify the presence of different components/molecules in the unknown mixture, design a particular organic synthesis purify the reaction products by various techniques such as recrystallization, TLC, column chromatography etc.

DSE-2: CYPCTD4- Electrochemistry (Credit-3)

OBJECTIVE AND LEARNING: To understand the electrical double layer as Metal electrolyte interfaces and differential capacitance, concept of electro capillary phenomenon, and thermodynamic aspects of metal electrolyte interfaces, the concept of over potential, exchange current density, Tafel equations and Tafel plot, the Butler Volmer multielectron electrodic kinetics.

1. **Introduction and overview of electrochemical Processes:** Electrochemical Cell and reactions, Faradiac and Non-Faradiac processes, electrochemical experiments and variables in electrochemical cells, Basic Electrochemical thermodynamics, free energy and cell EMF.

2. **Electrical Double Layer at Metal/Electrolyte Interface:** OHP and IHP, Structure of the double layer: Helmholtz-Perrin, Gouy-Chapman, and Stern models. Butler-Volmer equation under near equilibrium and non-equilibrium conditions, overpotential, exchange current density, Tafel plot. Polarizable and non-polarizable interfaces.

3. **Metal/Electrolyteinterfaces:** Semiconductor (SC)/electrolyte interface: Structure of Semiconductor interfaces, Creation of space charge region (Garrett-Brattain Space charge), Capacity of space-charge. Metal/ water interaction- Contact adsorption, its influence on capacity of interface, Complete capacity- potential curve, Constant capacity region hump.

4. **Electrified Interface properties:** Determination of interfacial tension of mercury as a function of potential across the interface, Thermodynamics of double layer (Lippmann equation), Electrocapillary equation, Determination of surface excess and other electrical parameters- electrical capacitance of the interface and relative surface excesses.

5. **Electrode Kinetics:** Essentials of Electrode Reaction, Multistep reactions- a near equilibrium relation between current density and over potential, Concept of rate determining step. Determination of reaction order. stoichiometric number, and transfer coefficient.

OUTCOMES:

- The learner should be able to apply theories in electrochemistry to analyze electrode kinetics
- To understand representing electrochemical cell
- The learner will be able to explain various over potential involved during the operation the cell using tafel equations
- The students will be able to apply the knowledge to calculate electrochemical cell parameters, over potential, active surface areas, charge on electrode and their surface excess.
- The students will be able to apply the Butler Volmer multielectron electrodic kinetics to the particular electrolysis process.

Books Recommended:

1. Modern Electrochemistry, Vol. 1 & 2A and 2 B, J.O'M. Bockris and A.K.N. Reddy,Plenum Press, New York (1998).
2. Electrochemical Methods: Fundamentals and Applications; A.J. Bard and L.R. Faulkner, 2nd edition (2001), John Wiley & Sons, New York.

DSE-2: CYPCLD4-Physical Chemistry Practical-III (Credit-2)

OBJECTIVE AND LEARNING: Teaching and learning: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Conductometric study of the kinetics of saponification of ethyl acetate.
2. Conductometric titration of a polybasic acid.
3. Conductometric titration of triple mixture (HCl+NH4Cl+KCl) with NaOH.
4. Ternary phase diagram of water, benzene, and acetic acid.
5. Determination of molecular weight of a macromolecule by viscometry.
6. Synthesis of Metal Nanoparticles by Chemical method.
7. UV analysis of synthesized metal Nanoparticles
8. To Study the kinetics of Iodination of acetone

OUTCOMES: Upon course completion, the student will be able to apply the experiment based on adsorption, phase diagram and molecular weight in relevant industry and further in higher studies for the outcome.

- To interpret the experimental results obtained by conductometer and Polarimeter.
- Students will be able to conduct the Chemical kinetics experiment on various important reactions.
- Students will be able to describe the principles behind the experiment performed in the laboratory.

DSE-3: CYPCTD5-Chemical Analysis (Credit-3)

OBJECTIVE AND LEARNING: The primary objective of this course is to acquire basic concepts, principles, and techniques of modern analytical chemistry that would empower students with an analytical mind set and the abilities to solve diverse analytical problems in an efficient and quantitative way that conveys the importance of accuracy and precision of the analytical results.

1. **Sampling, Standardization & Calibration:** Analytical samples and methods, sampling and sample handling of minerals, ores, metals, liquid, gaseous, solids and biological samples, obtaining a representative sample, sampling uncertainties, the gross sample, preparing a laboratory sample, standardization and calibration, comparison with standards, external standard calibration, minimizing errors in analytical procedures.

2. **Molecular recognition and applications:** Definition and principle of recognition process, host guest interaction, receptor in separation of cation and anions, crown ethers, cryptands, calixarenes.

3. **Biochemical analysis:** Estimation of carbohydrates, amino acids and ascorbic acid in biological systems, purification of proteins (spectrophotometric and ELISA), estimation of protein in egg albumin, estimation of free fatty acid, Iodine value and saponification value of fats/oils, estimation of blood cholesterol, DNA and RNA.

4. **Soil and water analysis:** Determination of nitrogen, phosphorus (spectrophotometric),potassium, calcium, sodium (flame photometric) in soil samples; determination of metals, iron, copper, nickel and zinc (spectrophotometric) arsenic, lead, mercury, chromium, selenium (AAS) in soil and water samples.

5. **Organic group analysis:** Determination of hydroxyl, carbonyl, amides and ester groups, Determination of molecular weight and percentage purity of carboxylic acid, Estimation of sugars, Estimation of unsaturation.

OUTCOMES: The student learns the skill to prepare standard solution, samples and analysis of the samples through using accurate methods. The course makes the student to learn how to prepare solutions quantitatively and analysis the analyte with high accuracy.Therefore, students will be able:

1. To develop an understanding of the range and uses of analytical methods in chemistry.
2. To establish an appreciation of the role of chemistry in quantitative analysis
3. To develop an understanding of the broad role of the chemist in measurement and problem solving for analytical tasks.
4. To provide an understanding of chemical methods employed for elemental and compound analysis.
5. To provide experience in some scientific methods employed in analytical chemistry.

6. To develop some understanding of the professional and safety responsibilities residing inworking on chemical analysis.

Books Recommended:

1. P.L. Kirk, Quantitative Ultramicroanalysis, John Wiley.
2. C.L. Wilson and D.L. Wilson, Comprehensive Analytical Chemistry", Vol. I (A) and I(B), Elsevier.
3. G.D. Christian, Analytical Chemistry, John Wiley & Sons, New York (2001).
4. S.M. Khopkar, Analytical Chemistry of Macrocyclic and Supramolecular Compounds, Narosa Publishing House, New Delhi (2002).
5. Jag Mohan, Organic Analytical Chemistry - Theory and Practice, Narosa Publishing House, New Delhi (2003).

DSE-3: CYPCLD5- Analytical Chemistry Practical-IV (Credit-2)

OBJECTIVE AND LEARNING: Experiments of estimation of different elements in soil, water quality parameters, and other biomolecules' determination

1. Determination of nitrogen and phosphorus in soil samples
2. Determination of ascorbic acid by titration method
3. Estimation of cholesterol in blood sample
4. Estimation of water quality parameters of given water samples
5. Determination of Ni2+ concentration by EDTA back titration method
6. Determination of purity of oxalic acid sample by (1) Potentiometric method (2) Volumetric method.

Note: *Experiments may be added/deleted subject to availability of time and facilities*

OUTCOMES: The module will provide the hands-on analysis of different elements in soil samples, analytical instruments to prepare, separate and quantify samples from various matrices.Apply the scientific process, including statistical analysis of data, conducting and presenting the data of chemical analysis.Able to develop methods for tracing and measuring some compounds, such as cholesterol etc.

DSE-3: CYPCTD6-Inorganic - Rings, Chains, Clusters and Photochemistry (Credit-3)

OBJECTIVE AND LEARNING: Objective of this course is

- The students should be able to Know Synthesis and structural principles Isopoly and Heteropoly Acids and Salts.
- The students should able to explain Metal Clusters and Metal-Metal Bonds.
- The students should be able to explain Structure and Bonding in Boranes.
- The students should be able to know main group and organometallic chemistry.
- The students should be able to know Classification of Inorganic Polymers.
- The students should be able to know basic principle of inorganic photochemistry and its application.

1. **Isopoly and Heteropoly Acid and Metal clusters:** Synthesis and structural principles with reference to those of V, Nb, Ta, Cr, Mo and W. Metal clusters and metal-metal

bonds, compounds with metal-metal multiple bonds, metal carbonyl, halide and chalcogenide clusters.

2. **Inorganic Photochemistry:** Basic Principles, Basic photochemical processes, photosubstitution, photoredox, photoisomerisation and photo rearrangement reactions in inorganic complexes. Photovoltaic and photogalvanic cells- photoelectrochemical cells, photoassisted electrolysis of water – aspects of solar energy conversion. Application of metal complexes in solar energy conversion.

3. **Polyhedral Boranes:** Lipscomb's Topological concept,Higher boranes, carboranes, metallo-boranes and metallo-carboranes –Structure and Bonding in the light of Wade's Rules, Wade- Mingo's Rule, Jemmismno rule, Polyatomic Zintl cations and anions

4. **Parallels between main group and Organometallic Chemistry:**Isolobal, Isoelectronic concept (Hoffman) in organometallic and metal-cluster chemistry, Chevrel Phases. infinite metal chains, multidecker molecules, cluster-surface analogy

5. **Inorganic Polymers:** Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulfur-nitrogen, sulfur-nitrogen-fluorine compounds, – binary and multi-component systems, hemolytic inorganic systems.

OUTCOMES: After completion of the course, the learner can be able to understand:

- Synthesis and structural principles Isopoly and Heteropoly Acids and Salts.
- Metal Clusters and Metal-Metal Bonds.
- Structure and Bonding in Boranes.
- Main group and organometallic chemistry.
- Types of Inorganic Polymers.
- The basic principle of photochemistry.
- Photomaterial for a specific application particularly metal complexes in solar energy conversion.

Books Recommended:

1. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John-Wiley & Sons, New York.
2. James E. Huheey, Inorganic Chemistry, 4th Edn. (1993), Addison Wesley Pub. Co., New York.
3. N. N. Greenwood and A. Earnshaw, Chemistry of the Elements, 2nd Edn. (1997), Butterworth Heinemann, London.
4. Charles H. De Puy, Orville L. Chapman Molecular Reactions and Photochemistry, , Prentice Hall of India Private Limited, New Delhi, 1988
5. K.K.Rohatgi Mukherjee, Fundamentals of Photochemistry, Wiley Eastern Ltd., 1978
6. N.J.Turro, Modern molecular Photochemistry Benjamin / cummings, Menlo park, California (1978).

DSE-3: CYPCLD6- Inorganic Chemistry Practical – IV (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

Any three/four techniques covered in the semester out of the following syllabus:

(i) Instrumental methods of analysis utilizing flame photometer, UV-Vis Spectrophotometer, pH-meter, potentiometer, Fluorometer, turbidimeter, electrochemical methods, separation of mixtures of metal ions by ion exchange chromatography.
(ii) Study of electronic spectra of various transition metal complexes using UV-Vis spectrophotometer for determination of Racah Parameter.
(iii) Quantum chemical calculation of structure and IR Spectra of H_2O molecule by using Gaussian Program.
(iv) Quantum Yield Calculation of fluorescent molecule using spectrofluorometer.
(v) Determination of redox potential of some redox active molecule

Any other experiments done in the class during the current academic semester.

Note: *Experiments may be added/deleted subject to availability of time and facilities.*

OUTCOMES: After completion of the course, the learner can be able to understand:

- Hands- on experience about IR, flame photometer, UV-Vis Spectrophotometer , pH-meter, potentiometer, Fluorometer, turbidimeter, electrochemical methods .
- And Calculate ligand field parameters and quantum yield based on electronic spectra of various transition metal complexes.

DSE-3: CYPCTD7- Chemistry of Natural Products (Credit-3)

OBJECTIVE AND LEARNING: The concerned students manifest their capability of imagination and understanding by learning a specified course. They develop their ability to understand complex situations and improve their vision for taking decision.

1. **Alkaloids:** Structure elucidation of alkaloids – A general account; Structural and, Retrosynthetic analysis, synthesis and stereochemistry of Quinine, Reserpine and Morphine.

2. **Terpenoids:** Definition and examples; terpenes – isoprene rule; mono terpenes: Structure elucidation, Retrosynthetic analysis and synthesis of Geraneol, Camphor, longfolene and Abietic acid.

3. **Steroids**: Introduction, nomenclature of steroids, absolute configuration of steroid. Structure elucidation and Synthesis of Cholesterol; Synthesis of Progesterone and Aldosterone

4. **Prostaglandins**: Introduction, nomenclature of prostaglandins; approaches to prostaglandin synthesis; cyclohexane precurors (Woodward synthesis of PGF2α), bicycloheptane precursors (Corey's synthesis of prostaglandins E and F)

5. **Carbohydrates**: Conformational analysis of monosaccharides (e.g. pentoses and hexoses); Anomeric and reverse anomeric effect; Mutarotation and abnormal mutarotation; Use of complexing agents: Borates and Phosphates; synthesis of glycosides; general treatment of polysaccharide chemistry: Hydrolysis, methylation and periodic oxidation, Smith degradation.

OUTCOMES: A student having studied a subject like 'NATURAL PRODUCT' will be capable of understanding the chemical sciences which are involved in the flora and the fauna. This will impart the students' knowledge regarding biologically active molecules which represent a major class of pharmaceuticals and drugs.

Books Recommended:

1. Nitya Anand, J.S. Bindra and S. Ranganathan, Art in Organic Synthesis, 2nd Edition (1970), Holden Day, San Francisco.
2. S.W. Pelletier, Chemistry of the Alkaloids, (1970) Van Nostrand Reinhold Co., New York.
3. K.W. Bentley, The Alkaloids, Vol. I., (1957) Interscience Publishers, New York.
4. I. L. Finar, Organic Chemistry, Vol. II, 5th Edition (1975) Longman Ltd, New Delhi.
5. J.W. Apsimon, Total Synthesis of Natural Products, Vol. 1-6, Wiley-Interscience Publications, New York.
6. J.S. Bindra and R. Bindra, Creativity in Organic Synthesis.
7. J.S. Bindra and R. Bindra, Prostaglandins Synthesis.
8. S. Warren, Organic Synthesis: Disconnection Approach, (1982) Wiley, New York.
9. K. C. Nicolaou, Classics in Total Synthesis of Natural Products, Vol. I & II.
10. J. Clayden, N. Greeves, S. Warren, and P. Wothers, Organic Chemistry, Chapter 30, (2001) Oxford University Press, Oxford.
11. E. A. Davidson, Carbohydrate Chemistry, Holt, Rinehart and Winston, New York1967.
12. R. D. Guthrie and J. Honeyman, An Introduction of Chemistry of Carbohydrate, 3rd Edn., Clarendon Press, Oxford, 1988.
13. J. Kennedy, Carbohydrate Chemistry, Clarendon Press, Oxford, 1988.

DSE-3: CYPCLD7- Organic Chemistry Practical – IV (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Some important techniques related to organic separation: Paper Chromatography, Thin layer Chromatography, Column chromatography.
2. Green synthesis and structural analysis of organic compounds by FT-IR, UV-Vis spectroscopy.

OUTCOMES: On Completion of this module, the learner will be able to:identify the presence of different components/molecules in the unknown mixture, design a particular organic synthesis, purify the reaction products by various techniques such as recrystallization, TLC, column chromatography etc.

DSE-3: CYPCTD8- Quantum Chemistry (Credit-3)

OBJECTIVE AND LEARNING: To understand the deviation of classical mechanics and evolution of quantum mechanics, the Schodinger equation for some model systems (wave function and energy state determination), the approximation method to solve the Schodinger wave equation for some higher order system., the quantum mechanical treatment of molecular systems using Ab-initio or first principle calculation.

1. **Concepts of Quantum Chemistry**: General formulation of Quantum Mechanics: Eigen functions and Eigen values and quantum mechanical operators. Expectation value of a physical quantity. Orthogonalization and normalization of wave functions. Postulates and theorem of quantum mechanics,

2. **Solutions to Schrodinger Equation**: Schrodinger wave equation solution of Schrodinger wave equation to some model systems viz. particle in a box, rigid rotor, harmonic oscillator, H atom problems.

3. **Approximation Methods in Quantum Chemistry**: Variation method, Stationary perturbation theory for non-degenerate and degenerate. Ground state of He atom. Time-dependent perturbation theory. Radiative transition, Einstein coefficients.

4. **Angular momentum and many electron system**: ordinary Angular momentum, generalized angular momentum, eigen functions for angular momentum, eigen values of Angular momentum, Operator algebra: use of ladder operator, Addition of angular momenta,Antisymmetry and pauli exclusion principle.

5. **Molecular structure:** Born-Oppenheimer approximation, Molecular orbital treatment for H2+ moleule. Huckel theory of conjugated system, bond order and charge density calculation, Hückel MO treatment of simple and conjugated polyenes: ethene, 1,3 - butadiene, Cyclo Butadiene. Alternant hydrocarbons: Benzene. Introduction to Extended Huckel Molecular Orbital Theory.

OUTCOMES: After finishing the course, the student will be able to –
account for theory of angular momentum, theory for orbitals and electrons, and describe both coupled and uncoupled representation - account for the Born-Oppenheimer approximation – account for approximation methods such as variational theory and perturbation theory.

Books Recommended:

1. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics, 3rd edition (1997), Oxford University Press. Oxford.
2. H. Eyring, J. Walter and G.E. Kimball, Quantum Chemistry, John Wiley, New York (1944)
3. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ., Inc., New Delhi.
4. G. M. Barrow, Physical Chemistry, Fifth edition, Tata MacGraw Hill, New delhi (1994).
5. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry, Pragati Edition, Meerut (2009).

DSE-3: CYPCLD8- Physical Chemistry Practical-IV (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the theory classes.

1. Cyclic Voltammetry of the [Fe(CN)6]3-/[Fe(CN)6]4- system.
2. Corrosion study of Iron in an acid and basic solution.
3. Synthesis and FTIR analysis of synthesized metal Nanoparticle oxides.
4. Determination of molar mass of non-volatile substances by Lansberger method.
5. Determination of molar mass of naphthalene and acetanilide by Rast's method.
6. Determination of intrinsic viscosity of polyacrylamide and poly vinyl alcohol by viscometric method.
7. To investigate the effect of ionic strength on the reaction between potassium iodide and potassium peroxodisulphate.
8. Conductometric titration of triple mixture (HCl+NH4Cl+KCl) with NaOH.

OUTCOMES: Upon course completion, the student will be able to apply the experiment based on adsorption, phase diagram and molecular weight in relevant industry and further in higher studies for the outcome.To interpret the experimental results obtained by conductometer and Polarimeter. Students will be able to conduct the Chemical kinetics experiment on various important reactions. Students will be able to describe the principles behind the experiment performed in the laboratory.

SEMESTER–IV

CC-11: CYPDTT6- Biological Chemistry (Credit-3)

OBJECTIVE AND LEARNING:

The learners should be able to validate the conceptual understanding acquired from the theory classes

1. Learn about various biological entities such enzymes, lipids, carbohydrates, cell-membranes etc.
2. Various chemical and structural aspects of proteins, amino acids, nucleic acids etc.

Important roles of biological processes and further effects.

1. **Molecules of life:** Amino acids and proteins, Carbohydrates-polysaccharides, lipids, cell-membranes and nucleic acids.

2. **Structure and function:** Protein structure, Ramachandran - plot, protein folding: DNA/RNA structures, various forms (a, b, c, z) of DNA, t-RNA structure, transcription and translation, gene expression and DNA binding protein-zinc-finger protein.
3. **Metabolism and Energetics:** Glycolysis, citric acid cycle, oxidative phosphorylation and transport through membranes.

4. **Enzymes:** Introduction, classification, formation and function of enzymes, co-enzymes, cofactors (elementary idea); Enzyme kinetics, TON and TOF, Enzyme inhibitors.

5. **Metalloenzymes:** Hydrolytic and redox enzymes: Carbonic anhydrase and superoxide dismutase.

6. **Oxygen uptake proteins:** Hemerythrin and hemocyanin.

7. **Molecular recognition:** Molecular organization, Chiral recognition and role of sugar in biological recognition.

OUTCOMES: After completion of the course, the learner can be able to understand:

1. The basics properties and functions of various elements such as DNA/RNA, enzymes, protein structures etc.
2. Aspects of several metabolic cycles and oxygen uptake process
3. Concept of biological recognition and molecular organization

Books Recommended:

1. L. Stryer, Biochemistry, 5th Edition, (2002) Freeman &Co. New York
2. D.L. Nelson and M.M. Cox, Lehninger Principles of Biochemistry 3rd Edition ((2002) McMillan North Publication
3. D. Voet, J. G. Voet, Biochemistry 3rd Edition (2004), Wiley International Publication.
4. I. Bertini, H. B. Gray, S. J. Lippard, J.S. Valentine, 1st South Asian Edn., (1998) Viva Books Pvt. Limited, New Delhi
5. M. B. Smith, Organic Synthesis, (1998) Mc Graw Hill Inc, New York.

OE-2: CYPDTL6-Biological Chemistry Practical (Credit-2)

OBJECTIVE AND LEARNING: The learners should be able to validate the conceptual understanding acquired from the practical classes

1. Several separation techniques for biological compounds from a mixture
2. Basic techniques and analytical methods for biological compounds handling.

1. Paper chromatography: Separation of amino acids and carbohydrates in a mixture
2. Carbohydrates: Qualitative analysis, quantitation of glucose and ribose.
3. Amino acids and proteins: Qualitative analysis, quantitation of proteins and amino acids.
4. Fats: Acid number, saponification and iodine values.
5. Effect of pH and temperature on the rate of enzyme reaction.
6. Agarose Gel Electrophoresis and separation of DNA.

OUTCOMES: After completion of the course, the learner can be able to understand:
Qualitative and Qualitative analysis of several natural components such as proteins and amino acids.
Vital roles of internal and external reaction parameters in biological processes.

DSE-4: CYPDTD1- Advanced Separation Techniques (Credit-5)

OBJECTIVE AND LEARNING: The module will provide detail study of solvent extraction, chromatographic separations [Gas chromatography, high performance liquid chromatography, Ion-exchange chromatography, Reverse phase chromatography & Bonded phase chromatography (BPC), Size exclusion chromatography, Super critical fluid chromatography (SFC)], separation techniques based on rate processes [(a) Barrier-separation methods: Membrane separation-Ultrafiltration, dialysis, electrodialysis, electro-osmosis, reverse osmosis (b) Field separation methods: Electrophoresis, Ultracentrifugation], mass spectrometry and hyphenated mass spectrometric techniques such as GC-MS, LC-MS, CE-MS, ICP-MS.

1. **Separation Techniques Based on Phase Equilibria:** Solvent Extraction: Liquid-Liquid and super critical fluid extraction, Quantitative treatment of various solvent, extraction equilibria.

2. **Separation Techniques Based on Rate Processes:** (a) Barrier-separation methods: Membrane Separation-Ultrafiltration, dialysis, electrodialysis, electro-osmosis, reverse osmosis (b) Field separation methods: Electrophoresis, Ultracentrifugation.

3. **Chromatographic Separation:** Gas chromatography, high performance liquid chromatography, Ion-exchange chromatography, Reverse phase chromatography & Bonded phase chromatography (BPC), Size exclusion chromatography, Super critical fluid chromatography (SFC).

4. **Mass Spectrometry:** Principle, classification (EI, CI, FD and FAB, MALDI, SIMS and ESI) and applications in characterization of organic compounds, mass analyzers, mass spectral fragmentation of organic compounds, molecular ion peak, metastable peak and nitrogen rule.

5. **Hyphenated mass spectrometric techniques:** GC-MS, LC-MS, CE-MS, ICP-MS, tandem mass spectrometers, principle and applications.

OUTCOMES: Student will get the knowledge (principles and instrumentation and applications) about different types of separation techniques such as solvent extraction, chromatographic separation, hyphenated mass spectrometric techniques and analysis of different samples using these techniques.

Books Recommended:

1. Skoog, West, Holler & Crouch, Fundamentals of Analytical Chemistry, 8th Edition, Cengage Learning PVT. Ltd.
2. J.D. Seader and E.J. Henley, Separation Process Principles, 1st Edition (1998), John Wiley & Sons. Inc., New York.
3. Willard, Merrit, Dean, Settle, Instrumental Methods of Analysis, 7th Edition, CBS Publishers & Distributors PVT Ltd.
4. G.D. Christian, Analytical Chemistry, John Wiley & Sons, New York (2001).
5. J. H. Gross, Mass Spectrometry: A Textbook, Springer, Verlag, Berlin, (2011).

DSE-4: CYPDTD2- Structural Methods in Inorganic Chemistry (Credit-5)

OBJECTIVE AND LEARNING: Objective of this course is:

1. The students should be able to explain basic theory of NMR Spectroscopy and analyse NMR Spectra of compounds.
2. The students should know basic principle of ESR Spectroscopy and analyse Hyperfine Splitting and the g-value.
3. The students should be able to explain Basic principle, conditions for Mossbauer spectroscopy and Spectral parameters.
4. The students should be able to know theory of Infrared and Raman Spectroscopy ad spectral analysis.
5. The students should be able to knowtheory of Mass Spectrometry, Fragmentation pattern and recognition of the molecular ion peak.

1. **NMR Spectroscopy:** (i) Use of Chemical shifts and spin-spin couplings for structural determination, (ii) Double resonance, and Dynamic processes in NMR, (iii) Decoupling phenomenon, Nuclear Overhauser Effect, DEPT spectra and structural applications in 13C NMR, (iv) Use of Chemicals as NMR auxillary reagents (shift reagents and relaxation reagents (v) 1H NMR of paramagnetic substances. (VI) NMR of Metal nuclei

2. **Electron Spin Resonance Spectroscopy:** Basic principle, Hyperfine Splitting (isotropic systems); the g-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); Electron-electron interactions, Anisotropic effects (the g-value and the hyperfine couplings); Structural applications to transition metal complexes.

3. **Mössbauer Spectroscopy:** Basic principle, conditions for Mossbauer spectroscopy; Spectral parameters (Isomer shift, electric quadrupole interactions, magnetic interactions), temperature dependent effects, structural deductions for iron and tin complexes, miscellaneous applications.

4. **Infrared and Raman Spectroscopy:** Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factor affecting the band positions and intensities, far IR region, metal-ligand vibrations, normal co-ordinate analysis. Applications of vibrational spectroscopy in investigating (i) symmetry and shapes of simple AB_2, AB_3

and AB_4 molecules on the basis of spectral data, (ii) mode of bonding of ambidentate ligands (thiocyanate, nitrate, sulphate and urea). Classical and quantum theories of Raman Effect, pure rotational, vibrational, and vibrational-rotational Raman spectra, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti-stokes Raman spectroscopy (CARS).

5. **Mass Spectrometry:** Fragmentation pattern and Fingerprint applications in the interpretation of Mass spectra, effect of isotopes on the appearance of mass spectrum, recognition of the molecular ion peak; Ionization techniques (EI and FAB).

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Theory of NMR Spectroscopy and analyse NMR Spectra.
2. Basic principle of ESR Spectroscopy and analyse Hyperfine Splitting and the g-value.
3. Basic principle, conditions for Mossbauer spectroscopy and Spectral parameters.
4. Theory of Mass Spectrometry, Fragmentation pattern and recognition of the molecular ion peak.
5. Theory of Mass Spectrometry, Fragmentation pattern and recognition of the molecular ion peak.

Books Recommended:

1. E. A. V. Ebsworth, D. W. H. Rankin and S. Cradock, Structural Methods in Inorganic Chemistry, 1st Edn. (1987), Blackwell Scientific Publications, Oxford, London.
2. R. S. Drago, Physical Methods in Chemistry, International Edition (1992), Affiliated East-West Press, New Delhi.
3. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 4th Edn. (1986), John Wiley & Sons, New York.
4. W. Kemp, Organic Spectroscopy, 3rd Edn. (1991), Macmillan, London.
5. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice Hall of India Pvt. Ltd., New Delhi (2001).
6. R. L. Dutta and A. Syamal, "Elements of Magneto Chemistry," 2nd Edition, Affiliated East West Press, New Delhi.

DSE-4: CYPDTD3-Organic Spectroscopy for Structural Elucidation (Credit - 5)

OBJECTIVE AND LEARNING: Structure elucidation of the different organic compounds using UV, IR, PMR, CMR and Mass spectroscopy will be discussed to make students able to interpret and analyse the spectra of organic compounds.

1 **Infrared-Ultra-Violet Spectroscopy:** UV: Absorption of dienes, polyenes, carbonyl compounds and α,β-unsaturated carbonyl compounds. Woodward rule and its application. Aromatic compounds. IR: Vibration modes and bond stretching. Absorption of common functional groups, electrical and Steric effects, effects of Hydrogen bonding. Fingerprint region and interpretation of IR spectra.

2 **PMR Spectroscopy:** Interpretation of spectra, chemical shift, shielding mechanism and anisotropic effects, chemical exchange. Spin-spin interactions, naming spin systems, magnitude of coupling constant: geminal, vicinal and long-range couplings. Second order spectrum and analysis of AB, AMX and ABX systems. Simplification of Complicated Spectra: Aromatic induced shifts, spin decoupling, deuterium exchange, spectra at higher fields. Hindered rotation and rate processes.

3 **CMR Spectroscopy:** General considerations, chemical shift, coupling constants. Nuclear Overhauser effect. Spin-spin, spin-lattice relexations. Off resonance decoupling. DEPT. Interpretation of simple CMR spectra.

4 **2D NMR Spectroscopy:** COSY, NOESY and HETCOR.

5 **Mass Spectrometry:** Introduction, ion production, fragmentation, factors influencing ion abundance, single and multiple bond cleavage, rearrangements, cleavage associated with common functional groups, molecular ion peak, metastable ion peak, Nitrogen rule and interpretation of mass spectra.

OUTCOMES: To learn about the principle and applications of ultraviolet and Woodward Fisher Rule and understand the infra-red spectroscopy in organic structure determination. To know about the Nuclear magnetic resonance spectroscopy, proton chemical shift, spin-spin coupling, coupling constants and applications to organic structures ^{13}C resonance spectroscopy. To learn the Mass spectrometry and its applications including the optical rotatory dispersion and its applications. To study the concepts of Cotton effect, axial halo-ketone rule and octant rule. Student investigates the various chemical process by using a series of spectroscopic techniques. The various corner of synthetic chemistry related problem will be explained by these techniques.

Book Recommended:

1. J.R. Dyer, Application of Absorption Spectroscopy of Organic Compounds, Prentice Hall, New Delhi (1978).
2. R.M. Silverstein and F.X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition (2003) John Wiley, New York.
3. D.H. Williams and I.F. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Edition (1988), Tata-McGraw Hill, New Delhi.
4. P.Y Bruice, Organic Chemistry, 2nd Edition (1998) Prentice – Hall, New Delhi.

DSE-4: CYPDTD4-Statistical Mechanics (Credit-5)

OBJECTIVE AND LEARNING: To learn the laws of Thermodynamics, To learn Ensembles: Phase Chemistry: Proposed Syllabi (effective from session 2012-13) Page 41 of 47 space. Canonical and grand canonical ensembles. Ideal gas in canonical and grand canonical ensembles. Partition Function, Bose Einstein statistics, Fermi Dirac Statistics.

1. **Review of Thermodynamics:** Laws of Thermodynamics, free energy, chemical potential and entropy, partial molar properties: free energy, volume and heat content, and their significances. Concept of fugacity and determination of fugacity.

2. **Basic Statistical Mechanics Ensembles:** Phase space. Ensemble. Equal a priori probability. Microcanonical ensemble. Entropy. Gibb's paradox. Entropy of a two-level system. Canonical and grand canonical ensembles. Ideal gas in canonical and grand canonical ensembles.

3. **Partition Function:**Canonical partition function, molecular partition function, Review of rotational, vibrational and translational partition functions. Application of partition functions to specific heat of solids and chemical equilibrium, relationship between partition function and enthalpy, entropy and other thermodynamic quantities.

4. **Ideal Bose-Einstein Gas:** Bosons: General introduction and characteristics, Bose Einstein statistics, Bose-Einstein distribution, Bose- Einstein condensation. Thermodynamic properties of ideal BE gas.

5. **Ideal Fermi-Dirac Gas:** Fermions: General introduction and characteristics, Fermi-Dirac statistics,Fermi- Dirac Fermi-Dirac distribution, Degenerate Fermi gas. Electron in metals. Magnetic susceptibility, Superconductivity.

OUTCOMES:

After finishing this course the students will be able to:

Grasp the basis of ensemble approach in statistical mechanics to a range of situations.Explain the fundamentals of thermodynamics, carnot cycle, statistics and distributions.Explain the fundamental differences between classical and quantum statistics and learn about quantum statistical distribution laws.Analyze important examples of ideal Bose systems and Fermi systems.

Books Recommended:

1. Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern, New Delhi (1988).
2. Statistical Mechanics, D.A. Mcquarrie, Harper and Row Publishers, New York (1976).

DSE-5: CYPDTD5- Electroanalytical Methods (Credit-5)

OBJECTIVE AND LEARNING: The module will provide an introduction into the fundamentals of chemical analysis, including an understanding of some of the most important analytical techniques, theoretical idea to different types of electroanalytical techniques cyclic voltammetry, polarography, amperometry, choranoamperometry etc.Thorough theoretical and practical understanding of advanced analytical instruments, for example for measuring metals, proteins, medicinal and non-medicinal drugs.Able to assess the different modified electrodes and role of cyclic voltammetry in sensing.

1. **General Introduction:** Overviews of electrode processes, polarization and overvoltage, reference electrodes (Ag/AgCl, hydrogen, mercury pool) working electrodes (Pt, GCE, DME, SME, HMDE, rotating platinum electrode), Three-electrode system, factors affecting electrode reaction rate and current, Modes of mass transfer (diffusion, migration, convection).

2. **Polarography:**Illkovic equation and its derivation, Criteria of polarographic reversibility, Interpretation of catalytic, kinetic, adsorption and capacitive currents. Polarographic maxima and maximum suppressors.

3. **Modern electroanalytical techniques:** Necessity and development of new voltammetric techniques, Oscilliography, Differential pulse voltammetry, Normal pulse voltammtery, Derivative voltammetry, Cyclic voltammetry (Reversible, irreversible, quasireversible), Linear sweep volatammetry, Alternating current voltammetry.

4. **Other related techniques:** Chronoamperometry, Chronopotentiometry. Controlled-potential and constant current coulometry, Stripping voltammetry, Electrogravimetry.

5. **Electroactive layers and modified electrodes:** chemically modified electrodes, Types, preparation and properties of films and modified electrodes: monolayers, polymers, inorganic films, biologically related materials, composites and multilayers assemblies, role of cyclic voltammetry in sensing.

OUTCOMES: Students will learn principles, instrumentation and applications of different electroanalytical techniques, preparation methods of modified electrodes, study of different electrochemical sensors.

Books Recommended:

1. L. Meites, Polarographic Techniques, 2nd Edition (1965), John Wiley, New York.
2. J. Heyrovsky and K. Kuta, Principles of Polarography, 1st Edition (1966), Academic Press, New York.
3. D.A. Skoog, F.J. Holler and T.A. Nieman, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College Publishing, Harcourt Brace & Company, U.S.A.
4. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications, 2nd Edition (2000), Wiley, New York.
5. S. Ahuja, N. Jespersen, Modern instrumental analysis, Elsevier B.V., 2006, UK.

Additional References:

1. C.W.C. Milner and G. Phillips, Coulometry in Analytical Chemistry, Pregamon Press, New York (1967).

DSE-5: CYPDTD6- Special Topics in Inorganic Chemistry (Credit-5)

OBJECTIVE AND LEARNING: Objective of this course is

1. The students should be able to know design and synthesis of Macrocyclic Complexes.
2. The students should able to describe Ligand design and ligand synthesis for the synthesis of metal complexes.
3. The students should be able to explain basic concepts of molecular magnetism and types of magnetic interactions.
4. The students should be able to know basic concepts, types of meso-phases, synthetic strategies for Liquid Crystal and Metallomesogens
5. The students should be able to knowNanostructured material and nanocatalysis.

1. **Macrocyclic Complexes:** Types of macrocyclic ligands – design and synthesis by coordination template effect, di- & poly-nuclear macrocyclic complexes; applications of macrocyclic complexes.

2. **Molecular Magnetic Materials:** Basic concepts of molecular magnetism, types of magnetic interactions, inorganic and organic ferro-magnetic materials, low-spin-high-spin transitions, isotropic interactions in Cu(II) dinuclear compounds.

3. **Liquid Crystal and Metallomesogens:** Basic concepts, types of meso-phases, synthetic strategies, characterization and applications.

4. **Chemistry in nanoscience and technology:** Introduction, definition of nanomaterials and Nano technology. History of nanomaterials, causes of interest in nanomaterials, properties and types. Synthesis of nanomaterials, their characterization techniques and applications of nanomaterials, Nanostructured material and nanocatalysis.

5. **Uses of Inorganic reagents in inorganic analysis:** General discussion and uses of some inorganic reagents: Potassium bromate (KBrO3), potassium iodate(KIO3), ammonium vanadate (NH4VO3), ceric sulphate [Ce(SO4)2], ethylenediamine tetra acetic acid (EDTA).

OUTCOMES: After completion of the course, the learner can be able to understand:

1. Design and synthesis of Macrocyclic Complexes.
2. Ligand design and ligand synthesis for the synthesis of metal complexes.
3. Basic concepts of molecular magnetism and types of magnetic interactions.
4. Basic concepts, types of meso-phases, synthetic strategies for Liquid Crystal and Metallomesogens.
5. Nanostructured material and nanocatalysis.

Books Recommended:

1. Jean-Marie Lehn, Supramolecular Chemistry, VCH, Weinheim (1995).
2. J. L. Serrano, Metallomesogens, VCH, Weinheim (1996).
3. Oliver Kahn, Molecular Magnetism, VCH, Weinheim (1993).
4. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. BoCMTann, Advanced Inorganic Chemistry, 6th Edn., John Wiley & Sons (Asia) Singapore (2003).
5. P. Yang. The Chemistry of Nanostructured Materials World Scientific Publ. Co. Pte. Ltd. (2003) ISBN 981-238-405-7.
6. U. Heiz and U. Landman (Eds.) Nanocatalysis, Springer, 2007.
7. Vogel's Text book of Quantitative Inorganic Analysis, ELBS Press.

DSE-5: CYPDTD7- Reagents and Reactions in Organic Synthesis (Credit-5)

OBJECTIVE AND LEARNING: To get the knowledge about importance of protection in organic synthesis, Use of reagents and catalysts in oxidation, reduction and other reactions. Metal ion promoted reactions.

1. **Protecting groups:** Importance of protection in organic synthesis, Hydroxy (acetate, MEM, MOM, Trityl), carbonyl (Acetal, ketal, Dithiane) and amines (BOC, F-MOC, CBZ, Bn, Acetate etc).

2. **Reduction:** (i) Complex metal hydride reductions: LiAlH4, NaBH4 and DIBAL; reduction of aldehydes and ketones, stereochemistry of ketone reduction, (ii) Reduction of conjugated systems: Birch reduction, (iii) Hydroboration (iv) Miscellaneous: Tributyltin hydride, Wilkinson's catalyst.

3. **Oxidation:** (i) Oxidation with peracids: Oxidation of carbon-carbon double bonds (Sharpless epoxidation), carbonyl compounds, allylic carbon-hydrogen bonds, (ii)

Oxidation with selenium dioxide and Osmium tetroxide, (iii) Woodward and Prevost hydroxylation.

4. **Reagents and Reactions:**
   (i) Advantages and limitation of Homogeneous and heterogenous process
   (ii) Gilman's reagent – Lithium dimethylcuprate
   (iii) Lithium diisopropylamide (LDA)
   (iv) Dicyclohexyl carbodiimide (DDC)
   (v) 1,3-Dithiane (Umpolung reagent)
   (vi) Peterson's synthesis
   (vii) Organophosphorus compounds (Wittig reaction)

5. **Metal ion Promoted Reactions:** Heck reaction, Suzuki reaction, Sonogashira reaction, Nigeshi, Stille reaction, Metathesis reaction, Water gas shift reaction (WGSR), Wacker-Smidt synthesis.

OUTCOMES: On Completion of this module, the learner will be able to

- Take decision in selecting reagents for a particular organic synthesis
- Improve the yield of chemical reaction
- Perform direct inter-conversion of a particular functional group without protecting others
- Minimize formation of the by-products or un-wanted molecules by choosing suitable reagents
- Synthesize important organic scaffolds via benign reaction conditions.

Books Recommended:

1. H.O. House, Modern Synthetic Reactions, 2nd Edition (1972), Benjamin/Cummings Publishing Company, California.
2. L.F. Fieser and M. Fieser, Reagents for Organic Synthesis, Vol. 1-16, Wiley-Interscience, New York.
3. M.B. Smith and J. March, March's Advanced Organic Chemistry – Reactions, Mechanisms & Structure, 5th ed. (2001), Wiley-Interscience, New York.
4. M. B. Smith, Organic Synthesis, (1995) McGraw Hill Inc., New York.
5. J. Clayden, N. Greeves, S. Warren, and P. Wothers, Organic Chemistry, (2001) Oxford Univ. Press, Oxford.
6. P. R. Jenkins, Organometallic Reagents in Synthesis, (1992) Oxford Science Publ., Oxford.
7. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
8. J. D. Atwood, Inorganic and Organometallic Reaction Mechanisms, 2nd Edn, VCH, New York, 1997.
9. G. W. Parshall, Homogeneous Catalysis, Wiley, New York, 1980.
10. C. N. Satterfield, Heterogeneous Catalysis in Practice, McGraw-Hill, New York, 1980.

DSE-5: CYPDTD8- Chemical Kinetics (Credit-5)

OBJECTIVE AND LEARNING: To understand the details of different Theories of reaction rates and their differences, the detailed study of thermodynamic and statistical approach of transition state theory, Kinetics of reactions in liquid state, Effect of substituent's on reaction rate, Hammette relations and Taft significance.

1. **Experimental Techniques for Fast Reaction:**Flow techniques, relaxation methods, flash photolysis.

2. **Transition State Theory:** Conventional transition state theory(CTST), some applications of transition state theory, Thermodynamic treatment of CTST, assumptions and limitations of conventional transition state theory, Application of statistical mechanics to transition state theory, extension of TST.

3. **Elementary gas phase reactions:** Bimolecular, trimolecular and Theories of unimolecular reactions--treatments of Lindmann, Hinshelwood, Rice-Ramsperger-Kassel (RRK), and Rice-Ramsperger-Kassel-Marcus (RRKM), combination and disproportionation reactions.

4. **Reactions in Solution:** Theories of the reaction rates applied to reaction in solution, Diffusion controlled reaction, reaction between molecules, Reaction between ions: Effect of solvent, interpretation of frequency factor and entropy of activation, reaction between dipoles, influence of ionic strength on rate of reaction, Influence of substituents on reaction rates, Linear free energy relationships, The Hammett equation, significance of s and r. The Taft equation.

5. **Homogeneous Catalysis:** General catalytic mechanism: equilibrium and steady state treatment, Mechanism of acid-base catalysis (protolytic and prototropic). Bronsted catalytic law, industrially important homogeneous catalysis processes, kinetics of enzyme catalyzed reaction.

OUTCOMES:

- Student will acquire knowledge of kinetics of some special reactions and different techniques of fast reaction.
- Students will be able to explain the concept of activation energy and its effects on the rates of chemical and calculate the entropy of activation
- Students will be able to explain Reaction between ions,Effect of solvent, interpretation of frequency factor and, reaction between dipoles, influence of ionic strength on rate of reaction and apply to see the influence of substituents on different organic reaction.

Books Recommended:

1. M. J. Pilling and A.P.W, Seakins, Reaction Kinetics, Oxford Science Publication, New York (1998).
2. K.J. Laidler, Chemical Kinetics, 3rd Edition (1967), Harper & Row Publishers, New York.
3. J. Rajaram and J.C. Kuriacose, Kinetics and Mechanism of Chemical Transformation, Ist Edition (1993), MacMillan India Ltd., New Delhi.
4. B. G. Cox, Modern Liquid Phase Kinetics, Oxford University Press, Oxford (1994).

DSE-6: CYPDTD9- Environmental Chemistry (Credit-5)

OBJECTIVE AND LEARNING: Environmentally benign chemical reactions are nowadays growing concerns of academics and industries and this study will make students aware with environmental ethics and knowledge needed to pursue their further chemical research work.

1. **Introduction:** Concept and scope of environmental chemistry, Environmental terminology and nomenclatures, Environmental segments, Solar Energy. The natural cycles of environment (Hydrological, Oxygen, Nitrogen, Phosphorous and Sulphur cycles) and their importance.

2. **Particles, ion and radicals in the atmosphere, stratospheric chemistry:** chemistry of ozone layer, role of chemicals in ozone destruction, Temperature inversion and its effects, Chemistry of Smog and its harmful effects. The green-house effect and Global warming,

3. **Basic principles of Sustainable Chemistry**: Eco-Friendly catalysts, synthesis, solvents. Biodegradable polymeric composite sorbents, Eco-friendly protocols for heavy metal water pollutants. Chemistry of soil formation and role of fertilizers and insecticides in soil pollution. Plume and its significance.

4. **Sources and effects, of oxides of sulphur, oxides of nitrogen, oxides of carbon**: Monitoring of air pollutants by Instrumental methods. Control of air pollution by raw material change, process modification, adsorption, absorption and combustion methods.

5. **Classification of Water Pollutants:** Chemical Pollutants; Physical Pollutants; Physiological Pollutants; Thermal Pollution. Unique characteristics of water; Water and the Living Environment; Water and the Non-living Environment; Monitoring of Water Pollutants: Pollution indicators, Dissolved Oxygen; Biological Oxygen Demand; Chemical Oxygen Demand; Waste water: Constituents – Microorganisms; Solids; Inorganic constituents, Organic matter, Water Quality requirements, pH values of Wastes and Receiving water, Suspended solids. El-Nino phenomenon.

OUTCOMES: A student having studied a subject like 'ENVIRONMENTAL CHEMISTRY' will be capable of understanding about the Environment and the chemical sciences involved in it. The students improve their knowledge regarding the different pollutions/ pollutants occurring in the environment. The students also develop their knowledge regarding Toxic substances and their distributions in the environment and their anti-dotes.

Books Recommended:

1. G.W. Vanloon, S.J. Duffer, Environmental Chemistry - A Global Perspective, Oxford University Press (2000).
2. F.W. Fifield and W.P.J. Hairens, Environmental Analytical Chemistry, 2nd Edition (2000), Black Well Science Ltd.
3. Colin Baird, Environmental Chemistry, W.H. Freeman and Company, New York (1995).
4. A.K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd.,New Delhi.

Additional References:

1. Peter O. Warner, Analysis of Air Pollutants, 1st Edition (1996), John Wiley, New York.
2. S.M. Khopkar, Environmental Pollution Analysis, 1st Edition (1993), Wiley Estern Ltd., New Delhi.
3. S.K. Banerji, Environmental Chemistry, 1st Edition (1993), Prentice-Hall of India, New Delhi. CMT-406: Photo Inorganic Chemistry C.

D: CYPDDD1-Project/Dissertation/Field work/Internship/Industry visit (Credit – 6)

OBJECTIVES AND LEARNING: The term courses also include a dissertation a research-based thesis project enhancing the students understanding.

Topic selection in consultation with the teacher; literature search from different reference books, scientific journals and using internet search; Bench work, typed write-up with proper tables, structures, figures and literature to be submitted; seminar lecture on this topic to be delivered in presence of all the teachers.

OUTCOMES: On successful completion of these semesters, students will be able to: (a) Describe and compare a range of analytical chemistry methods and explain the underlying theoretical principles. (b) Explain the broad role of chemists in quality control and assessment of experimental measurements and analytical tasks. (c) Employ a variety of analytical and instrumental methods to prepare, separate and quantify samples from various matrices. (d)Apply the scientific process, including statistical treatment of data, in the conduct and reporting of chemical analysis.

D: CYPCTC1-Value Added Course (Certificate Course)

1. Certificate Course in Lab Safety Management

- **Department:** Chemistry
- **Name of the Course:** Certificate Course in Lab Safety Management
- **Nature of Course:** Certificate Course
- **Mode of Course:** Online / Offline / Hybrid Mode
- **Number of Seats:** 20
- **Eligibility Criteria:** B. Sc. in any discipline with Chemistry as a paper
- **Introduction and relevance of Course:** Everywhere the safety comes first. Working safely in the laboratory is the basic requirement of every student. Laboratory safety management should be an integral part of every chemistry curriculum. The safety responsiveness must be included into each laboratory course. The primary goal of this course is to educate the students with the basics of laboratory safety. They will learn about common hazards found in the lab environment and effective ways to prevent risks to their safety and health. Through this course the students will learn general lab safety rules and guidelines, how to detect and control lab hazards and the requirements for a Chemical Hygiene Plan.

- **Objectives of the course:** 1.The students must understand the importance of safety in the laboratory as it relates to themselves and those around them. 2. They must be able to explainthe meaning of common safety symbols used in specific scientific fields of study.3.They must demonstratecomplete knowledge of laboratory safety rules.4.The student must be able to displayproper safety practices in the laboratory setting.

- **Learning outcome of the course:** 1. The ability to understand the terms hazard and risk; 2. The ability to conduct risk assessments for chemical hazards; 3. The ability to understand the fire hazard; 4. A thorough knowledge of the legal requirements and best practice for the disposal of all types of solid and liquid waste; 5. to know the symbols for different types of hazards and the actions for remedial; 6. awareness of other key safety issues, such as lone working, stress, ergonomics
- **Number of lectures:** 2 hour per week (2 credits)
- **Number of practical:** 2 hour per week (1 credit)

- **List of experiments:** Hands on training on handling chemical hazards, fire hazards, waste management.
- **Syllabus:**

  Unit 1: Good Laboratory practices and safety guidelines:

  Safe working procedure and protective environment, Laboratory safety measures basic principles, Classification of dangerous materials with pictorial symbols, common hazard and commonprecautions for each class, Safe chemical use, Proper storage and disposal of hazardous

2. Certificate Course in Green Water Technology

Department: CHEMISTRY

Name of the Course: GREEN WATER TECHNOLOGY

Nature of Course: CERTIFICATE

Mode of Course: Online /Offline /Physical

Number of Seats: 20

Eligibility Criteria for Admission: B. Sc. (ongoing PG students)

Introduction and relevance of course: The green water technology course is designed for students who want a career in the power plants, automobile industries, municipal corporation, pharmaceutical industries, water treatment plants and package water industries. this unique course provides students with specific scientific knowledge and skills indifferent areas acquainting them with green water technology.

Objectives of the course: This course is intended to provide a comprehensive survey of water quality required by the different industries depending upon their usage. The course will emphasize greener trends in water treatment plants and industries. The chemistry and technology of polluted water treatment will be related to their utilization in the respective industries. In this way, it is intended to generate a better understanding of the contributions of green water technology principles. Emphasis will be placed on recognizing and dealing with problem areas associated with the use of different green technologies for water purification. Safety consideration and other concerned matters which can influence the treated water will be include in these discussions.

Learning outcome of the course

Course Outcomes: The students at the completion of the course will be able:

- To understand the quality of potable water.
- To learn and understand the types of water and its usage.
- To get the knowledge of water pollution and its effects on flora and fauna.
- To enable the students, develop skill and excellent knowledge of water testing.
- They can pursue jobs in municipal corporation.

Above all the students can communicate in their family and society about potable water qualities and how it can be checked in order to prevent an Epidemic. After completing the course, students may apply for chemist job in the different industries.

Number of lectures: 02 hrs. per week (2 Credit)

Number of practicals: 02 hrs. per week (1 Credit)

List of experiments: Recognizing soft and hard water, determining hardness of water, eliminating the hardness of water, determining the TDS of water, Osmosis, determination of D.O., B.O.D and C.O.D.

Syllabus:

UNIT - I: Distribution of water on Earth, types of water, water quality as given by W.H.O., Indian standard specifications laid down for potable water. Sampling and testing of various water bodies. Factors affecting quality and stability of particular water bodies. What is natural water.

UNIT - II: Determination of physical and chemical properties of water. What are D.O., B.O.D. and C.O.D. What are soft and hard water. Sources responsible for contaminating water. What are their effects on flora and fauna? Definition of pure water. What is potable water, why water is necessary for life, what is water pollution. How environment is affected by the polluted water.

UNIT III: Study of different water pollutants and their effects on flora and fauna. Water treatment methods. Brief introduction of the following water treatment technologies: Osmosis, Reverse Osmosis, Resins for Cationic and Anionic exchanges, Charcoal filtration, Sorbents of Phyto & Animal origin.

UNIT- IV: Some knowledge on composite materials. What is natural polymer based composite materials. Different methods of using such composite materials in addressing polluted water. How they are environment friendly.

14. Suggestive readings:

1. A Textbook of Engineering Chemistry, Dr S. S. Dara, S. Chand & Company.
2. Engineering Chemistry, Jain & Jain, Dhanpat Rai & Sons.
3. Environmental Pollution, Monitoring and Control, Khopkar. S. M., New Age International Publishers.
4. A Text Book of Engineering Chemistry, Shashi Chawla, Dhanpat Rai & Sons.
5. Engineering Chemistry by Dr Subita Rasttan, S. K. Kataria & Sons.
6. Engineering Chemistry by B. K. Sharma, Krishna Prakashan Medis (P) Ltd., Meerut.
7. Engineering Chemistry by Daniel Yesudian, Hi-Tech Publications
8. A Text Book on Engineering Chemistry by Balaram Pani, Galgotia Publications Pvt. Ltd.
9. Analytical Methods for Drinking Water: Advanced in Sampling and Analysis by K. Clive Thompson and Philippe Quevauviller. (2005) Wiley.
10. A Text Book n Water Chemistry: Sampling, Data Analysis and Interpretation by A.G.S. Reddy (2020) Nova.

15. Course coordinator (Name & Designation): Dr. Sunil Kumar Singh, Associate Prof
Dr. Uday Pratap Azad, Assistant Prof.

16. Evaluation criteria:

Components	Class Test	Hands on Experiment	End Semester	Total
Weightage (%)	15	15	70	100

17.Infrastructure requirements: Basic laboratory with small equipment like magnetic stirrer, conductivity meter, pH meter and characterization and testing equipment.

18. Financial requirement: Approximate Rs 50,000 is required for the Water Kit in order to perform the tests of the eater on site.

19.Proposed fee for the course: 5000 (As per the GGV norms)

20. Budgetary provisions: Rs 50,000

3. Certificate Course in Agrochemical Formulation

1. **Department:** **CHEMISTRY**
2. **Name of the Course:** **AGROCHEMICALS FORMULATION**
3. **Nature of Course:** **CERTIFICATE**
4. **Mode of Course :** **Online/Offline/Physical**
5. **Number of Seats:** **20**
6. **Eligibility Criteria for Admission:** **B Sc (ongoing PG students)**
7. **Introduction and relevance of Course:** The Agro-chemicals formulation course is designed for students who want a career in the agrochemical and fertilizer industries. Agrochemicals are essential to the agricultural sector as they ensure farmers achieve healthy crop yields. This unique course provides students with skills indifferent areas of agrochemicals, and fertilizer industries.
8. The Pesticides Manufactures and Formulators Association of India (PMFAI) recognize the course as one of 'immediate relevance to the industry due to its scientific and technological curriculum.
9. **Objectives of the course:** This course provides basic knowledge of Pesticides and Formulation Technology. The course emphasizes current trends in formulations of pesticides including development and challenges for nanoscale formulation of botanical pesticides. Students will get an idea of residue analysis, optimum dose and eco-friendly formulations. Safety considerations and other pertinent matters which can influence ingredients election will be included in these discussions.
10. **Learning outcome of the course**

- After completing the course, students can set up on start-up for the making of agrochemicals, pesticides, insecticides, fertilizers.
- Students can give consultation to farmers regarding application of pesticides, insecticides and fertilizers.
- They can get jobs in agrochemical industries (manufacturing, consultation and R and D units).
- Students can give consultation to farmers regarding soil health.

11. **Number of lectures:** 02hr per week (2 Credit)
12. **Number of practicals:** 02 hrs per week (1 Credit)
13. **List of experiments:** Formulation of herbal pesticides, testing effectiveness of pesticides, residue analysis of agrochemicals using chromatographic techniques GC and HPLC.
14. **Syllabus:**

UNIT - I: Pesticides and Formulation Technology: Pesticide Products and the Modern Marketplace, An Overview of the Formulation Process, Common Pesticide Formulations, Formulations and Label Information, Classification, Synergists, Adjuvants, Liquid formulations, dry or solid formulations, Testing of pesticide formulations

UNIT - II:

Nanotechnology in agrochemical formulation: Development of stimuli-responsive nano-based pesticides, Development and Challenges for Nanoscale Formulation of Botanical Pesticides.

UNIT III: Application of GC & HPLC for pesticide detection: Basic principle of Chromatographic techniques, Instrumentation and method development, GC versus HPLC.

UNIT- IV: PesticideResidue Analysis: Introduction, Sample Collection, Reporting results: Detection and quantitation limits of the analytical method, Extraction and clean-up methods in pesticide residue analysis.

15. SuggestiveReadings:

1. Ware, G.W. *The Pesticide Book*, 4th ed; W.H. Freeman: Fresno, CA, 1994.
2. University of Nebraska Cooperative Extension Service. *A guide for private and commercial applicators: Applying pesticides correctly*. National pesticide applicator training core manual, University of Nebraska: Lincoln, 1992.
3. *Oregon Pesticide Applicator's Manual: a guide to the safe use and handling of pesticides*; Miller, T.L, ed. Oregon State University Extension Service: Corvallis, 1993.
4. *Label Review Manual*; U.S. Environmental Protection Agency, Office of Pesticide Programs, U.S. Government Printing Office: Washington, DC, 1998. https://www.epa.gov/pesticide-registration/label-review-manual
5. *Terms of the Environment*; U.S. Environmental Protection Agency, Office of Pesticide Programs, U.S. Government Printing Office: Washington, DC, 1997. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=4000081B.TXT
6. Bohmont, B.L. *The standard pesticide user's guide (revised)*. Prentice Hall: Princeton, NJ, 1990.
7. *Farm Chemicals Handbook 1997*; Meister Publishing Company, Willoughby, OH, 1997.
8. Official Methods of Analysis. AOAC. 17th Edition, pp. 1-10.
9. Indian Standard 14628:1999
10. G.H.Jeffery,J.Basset,J.Mendham,R.C.Denny(Rev.by)VogelsTextBookofQuantitativeChemical Analysis, 5thEdition 1989, ELBS.
11. PracticalHPLCmethoddevelopmentbyLloydR.Snyder,JosephJ.Kirkland,Joseph I. Glajch,JohnWileyandSons2ndEdition –1997
12. Chang.W.N"Nanofibresfabrication,performanceandapplications",NovaSciencePublishersInc, 2009.
13. Carbon Nanotubes: Synthesis, Structure, Properties, and Applications, Edited by M. S. Dresselhaus, G.Dresselhaus, P.Avouris,Springer-Verlag,2000.
14. Textbook of Nanoscience and Nanotechnology, B.S.Muty, P. Shankar, Baldev Raj, B.B Rathand James Murday,University Press,IIM(ISBN-9788173717383).
15. IntroductiontoNanotechnologybyCharlesP.PooleJrand.FrankJ.Owens,Wiley-Interscience,2003.
16. NanoscaleMaterialsinChemistryEditedbyKennethJ.Klabunde,JohnWiley&Sons,Inc.,ISBNs: 0-471-38395-3(Hardback);0-471-22062-0.

17. **Course Coordinator (Name & Designation):** Dr Charu Arora, Associate Prof.

18. EvaluationCriteria:

Components	ClassTest	Hands on Experiment	EndSemester	Total
Weightage (%)	15	15	70	100

19. **Infrastructure requirements:** Basic laboratory with equipments like magnetic stirrer, centrifugation and BOD incubator, Laminar flow, autoclave and
20. **Financial Requirement:** Approximate Rs 50,000 is required for the laboratory chemicals and minor instruments

21. **Proposed fee for the Course:**5000 (As per the GGV norms)
22. **Budgetary provisions: Rs 50,000**

4. Certificate Course in Cement Chemistry

- **Department** Chemistry
- **Name of the Course:** **Value Added Certificate Course** in Cement Chemistry
- **Nature of Course: Certificate: or Value Added Course** Certificate
- **Mode of Course:: Online / Offline / Physical** Hybrid Mode (Online + Offline)
- **Number of Seats:** 20
- **Eligibility Criteria for Admission:** B Sc, Ongoing M Sc student of any discipline
- **Introduction and relevance of Course**:

  In the present scenario cementing materials are very much required for the socio-economic development of the society and nation as well solves the sustainable development goals (SDGs). This course will enable the chemistry, skill and hands-on process involved and manufacture of cement to meet out the constructional material demand of the country. This will assist the students to be placed in industry ready to contribute effectively in the field of cement industry located in Chhattisgarh and India. In Chhattisgarh there are large scale cement Industry where they recruit the chemist having the knowledge and experience on chemistry and cement chemistry, therefore, this course will provide job opportunities too.
- **Objectives of the course**: The course will have the following objectives
  - To know about the various types of cement.
  - To study the raw materials of cement.
  - To know the chemical compositions of cement.
  - To study cement manufacturing and cement Industry in India.
  - To learn about properties and ISI specifications of Portland cement.
- **Learning outcome of the course**:
  - Understand the various types of cement.
  - Understand the chemistry that underpins coal and cement science and technology.
  - Students will understand the manufacturing processes used to produce cement and will know how differences in chemical composition affect properties of cement and their usage in different applications.
  - Understand the cement product specifications, various test methods used to qualify different standarization.
  - They will get experimental experience on cement
  - Students can get job opportunities in cement industries located in Chhattisgarh like Ambuja Cement, Ultratech, Nuvoco Lafarge, Century, Shree Cement etc.
- **Number of lectures**: 2 hour per week (02 Credit)
- **Number of practical's (if any)**: 2 hour per week (01 Credit)
- **List of experiments (If any)-**
  - Physical analysis of cement i.e. hardness, compressive strength etc.
  - Estimation of iron content in cement by spectrophotometer

- Chemical analysis of cement
- Determination of heat of hydration of cement
- Hydrophobicity of cement
- Determination of hardness of water
- Determination of water of absorption of cement
- Technical analysis of cement by flame photometer
- Industrial laboratories or mining visit may be done.

Syllabus:

CEMENT CHEMISTRY

Credits: 02 **30 Lectures**

UNIT-1

Origin, history and development of cement industries, lime and other building materials, different classes of building limeand their properties, Classification of cement. Raw materials, their selection and proportioning, calcareous andargillaceous materials,the present status and future of cementindustry in India.

UNIT- 2

Types of cements and their use: quick setting cement, rapid hardening cement, low heat cement, blast furnace slagcement, pozzolona and pozzolonic cement, high alumina cement, sorrel cement, hydrophobic cement, water proofcement, expanding and stressing cement, sulphate resisting cement, super-sulphate cement, trief cement.

UNIT-3

Calcareous Raw Materials: Source of Lime, Limestone, Chalk, Marl, Industrial waste, geological distribution of limestone deposits in India, Assessment of limestone deposits for Cement manufacture.
Argillaceous Raw Materials: Source of Silica, Alumina, Iron Oxide, Shale and effect of coal ash and additives use as corrective materials, Fly ash , Slag, lime sludge as cement raw materials.

UNIT-4

Cement quality requirements, corrective materials and additives, industrial waste and by-products,, Hydration of Portland cement – hydration and hydrolysis mechanisms and relatedtheories for C_3S phase and mechanisms of C_2S and C_3A, Setting and hardening of Portland cement, set regulations for gypsum.

Unit -5

Manufacture of Portland cement, physical and mechanical properties of Portland cement. ISI specifications of Portland cement. Decay of cement, lime, plaster of Paris.

Suggestive Readings:

- A Text book of Engineering Chemistry 12 edition by S. S. Dara, S SUmare S. (1986) Chand New Delhi, ISBN : 9788121903592
- Engineering Chemistry 16th edition (2015) by Jain and Jain Dhanpat Rai Publishing House, ISBN : 9352160002
- Chemistry in Engineering and Technology Vol 1 by J. C. Kuriacose and J. Rajaram (1996), Tata McGraw-Hill Co. New-Delhi.ISBN:9780074517352.
- Text Book of Geology (2013) by P K Mukherjree Pub: World Press Private Ltd.ISBN:18187567546
- Advances in Cement Technology- Chemistry, Manufacture and Testing 2nd edition (2003)by S.N. Ghosh,.CRCPressISBN: 8188305049
- Cement Chemistry 2nd edition by HFW Taylor (1997), Thomas Telford Pub London
- Lea's Chemistry of Cement and Concrete, 4th edition (2003) by Peter Hewlett, Elsevier, Amsterdam, ISBN:9780080535418
- Text book of Cement and Concretes 3rd edition (1971) by F.M.Lee Chemical Publishing Co Inc.,U.SISBN:0820602124
- Concrete Engineering Handbook: McGraw Hill Handbooks (2013) by William S La Londe Jr Pub. Literary Licensing, LLC ISBN: 1258715279
- Cement Data Book, Volume One: International Process Engineering in the Cement Industry3rd edition by Walter H. Duda (1985) by Pub: French & European ISBN 0828802041
- Norms for limestone exploration for cement manufacture : National Council for Cement and Building MaterialsNCCBM (https://www.ncbindia.com)
- National Inventory of cement grade limestone deposits in India : National Council for Cement and Building Materials (NCCBM-https://www.ncbindia.com/geology-mining-and-raw-materials.php)

- **Course Coordinator** (Name & Designation): Dr S S Thakur Asst Prof
- **Co-Coodinator**: Prof G, K Patra, Professor

5. Certificate Course in Smart Materials and technology

- **Department**: Chemistry
- **Name of the Course**: Certificate Course in **Chemistry of Smart Materials and Technology**
- **Nature of Course**: Certificate or Value Added Course: Certificate
- **Mode of Course**: Online / Offline / Physical: Hybrid Mode (online + Offline 60:40 %)
- **Number of Seats**: 20
- **Eligibility Criteria for Admission**: B Sc in any discipline with Chemistry as a paper
- **Introduction and relevance of Course**: Nanostructured materials consist of nanoparticles (NPs), nanorods, nanowires, thin films, or bulk materials made of nanoscale building blocks or composed of nanoscale structures with at least one dimension falling on a

nanometer scale. The use of nanomaterials in chemical sensors and biosensors has brought progress in this field over the past decade, leading to substantial improvements in performance. Nanostructures have exceptional physicochemical properties that are absent from their bulk counterparts. For this reason, nanomaterials have been actively explored and applied as the foundation of advantageous sensing applications over the last few decades An example structure of a chemical sensor containing biopolymer nanostructures. Polymer is a natural or artificial chemical compound consisting of large molecules which is made up of smaller, joined-together molecules called monomers. Due to their broad spectrum of properties, both synthetic and natural polymers play essential and versatile roles in everyday life.Polymers range from familiar synthetic plastics such as polystyrene to natural biopolymers such as DNA and proteins that are fundamental to biological structure and function. Chemical sensors currently represent a valuable new technology that provides advantageous options in a wide range of applications in terms of simplicity, time, and cost-effectiveness. The goal of sensing technology is to revolutionize the way in which we measure key parameters related to diagnostics, monitoring of the environment, safety, and protection. Chemical sensors can be divided into several types, such as optical, electrochemical, mass, magnetic, and thermal. This course will provide the opportunity to the learner to get job in various industries. Learner can start own small level work based on different materials Processing that are one of the part of Syllabus.

- **Objectives of the course**: To study the methods for preparation of variety of nanomaterials and its application in sensing by introducing the host guest type material
  To study the utilization of polymeric materials with nanoparticles in the preparation of different industrial articles along with other important compounds.
- **Learning outcome of the course**: This course will educate the students on the subject of polymers, nanomaterials and supramolecules that constitute one of the most important materials used presently. The course will include fundamentals of synthesis, characterization, properties and include discussion on the applications of polymers nanomaterials and supramolecules, as well as challenges pertaining to contemporary research based on nanomaterials.
- Number of lectures (I hour =1 credit per week): 1 (01 hour)
- Number of practicals (if any) (2 hours = 1 Credit per week) 1(2 Hour)
- List of experiments (If any)- attached with annexure I
- Syllabus:

Syllabus on Chemistry of Smart Materials and technology
(Certificate Course)

Credits: 02 **30 Lectures**

Syllabus

Unit 1: Chemistry of Nanostructured Materials: Intermolecular forces during the formation of nanostructured materials, Synthesis, sol – gel chemistry, micro, meso and macroporous materials, mesoporous and mesostructured materials.

Unit 2:Application of Nanomaterial: Ferroelectric materials, coating, molecular electronics and nanoelectronics, biological and environmental, membrane based application, polymer based application

Unit 3: Chemistry of polymeric materials: Introduction about Advance polymeric materials and its industrial application. Preparation, properties and applications of polycarbonates,Gels, epoxy resins – polyamides – Nylon and Kevlar.

Unit 4: Chemistry of Sensor: Forces of interactions (Covalent and non-covalent), Fundamental sensing processes (electrical, chemical, molecular sensors). Transduction processes (PET, ICT, FRET, ESIPT, electrochemical redox process etc.).

Unit 5: Host Guest Chemistry: Introduction to chemosensor, Design of chemosensor for cations, anions, neutral molecules, different sensing techniques: Fluorescence sensors, colorimetric sensors, electrochemical sensors, Array-based sensors, molecular switches, Gas sensor, Nanomaterial based biosensors and its importance Applications.

- Suggestive Readings:

1. Van Vlack, Lawrence H, "Elements of Material Science and Engineering", 6th edition, New York Addison, Wesley, (1989).
2. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao et.al.
3. Introduction to Nanotechnology- Charles P Poole & Frank J. Ownes.
4. Nanoparticles: From theory to applications – G. Schmidt, Wiley Weinheim 2004.
5. Instrument E L Principe, P Gnauck and P Hoffrogge, Microscopy and Microanalysis (2005), 11: 830- 831, Cambridge University Press.
6. Processing & properties of structural naonmaterials - Leon L. Shaw. Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry, Cambridge UK 2005.
7. Nanoscale Materials - Luis M. Liz-Marzán and Prashant V. Kamat
8. Carbon Nanomaterials for Environmental and Biological Applications, Bergmann and Machado, Springer.
9. Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge, UK (2005).
10. F. W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Willey-Interscience, New York.
11. G. Odian, P. W. Atkins, Physical Chemistry, 6th Edition, Oxford University Press, New York.
12. G. Odian, Principles of Polymerization, 3rd edition (1991) John Wiley, Singapore
13. P.Bahadur and N.V. Sastry, Principle of Polymer Sciences , Narosa Publishing House, New Delhi (2002)
14. Chemical Sensors and Biosensors; Brian, R Eggins; Wiley; New York, Chichester, 2002.
15. Biosensors: A Practical Approach, J. Cooper & C. Tass, Oxford University Press, 2004.
16. Nanomaterials for Biosensors, Cs. Kumar, Wiley – VCH, 2007.
17. Smart Biosensor Technology, G.K. Knoff, A.S. Bassi, CRC Press, 2006.
18. Supramolecular Chemistry from Molecules to Nanomaterials, Gale and Steed, 2012.
19. Modern Supramolecular Chemistry, Diederich, Stang, Tykwinski, 2008.
20. J. W. Steed, D. R. Turner, K. J. Wallace, Core Concepts in Supramolecular Chemistry and Nanochemistry, John Wiley & Sons, 2007

21. Steed, J. W., and Atwood, J. L., Supramolecular Chemistry, Wiley, Chichester, 2009

- **Course Coordinator**: 1. Dr Arti Srivastava, Assistant Professor
  2. Dr Niraj Kumari, Assistant Professor

Evaluation Criteria (to be decided by HOD and Course Teacher) by Written examination of theory and practical.

- Infra-Structure requirements (if any): Available in the department, 01 instrument required
- Financial Requirement (if any):
- Proposed fee for the Course (if any): 5000/-
- Budgetary provisions – See annexure II
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(Existing staff will handle all the classes, No separate/additional Faculty will be provided for the conduct of the course, however guest faculty may be called on demand basis, payment of which may be made as per budgetary provisions of the course)

Suggested list of Experiments (based on availability of the resources)

1. Synthesis and characterization of nanomaterials.
2. Radical polymerization vinyl monomers.
3. Determination of molecular weight of polymer by viscometric method.
4. Determination of molecular weight of polymer by GPC method
5. Synthesis of Nylon.
6. Synthesis of Hydrogel and its application.
7. Application of nanomaterials in Sensors
8. Application of polymer Nano composite in sensor.
9. Synthesis of nanomaterial complexes and study of the host guest relation.

A Visit to suitable Industry

Amount of Minimum Proposed Budget: Rs 50,000/-
Amount required for Chemical: Rs 40,0000/-
Miscellaneous budget: Rs 10,000/-

6. Certificate Course in Food Adulteration and Testing

1. Department: CHEMISTRY

2. Name of the Course: **FOOD ADULTERATION AND TESTING**

3. Nature of Course: CERTIFICATE

4. Mode of Course: Online /Offline/Physical

5. Number of Seats: 20

6. Eligibility Criteria for Admission: B. Sc. (ongoing PG students)

7. **Introduction and relevance of Course:** The certificate course in *food adulteration and testing* is designed for undergraduate students seeking career in food industry. The course focuses on processes that are followed to preserve a food product, especially to provide the knowledge for developing their practical approach about the selection and application of additives to preserve the processed food. The proposed course is the most recognized and important part of curriculum of food technology/science designed for professional studies towards strengthen the manpower in terms of basic knowledge of theory and experiments to be used in various food industries.

8. Objectives of the course: The course is proposed to fulfill the need and scope of undergraduate students to educate them about food chemistry perspectives, especially; processes that are followed to preserve a food product, and to test the adulteration and food quality. The course would provide the basic as well as necessary components of knowledge to the students to establish them in food industry and to develop their practical approach about the selection and application of additives to preserve the processed food and testing in adulteration. Furthermore, this course is aimed to provide the undergraduate students a conceptual understanding of food safety and analysis along with their limitations. Testing of foods is incessantly demanding the development of more robust, efficient, sensitive, and cost-effective analytical methodologies to guarantee the safety, quality, and traceability of foods in compliance with legislation and consumer demands. *This is usually used as a specialization by those who want to further continue their studies in the food science industry. But one can be placed in beginner level jobs under food analyst and as marketing assistants.*

9. Learning outcome of the course:

Course Outcomes: The student at the completion of the course will be able:

- To understand the history, relevance of food basics.
- To learn and understand the types of food and its functions.

- To get the knowledge of food adulteration.
- To gain knowledge by food preservation.
- To enable the students to get the excellent knowledge of adulteration testing in food
- To enable the students to get sufficient knowledge about food industry.

10. Number of Lectures: 2 h per week (2 Credit)

11. Number of Practicals: 2 h per week (1 Credit)

12. List of experiments: (1) Testing of Adulteration in Milk products (2) Testing of Food Colorants in food items (3) Testing of Adulteration in Food Materials (4) Testing of Adulteration in Spices.

13. Syllabus:

Unit I.**Introduction to Food Chemistry:**

Food Chemistry, Food and its Components: Food Proteins, Enzymes, Carbohydrates *etc*. Food additives: Food preservative, Food Color *etc*. Food Standards and Permissible Limits.

Unit II.**Food Pigments and Colors:**

Food Oxidants, Food Pigments: Alizarin, Azo- pigments (the yellow, orange and red colour range), Phthalocyanine (blue and green colour range), Quinacridone (a lightfast red-violet pigment), Inorganic pigments of mineral origins. Natural and Synthetic food colors (Allura Red, Tartrazine, Carmine, Amaranth *etc.*). Flavoring agents, Sweeteners, Emulsifiers and Stabilizers, Spices and Herbs.

Unit III.**Adulteration of Food:**

Food Adulteration, Types of Adulteration: Intentional adulteration, Incidental adulteration. Poisonous or deleterious substances, Economic adulteration, Microbial contamination.Adulteration through hazardous chemicals, Filth and Foreign Matter.

Unit IV.Evaluation of Food Quality:

Evaluation of food quality, sensory tests, types of tests, objective evaluation and instruments used for texture evaluation.

14. Suggestive Readings:

1. Desrosier NW and Desrosier JN, The Technology of Food Preservation, CBS Publication, New Delhi, 1998
2. Paine FA and Paine HY, Handbook of Food Packaging, Thomson Press India Pvt Ltd, New Delhi-1992
3. Potter NH, Food Science, CBS Publication, New Delhi, 1998
4. Ramaswamy H and Marcott M, Food Processing Principles and Applications CRC Press, 2006
5. Rao PG, Fundamentals of Food Engineering, PHI Learning Pvt Ltd, New Delhi, 2010

6. Toledo Romeo T, Fundamentals of Food Process Engineering, Aspen Publishers, 1999.
7. Bamji MS, Krishnaswamy K, Brahmam GNV (2009). Textbook of Human Nutrition, 3rd edition.Oxford and IBH Publishing Co. Pvt. Ltd.
8. Srilakshmi (2007). Food Science, 4th Edition. New Age International Ltd.
9. Girdharilal, Siddappaa, G.S and Tandon, G.L.1998. Preservation of fruits & Vegetables, ICAR, New Delhi.

15. Course Coordinator (Name & Designation):

1. Dr Vijai K. Rai, Assistant Professor
2. Dr Manorama, Assistant Professor

16. Evaluation Criteria (to be decided by HOD and Course Teacher):

Components	Class-Test	Experiment	End Semester	Total Marks
Weightage (%)	**20**	**20**	**60**	**100**

17. Infrastructure requirements (if any): Basic laboratory system with pH meter, magnetic stirrer, characterization and small testing equipments.

18. Financial Requirement (if any): Approx. Rs 50,000

19. Proposed fee for the Course (if any): Rs.5000.00 (As per the University's norms).

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Minutes of BOS Meeting
Department of Chemistry, GGV
Date: 28/10/2021

As per the notification (216/*Academic/2021,* dated 08-10-2021), a meeting of the Board of Studies (BoS) for the Department of Chemistry was convened on 28-10-2021 at 12:00 noon at the Departmental meeting room. The external expert of BoS attended the meeting through online video conferencing using Google meet.

The following members were present in the meeting:

1. Dr Santosh Singh Thakur – Chairman
2. Prof. C. R. Sinha – External Expert
3. Prof. G. K. Patra – Member
4. Dr. A. K. Singh– Member
5. Dr. V. K. Rai – Member

In this meeting, the contents of each paper of learning outcome based curriculum framework (LOCF) at undergraduate (UG) level and choice based credit system (CBCS) at postgraduate level (P.G.) were thoroughly discussed and suggestions made by members (both internal and external) were considered and incorporated. The syllabus of Chemistry was thoroughly modified and restructured as per university as well as UGC guidelines. The schemes and syllabus of UG and PG course in Chemistry are attached (Annexure –I and Annexure –II) which would be submitted to the university authority for approval.

Signature of BoS Members:

1. Dr. Santosh Singh Thakur
(Chairman)

2. Prof. C. R. Sinha
(External Expert)

3. Prof. G. K. Patra
(Member)

4. Dr. A. K. Singh
(Member)

4. Dr. V. K. Rai
(Member)