1.1.3

List of Employability/ Entrepreneurship/ Skill Development Courses with Course Contents

Colour Codes		
Name of the Subjects	Yellow	
Employability Contents	Green	
Entrepreneurship Contents	Light Blue	
Skill Development Contents	Pink	

List of Courses Focus on Employability/ Entrepreneurship/ Skill Development

Department : *Chemistry*

Programme Name : *M. Sc.*

Academic Year : 2022-23

List of Courses Focus on Employability/ Entrepreneurship/Skill Development

Sr. No.	Course Code	Name of the Course
01.	CYPATT1	Analytical Chemistry I
02.	CYPATO1	Polymer Chemistry
03.	CYPALT2	Inorganic Chemistry Practical I
04.	CYPALT3	Organic Chemistry Practical I
05.	CYPALT4	Physical Chemistry Practical I
06.	CYPALT1	Analytical Chemistry Practical I
07.	CYPALO1	Polymer Chemistry Practical I
08.	CYPATC1	Value added courses
09.	CYPBTT1	Analytical Chemistry II
10.	CYPBLT2	Inorganic Chemistry Practical II
11.	CYPBLT3	Organic Chemistry Practical II
12.	CYPBLT4	Physical Chemistry Practical II
13.	CYPBLT1	Analytical Chemistry Practical II
14.	CYPBTD1	Instrumental Analytical Techniques
15.	CYPBTD3	Chemistry of Heterocycles
16.	CYPATC1	Value-Added Course
17.	CYPCTA1	Research Methodology
18.	CYPCTO2	Medicinal Chemistry
19.	CYPCLO2	Medicinal Chemistry Practical
20.	CYPDTO3	Industrial Chemistry
21.	CYPDLO3	Industrial Chemistry Practical
22.	CYPCLD1	Analytical Chemistry Practical III
23.	CYPCLD2	Inorganic Chemistry Practical III
24.	CYPCLD3	Organic Chemistry Practical III
25.	CYPCLD4	Physical Chemistry Practical III
26.	CYPCLD5	Analytical Chemistry Practical IV
27.	CYPCLD6	Inorganic Chemistry Practical IV

28.	CYPCLD7	Organic Chemistry Practical IV
29.	CYPDTL6	Biological Chemistry Practical
30.	CYPDTD1	Advanced Separation Techniques
31.	CYPDTD3	Organic Spectroscopy for Structural Elucidation
32.	CYPDTD7	Reagents and Reactions in Organic Synthesis
33.	CMP-409	Project

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Scheme and Syllabus

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

(To be implemented from Session 2021-2022)

Course Structure	Course Code	Title	T/L	CCA	ESE	Total Marks	Credit	Final credit
SEMESTER -I								
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-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 $AgNO_3$.
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 weightDetermination:
   A. Determination of molecular weight by viscometry:
   B. Determination ofthe viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
4. CharacterizationTechniques:
   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:

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

materials, Safety in bulk storage of hazardous substances. Safety in shelf storage of hazardous substances,

Unit 2: Handling radiation, Control of electrical hazards, Bio-hazardous and other toxic experimental materials.

Unit 3: Statutory provisions regarding fire safety. Factors contributing towards fire. Chemistry of fire, Classification of fires, Common causes of industrial fires, Determination of fire load, Fire resistanceof building materials, Prevention of fire, Portableextinguishers, Water systems, carbon-di-oxide systems, Foam extinguisher systems.

Unit 4:Chemical Hygiene and Safety, Chemical Safety for various Industries like Pharma, Food, Petrochemical, Pesticides, Fertilizers etc.

Suggestive Readings:

1. R.K.Jain and Sunil S.Rao , Industrial Safety, Health and Environment Management Systems, Khanna publishers , New Delhi.
2. Slote.L. Handbook of Occupational Safety and Health, John Willey and Sons, NewYork .
3. Frank P. Lees, Loss of prevention in Process Industries , Vol. 1 and 2, Butterworth- Heinemann Ltd., London (1991).
4. Industrial Safety -National Safety Council of India.
5. Handbook of Environmental Health and Safety: Herman Koren and Michel Bisesi, Jaico Publishing House, New Delhi.
6. Handbook of Environmental Risk Assessment and Management: Peter Calow, Blackwell Science Ltd. USA.
7. Risk Assessment and Environmental Management: D. Kofi Asvite-Dualy, John Willey & Sons, West Sussex, England.
8. Introduction to Environmental Engineering & Science: Gilbert M. M., Pearson Education, Singapore.
9. Fire Equipment David L. Bever
10. Industrial Safety National Safety Council of India
11. Fire Technology, R.S. Gupta

- **Course Coordinator (Name & Designation)**: Dr. G.K. Patra, Professor, Department of Chemistry, Guru Ghasidas Vishwavidyalaya Bilaspur; CG, India
- **Evaluation Criteria**:

Components	Class test	Hands on experiment	End semester	Total
Weightage (%)	15	15	70	100

- **Infra Structure requirement**: Basic Laboratory facilities available in the Department
- **Financial Requirement**: Rupees 1,00,000/- is initially needed to start the course
- **Proposed fee for the Course (if any)**: Rupees 5000/-
- **Budgetary provisions**: Rupees 1,00,000/- is initially needed to start the course

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 susceptibilitymeasurements 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. **PericyclicReactions:** 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.).

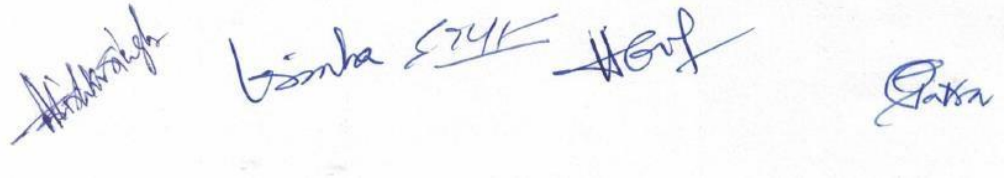
Note: *Experiments may be added/deleted subject to availability of time and facilities.*

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.



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 micellar 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; Theory 04 + Tutorial 01)

DSE-1: CYPBTD1-Instrumental Analytical Techniques (Credit-5 Theory 04 + Tutorial 01)

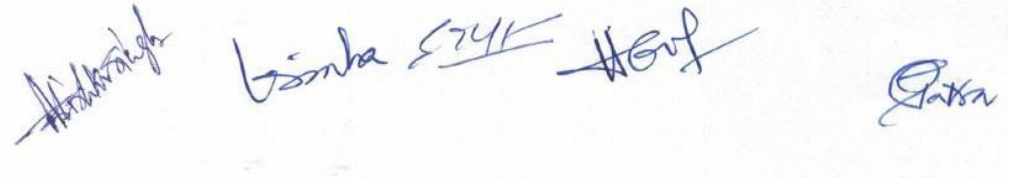
OBJECTIVE AND LEARNING: This module will provide theory, instrumentation and applications of different analytical instrumental techniques of Fourier Transform Infra-Red (FTIR), Raman, Nuclear Magnetic Resonance (NMR), Electron Spin Resonance (ESR), Scanning Electron Microscopy (SEM), Transmission Electron 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: CYPBTD3-Chemistry of Heterocycles (Credit-4 Theory 04 + Tutorial 01)

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.

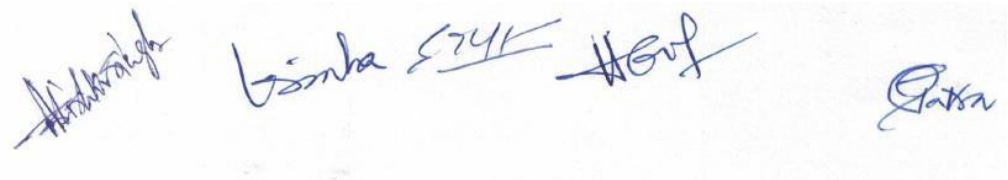
4. **Six Membered Heterocyclics with Two Hetero Atoms:** Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyridazine, Pyrimidine. Pyrazine. Oxazine, thiazine: Fused heterocycle: Benzimidazole, benzoxazole and benzthiazole.

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.



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.

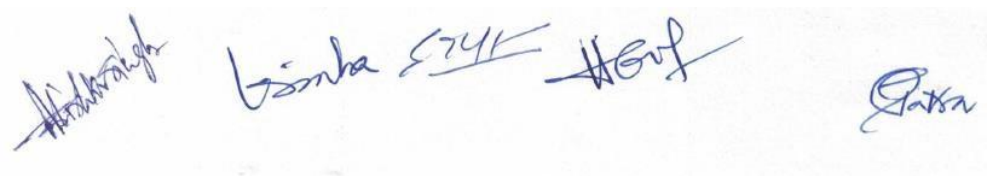
Objectives of the course: This course is intended to provide a comprehensive survey of water quality required by the different industries depending upon their usage. The course will emphasize greener trends in water treatment plants and industries. The chemistry and technology of polluted water treatment 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.

CC-10: CYPCTT1-Computer Applications in Chemistry (Credit-5 Theory 04 + Tutorial 01)

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.

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 transitionmetal complexes.
- Calculation of ligand field parameters based on electronic spectra of various transitionmetal 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,

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

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*

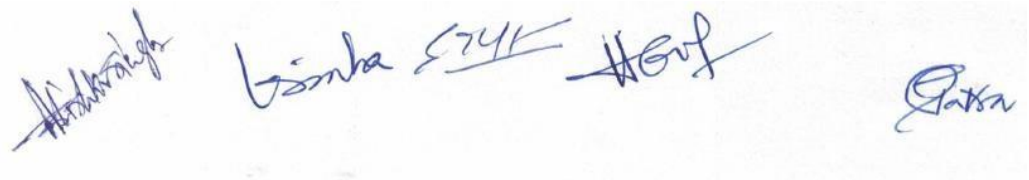
OUTCOMES: The module will provide the hands-on analysis of different elements in soil samples, analytical instruments to prepare, separate and quantify samples from various matrices.Apply the scientific process, including statistical analysis of data, conducting and presenting the data of chemical analysis.Able 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 knowClassification 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



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:

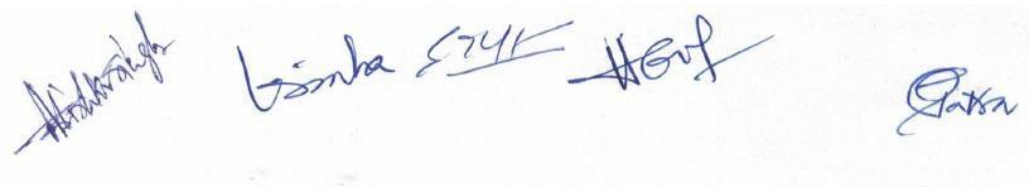
1. Nitya Anand, J.S. Bindra and S. Ranganathan, Art in Organic Synthesis, 2nd Edition (1970), Holden Day, San Francisco.
2. S.W. Pelletier, Chemistry of the Alkaloids, (1970) Van Nostrand Reinhold Co., New York.
3. K.W. Bentley, The Alkaloids, Vol. I., (1957) Interscience Publishers, New York.
4. I. 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.



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 Theory 04 + Tutorial 01)

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.

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 Theory 04 + Tutorial 01)

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 Theory 04 + Tutorial 01)

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. **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 Theory 04 + Tutorial 01)

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 Theory 04 + Tutorial 01)

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.

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.