# List of New Course(s) Introduced

**Department : *Chemistry***

**Programme Name : *M.Sc.***

***Academic Year : 2021-22***

## *List of New Course(s) Introduced*

| Sr. No. | Course Code | Name of the Course |
|---|---|---|
| 01. | CYPATT1 | Analytical Chemistry I |
| 02. | CYPALT1 | Analytical Chemistry Practical I |
| 03. | CYPATT2 | Inorganic Chemistry I |
| 04. | CYPALT2 | Inorganic Chemistry Practical I |
| 05. | CYPATT3 | Organic Chemistry I |
| 06. | CYPALT3 | Organic Chemistry Practical I |
| 07. | CYPATT4 | Physical Chemistry I |
| 08. | CYPALT4 | Physical Chemistry Practical I |
| 09. | CYPATO1 | Polymer Chemistry |
| 10. | CYPALO1 | Polymer Chemistry- Practical I |
| 11. | CYPATC1 | Refer the List of Value-Added Course |
| 12. | CYPALC1 | Refer the List of Value-Added Course |
| 13. | CYPBTT1 | Analytical Chemistry II |
| 14. | CYPBLT1 | Analytical Chemistry Practical-II |
| 15. | CYPBTT2 | Inorganic Chemistry II |
| 16. | CYPBLT2 | Inorganic Chemistry Practical-II |
| 17. | CYPBTT3 | Organic Chemistry II |
| 18. | CYPBLT3 | Organic Chemistry Practical-II |
| 19. | CYPBTT4 | Physical Chemistry II |

| | | |
|---|---|---|
| 20. | CYPBLT4 | Physical Chemistry Practical-II |
| 21. | CYPBTT5 | Molecular Spectroscopy |
| 22. | CYPBTD1 | Instrumental Analytical Techniques |
| 23. | CYPBTD2 | Bio-inorganic Chemistry |
| 24. | CYPBTD3 | Chemistry of Heterocycles |
| 25. | CYPBTD4 | Solid State Chemistry |
| 26. | CYPATC1 | Refer the List of Value-Added Course |
| 27. | CYPALC1 | Refer the List of Value-Added Course |

# Minutes of Meetings (MoM) of Board of Studies (BoS)

**Academic Year : 2021-22**

**School : *School of Studies of Physical Science***

**Department : *Chemistry***

**Date and Time : *Oct. 28, 2021 – 12:00 noon***

**Venue : *Meeting room***

The scheduled meeting of member of Board of Studies (BoS) of Department of Chemistry, School of Studies of Physical Science, Guru Ghasidas Vishwavidyalaya, Bilaspur was held to design and discuss the structure and scheme of examination of Integrated UG/PG, M. Sc. Chemistry syllabi.

The following members were present in the meeting:

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

Following points were discussed during the meeting

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

The following new courses were introduced in the B. Sc. and M. Sc.:

- B. Sc. LOCF scheme

| | |
|---|---|
| CYUATT1 | Inorganic Chemistry-I |
| CYUALT1 | Inorganic Chemistry Practical-I |
| CYUATT2 | Organic Chemistry-I |
| CYUALT2 | Organic Chemistry Practical-I |
| CYUATA1 | Select one from the Pool of AEC Courses offered |
| CYUATL1 | Select one from the Pool of SEC Courses offered |

CYUATG1 1A Physics-I, 1B Mathematics-I, 1C Zoology-I 1D Botany-1, 1EAnthropology-1, 1F Biotechnology-1,1G Forensic Science-1
CYUALG1 Generic Elective- Practical-I
CYUATC1 Select one from the Pool of Value added Courses offered
CYUBTT1 Physical Chemistry-I
CYUBLT1 Physical Chemistry Practical-I
CYUBTT2 Organic Chemistry-II
CYUBLT2 Organic Chemistry Practical-II
CYUBTA1 Select one from the Pool of AEC Courses offered
CYUBTL1 Select one from the Pool of SEC Courses offered
CYUBTG1 2A Physics-I, 2B Mathematics-I, 2C Zoology-I, 2D Botany-1, 2EAnthropology-1, 2F Biotechnology-1,2G Forensic Science-1
CYUBLG1 Generic Elective- Practical-II
CYUBTC1 Select one from the Pool of Value added Courses offered

- M. Sc. CBCS scheme

CYPATT1 Analytical Chemistry I
CYPALT1 Analytical Chemistry Practical I
CYPATT2 Inorganic Chemistry I
CYPALT2 Inorganic Chemistry Practical I
CYPATT3 Organic Chemistry I
CYPALT3 Organic Chemistry Practical I
CYPATT4 Physical Chemistry I
CYPALT4 Physical Chemistry Practical I
CYPATO1 Polymer Chemistry
CYPALO1 Polymer Chemistry- Practical I
CYPATC1 Refer the List of Value-Added Course
CYPALC1 Refer the List of Value-Added Course
CYPBTT1 Analytical Chemistry II
CYPBLT1 Analytical Chemistry Practical-II
CYPBTT2 Inorganic Chemistry II
CYPBLT2 Inorganic Chemistry Practical-II
CYPBTT3 Organic Chemistry II
CYPBLT3 Organic Chemistry Practical-II
CYPBTT4 Physical Chemistry II
CYPBLT4 Physical Chemistry Practical-II
CYPBTT5 Molecular Spectroscopy
CYPBTD1 Instrumental Analytical Techniques
CYPBTD2 Bio-inorganic Chemistry
CYPBTD3 Chemistry of Heterocycles
CYPBTD4 Solid State Chemistry
CYPATC1 Refer the List of Value-Added Course
CYPALC1 Refer the List of Value-Added Course

अध्यक्ष/Head
रसायन शास्त्र विभाग
Deptt. of Chemistry
गुरु घासीदास विश्वविद्यालय,
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Signature & Seal of HoD

# Scheme and Syllabus

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

(To be implemented from Session 2021-2022)

### SEMESTER -I

| Course Structure | Course Code | Title | T/L | CCA | ESE | Total Marks | Credit | Final credit |
|---|---|---|---|---|---|---|---|---|
| CC-1 | CYPATT1 | Analytical Chemistry I | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPALT1 | Analytical Chemistry Practical I | L-4 | 40 | 60 | 100 | 2 | |
| CC-2 | CYPATT2 | Inorganic Chemistry I | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPALT2 | Inorganic Chemistry Practical I | L-4 | 40 | 60 | 100 | 2 | |
| CC-3 | CYPATT3 | Organic Chemistry I | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPALT3 | Organic Chemistry Practical I | L-4 | 40 | 60 | 100 | 2 | |
| CC-4 | CYPATT4 | Physical Chemistry I | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPALT4 | Physical Chemistry Practical I | L-4 | 40 | 60 | 100 | 2 | |
| OE | CYPATO1 | Polymer Chemistry | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPALO1 | Polymer Chemistry- Practical I | L-4 | 40 | 60 | 100 | 2 | |
| VAC/ Certificate Course/ Optional | CYPATC1 | Refer the List of Value-Added Course (p. 5) | T-2 | 40 | 60 | 100 | 2 | Additional Credit Course |
| | CYPALC1 | | L-2 | 40 | 60 | 100 | 1 | |
| | | | | | | Total Credit | | 25 |

### Semester-II

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CC-5 | CYPBTT1 | Analytical Chemistry II | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPBLT1 | Analytical Chemistry Practical-II | L-4 | 40 | 60 | 100 | 2 | |
| CC-6 | CYPBTT2 | Inorganic Chemistry II | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPBLT2 | Inorganic Chemistry Practical-II | L-4 | 40 | 60 | 100 | 2 | |
| CC-7 | CYPBTT3 | Organic Chemistry II | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPBLT3 | Organic Chemistry Practical-II | L-4 | 40 | 60 | 100 | 2 | |
| CC-8 | CYPBTT4 | Physical Chemistry II | T-3 | 40 | 60 | 100 | 3 | 5 |
| | CYPBLT4 | Physical Chemistry Practical-II | L-4 | 40 | 60 | 100 | 2 | |
| CC-9 | CYPBTT5 | Molecular Spectroscopy | T – 4+1* | 40 | 60 | 100 | 5 | 5 |
| DSE-1 | CYPBTD1 | Instrumental Analytical Techniques | T – 4+1* | 40 | 60 | 100 | 5 | 5 |
| | CYPBTD2 | Bio-inorganic Chemistry | T – 4+1* | 40 | 60 | 100 | 5 | |
| | CYPBTD3 | Chemistry of Heterocycles | T – 4+1* | 40 | 60 | 100 | 5 | |
| | CYPBTD4 | Solid State Chemistry | T – 4+1* | 40 | 60 | 100 | 5 | |
| | **Remarks:** *Any one course from DSE-1 will be offered to each student by the Department.* | | | | | | | |
| VAC/ Certificate Course/ Optional | CYPATC1 | Refer the List of Value-Added Course (p. 5) | T-2 | 40 | 60 | 100 | 2 | Additional Credit Course |
| | CYPALC1 | | L-2 | 40 | 60 | 100 | 1 | |
| | | | | | | Total Credit | | 30 |

### Semester-III

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| CC-10 | CYPCTT1 | Computer Applications in Chemistry | T – 4+1* | 40 | 60 | 100 | 5 | 5 |
| RM | CYPCTA1 | Research Methodology | T-2 | 40 | 60 | 100 | 2 | 2 |

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

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

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

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

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

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

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

**Books Recommended:**

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

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

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

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

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

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

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

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

**OBJECTIVES AND LEARNING**:

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

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

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

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

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

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

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

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

**Books Recommended:**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**Books recommended:**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

**OUTCOMES:**

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

**Books Recommended:**

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

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

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

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

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

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

**OUTCOMES:**

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

## 1: CYPATO2-Polymer Chemistry (Credit-3)

**OBJECTIVE AND LEARNING:**

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

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

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

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

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

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

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

- Summarize historical evolution of the polymers.

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

**Books Recommended:**

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

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

**OBJECTIVE AND LEARNING:**

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

1. Purification of monomer
2. Polymer synthesis:
   A. Synthesis of homopolymer and their copolymers by Free radical polymerizationin aqueous solution.
   B. Polymerization of vinyl monomer in nonaqueous media.
   C. Preparation of urea-formaldehyde resin
   D. Preparation of hydrogel
   E. Preparation of Nylon 6,6
3. Polymer molecular 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:**

**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.

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

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

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

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

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

**OUTCOMES:**

- The course contains background for understanding various corrosion processes, protection methods and materials selection with practical examples. Based on physical chemical theory, the student shall be able to evaluate if corrosion can occur under specific operating conditions in a given equipment or construction. In cases where corrosion can occur, the student shall be able to determine the probable corrosion type, estimate the corrosion rate and propose the most reasonable protection method with regard to safety, price and environmental considerations.
- Students will be able to understand the physicochemical fundamentals that allow for the interpretation of transport phenomena in physical and chemical processes, phase equilibria and interface behaviour and adsorption phenomena.
- Students will be able to restate definition of system, surrounding, closed and open system, extensive and intensive properties. Student will be able to determine the reversibility or irreversibility of a thermodynamic process.
- Students will be able to Introduce about the Micelle, Critical Micelle Concentration and Micellization and its thermodynamics. Students will be able to Determination of CMC of any Surfactant.
- Students will be able to explain the concepts of Radiation Chemistry. Applications of Radioisotopes in different field is very useful for the students.

**Books Recommended:**

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

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

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

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

**OUTCOMES:**

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

## CC-9: CYPBTT5-Molecular Spectroscopy (Credit-5; Theory 04 + Tutorial 01)

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

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

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

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

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

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

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

**Book Recommended:**

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

**DSE-1: CYPBTD1-Instrumental Analytical Techniques (Credit-5 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: CYPBTD2- Bio-inorganic Chemistry (Credit-5 Theory 04 + Tutorial 01)

**OBJECTIVE AND LEARNING:** Objective of this course is

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

1. **Role of alkaline earth metal ions in biological systems:** (i) Catalysis of phosphate transfer by $Mg^{2+}$ ion, (ii) Ubiquitous regulatory role of $Ca^{2+}$ -muscle contraction.

2. **Iron, copper and molybdenum proteins with reference to their oxygenation and oxidase activity:** (i) Anti-oxidative functions: cytochrome P-450, catalases and peroxidases, (ii) Nitrate and nitrite reduction: $NO_3$ and $NO_2$ reductase, (iii) Electron transfer: cytochromes; blue copper proteins and iron-sulfur proteins and their Synthetic models, (iv) Nitrogen fixation through metal complexation, nitrogenase, (v) Photosynthesis (PS-I and PS-II).

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

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

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

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

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

**Books recommended:**

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

## DSE-1: CYPBTD3-Chemistry of Heterocycles (Credit-4 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,

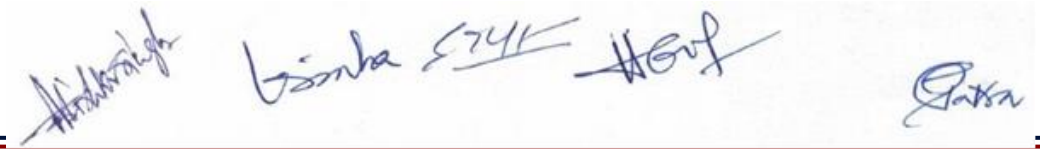
4. **Six Membered Heterocyclics with Two Hetero Atoms**: Synthesis, reactivity, aromatic character and importance of the following heterocycles: Pyridazine, Pyrimidine. Pyrazine, Oxazine, thiazine: Fused heterocycle: Benzimidazole, benzoxazole and benzthiazole.

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.



## DSE-1: CYPBTD4-Solid State Chemistry (Credit-5 Theory 04 + Tutorial 01)

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

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

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

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

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

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

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

**Books Recommended:**

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