**Minutes of BOS Meeting**
**Department of Chemistry, GGV**
**Date: 23/11/2023**

As per notification (*GGU/BOS/2023/02* Date: 07/11/2023), a off-line meeting of the Board of Studies (BoS) for the Department of Chemistry was convened on 23rd November 2023 at 12:00 Noon at the Departmental Seminar Hall to discuss the following agenda:

(a) Framing of Course structure and Syllabus of Semester -I of 4-Year UG Program as per NEP 2020 and University Ordinance-97 NEP

(b) Modification of existing LOCF syllabus of UG and CBCS Syllabus of PG

(c) Modification of Pre-Ph.D. Course work syllabus as per the expertise of the existing faculty members of the Department.

(d) Introduction of one AEC Paper in UG Course

The following members were present in the meeting:

1. Prof. Chittaranjan Sinha – External Exper
2. Prof. G.K. Patra – Chairman
3. Prof. Charu Arora – Member
4. Dr. Asish Kumar Singh- Member
5. Dr. Manorama- Member
6. Prof. Khemchand Dewangan- Invitee
7. Dr. S. K. Singh – Invitee
8. Dr. S.S. Thakur- Invitee
9. Dr. Arti Shrivastava- Invitee
10. Dr. Bhaskar Sharma- Invitee
11. Dr. S. Banerjee – Invitee
12. Dr. Bharatlal Sahu- Invitee
13. Dr. Suryabhan Singh-Invitee
14. Dr. Niraj Kumari-Invitee
15. Dr. Bijanneswar Mondal-Invitee

At the outset of the meeting draft of course structure and syllabus of B.Sc. I Sem (Chemistry) of 4-Year UG Program as per NEP 2020 prepared by the faculty members of the Department was

put forward. After thorough discussion the course structure and syllabus of B.Sc. I Sem was approved with slight modification.

Following a comprehensive discussion of the current UG and PG LOCF and CBCS syllabuses, the external expert made certain modification proposals that were subsequently incorporated into the LOCF-UG and CBCS-PG syllabuses.

After thorough discussion on the existing syllabus on existing LOCF syllabus of UG and CBCS Syllabus of PG some modifications have been suggested by the external expert and accordingly the suggestions have been incorporated in the LOCF-UG and CBCS-PG syllabus.

In this meeting the Pre-Ph.D. Course work syllabus has been modified little bit as per the expertise of the existing faculty members of the Department.

The meeting considered the suggestion made by Dr. S.S. Thakur, Associate Professor in the Department of Chemistry, to include one AEC paper titled "Ancient Indian Chemistry in Modern Perspective" in the UG course. It was decided unanimously to include the course as an AEC course in the UG syllabus using the contents that Dr. Thakur and external expert had provided.

The revised syllabus is effective from the Academic Session 2023-24.

This MoM is submitted to the competent authority for kind approval.

The meeting ended with vote of thanks from the chair.

**Signature of BoS Members and invitees**

Prof. G.K. Patra
(Chairman)

Prof. Chittaranjan Sinha
(External Expert)

Prof. Charu Arora
(Member)

Dr. Asish. K. Singh
(Member)

Dr. S.K. Singh

Dr. Manorama
(Member)

Prof. K. Dewangan

Dr. S.S. Thakur

Dr. A. Shrivastava

Dr. Bhaskar Sharma

Dr. S. Banerjee

Dr. Bharatlal Sahu

Dr. Suryabhan Singh

Dr. Niraj Kumari

Dr. Bijanneswar Mondal

# DEPARTMENT OF CHEMISTRY
## B. Sc. (Chemistry) Course structure under NEP-2020
## Academic year 2023 – 2024

| Sem. | Courses | Course Code | Number of courses | Level | Credits | Credits (L+T+P) | Int. Marks | Ext. Marks | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Major-1 | CYUAMJT1 | Basic Concepts of Chemistry-I (Theory) | 2 | 3 | (3+0+0) | 30 | 70 | 100 |
| | | CYUAMJL1 | Basic Concepts of Chemistry-I (Lab) | | 1 | (0+0+1) | 30 | 70 | 100 |
| | Minor-1 | | Opted from the Pool Course offered by University | 2 | 4 | | 30 | 70 | 100 |
| | Multidisciplinary | | Opted from the Pool Course offered by the University | 1 | 3 | | 30 | 70 | 100 |
| | AEC | | Opted from the Pool Course offered by University | 1 | 2 | | 30 | 70 | 100 |
| | SEC | | Opted from the Pool Course offered by University | 1 | 3 | | 30 | 70 | 100 |
| | VAC-1 | | Opted from the Pool Course offered by University | 1 | 2 | | 30 | 70 | 100 |
| | VAC-2 | | Opted from the Pool Course offered by University | 1 | 2 | | 30 | 70 | 100 |
| | | | **Total** | | **20** | | | | **800** |

## Courses Offered by the Department of Chemistry/School of Physical Science

| Sem. | Courses | Course Code | Number of courses | Level | Credits | Credits (L+T+P) | Int. Marks | Ext. Marks | Total |
|---|---|---|---|---|---|---|---|---|---|
| I | Minor-I Offered by the Department | CYUAMNT1 | Fundamental Chemistry-I (Theory) | 2 | 4 | (3) | 30 | 70 | 100 |
| | | CYUAMNL1 | Fundamental Chemistry-I(Lab) | | | (1) | | | |
| | Multidisciplinary Offered by the School of Physical Sciences and Natural Sciences | | Conceptual Understanding of Physical Science – I | 1 | 3 | (2+1+0) | 30 | 70 | 100 |
| | SEC Offered by the Department | CYUASET1 | Science Communication and Popularization | 1 | 3 | (2+1+0) | 30 | 70 | 100 |

## BSc-I Inorganic Chemistry (Theory)

## Basic Concepts of Chemistry-I

### Section 1: Inorganic Chemistry

**Unit I: Atomic Structure** **6 Lectures**

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de' Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of $\psi$ and $\psi^2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams. Variation of orbital energy with atomic number.

**Unit II: Chemical Bonding** **7 Lectures**

(i) Ionic bond: General characteristics, radius ratio rule and its limitations. Born-Landé equation with derivation, expression for lattice energy. Born-Haber cycle and its application.

(ii) Covalent bond: Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Bents rule, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules e.g., $N_2$, $O_2$, $C_2$, $B_2$, $F_2$, CO, NO, and their ions; HCl, $BeF_2$, $CO_2$. Covalent character in ionic compounds, polarizing power and polarizability. Fajan rules, polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Ionic character from dipole moment and electronegativities.

(iii) Metallic Bond: Qualitative idea of free electron model, Semiconductors, Insulators.

### Section 2: Organic Chemistry

**UNIT I: Basics of Organic Chemistry** **7 Lectures**

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties. Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Aromaticity: Huckel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples.

**UNIT II: Reactive Organic Species and Reaction Intermediates** **7 Lectures**

Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; types, shape and relative stabilities of reaction intermediates (Carbocations, Carbanions, Free radicals and Carbenes). Organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

**Section 3: Physical Chemistry**

**UNIT I: Gaseous state** **8 Lectures**

**Behavior of real gases**: Deviations from ideal gas behavior, compressibility factor, and its variation with pressure for different gases. Causes of deviation from ideal behavior. van der Waals equation of state, its derivation and application in explaining real gas behaviour; van der Waals equation expressed in virial form, Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, critical and van der Waals constants, law of corresponding states. Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of $\sigma$ from $\eta$; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

**UNIT IV: Colloidal State** **5 Lectures**

Colloids Meaning and Definition, Preparation of Colloid Solutions, Classification of Colloids Purification of Colloids, Examples of Colloids, Application of Colloids

**Recommended Text books/references:**


1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill,(2007)
3. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.
4. P Sykes, *A Guide Book to Mechanism in Organic Chemistry*, 6th Edition (1997), Orient Longman, New Delhi.

5. Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 8th Ed., Oxford University Press (2006).
6. BR Puri, LR Sharma, MS Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2018

## BSc-I Chemistry (Major Lab)

## Basic Concepts of Chemistry I Laboratory

**Inorganic Chemistry**

**(A) Acid-Base Titrations**

(i) Titration of very weak acid-boric acid

(ii) Estimation of carbonate and hydroxide present together in mixture.y

(iii) Estimation of carbonate and bicarbonate present together in a mixture.

**(B) Redox Titrations**

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.

(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.

**Physical Chemistry**

1. **Surface tension measurements.**
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
   b. Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurements using Ostwald's viscometer.**
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   b. Viscosity of sucrose solution with the concentration of solute.
3. **pH metry**
   a. Effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   b. Preparation of buffer solutions of different pH
      i. Sodium acetate-acetic acid
      ii. Ammonium chloride-ammonium hydroxide
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   d. Determination of dissociation constant of a weak acid.

**Recommended text books/references:**

1. Khosla, B. D., Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co., New Delhi (2011).
2. Garland, C. W., Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry*, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry*, 3rd Ed., W. H. Freeman & Co., New York (2003).
4. Athawale, V. D. and Mathur, P. *Experimental Physical Chemistry*, New Age International (2001).

*Chemistry Minor*
*Fundamental Chemistry-1*

***Section – A: Inorganic Chemistry – 1***

**Unit – 1: Atomic Structure**

Review of: Bohr's theory and its limitations, dual behaviour of matterand radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of $\psi$ and $\psi^2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenicwavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers $m_l$ and $m_s$. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number ($m_s$).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

**(9 Hours)**

**Unit – 2: Chemical Bonding**

*Ionic Bonding:* General characteristics of ionic bonding. Energy considerations in ionicbonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

*Covalent bonding:* VB Approach: Shapes of some inorganic molecules and ions on the basisof VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonalbipyramidal and octahedral arrangements, such as $BeCl_2$, $BF_3$, $SiF_4$, $PCl_5$, $SF_6$, $NH_3$, $H_2O$, $OF_2$, $ClF_3$, $SF_4$, $XeF_4$, $XeF_6$, $H_3O^+$, $I_3^-$, $I_3^+$, $ICl_2^-$, $XeF_5^+$. Concept of resonance and resonating structures in various inorganic and organic compounds.

**(7 Hours)**

**Unit – 3: Molecular Orbital Theory**

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and $NO^+$. Comparison of VB and MO approaches.

**(7 Hours)**

***Section – B: Organic Chemistry – 1***

**Unit – 1: Fundamentals of Organic Chemistry**

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect,

Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.
Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

**(6 Hours)**

**Unit – 2: Stereochemistry**
Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis - trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

**(7 Hours)**

**Unit – 3: Aliphatic Hydrocarbons**
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

**Alkanes:** (Upto 5 Carbons).*Preparation:*Catalytic hydrogenation, Wurtz reaction, Kolbe'ssynthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

**Alkenes:** (Upto 5 Carbons)*Preparation:*Elimination reactions: Dehydration of alkenes anddehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:*cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

**Alkynes**: (Upto 5 Carbons)*Preparation:*Acetylene from $CaC_2$and conversion into higheralkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

*Reactions:* formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis and oxidation with hot alk. $KMnO_4$.

**(9 Hours)**

**Reference Books:**


- J. D. Lee: *A new Concise Inorganic Chemistry*, E L. B. S.
- F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- Douglas, McDaniel and Alexader: *Concepts and Models in Inorganic Chemistry*, John Wiley.
- James E. Huheey, *Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principlesof Structure and Reactivity*, Pearson Publication.
- T. W. Graham Solomon: *Organic Chemistry, John Wiley and Sons.*
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient

Longman.

- E. L. Eliel: *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
- I. L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- ArunBahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand

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**PRACTICAL – Fundamental Chemistry-1 (Lab)** **(30 Hours)**

***Section – A: Inorganic Chemistry - Volumetric Analysis***

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

***Section – B: Organic Chemistry***

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

(a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

(b) Identify and separate the sugars present in the given mixture by paper chromatography.

**Reference Books:**

- Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
- Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.
- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
- Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
- A. K. Nad, B. Mahapatra and A. Ghosal, An Advanced Course in Practical Chemistry, New Central Book Agency Priv. Ltd, 2011

**Multidisciplinary Course**

**On**

**Conceptual Understanding of Physical Science - 1**

**Chemistry in daily life:**

Organic molecules in daily life: Chemistry of carbohydrates, amino acids, lipids, fats, soaps, detergents: General structure, source, applications, detection and analysis.

**6 lectures**

General introduction to pesticides (natural and synthetic), benefits and adverse effects, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT); Quinones (Chloranil). **6 lectures**

Chemical constitution and physiological functions of vitamins A, vitamin C (Ascorbic acid).

**3 lectures**

**Measurement:** Physical quantities and dimensions of physical quantities, dimensional analysis and its applications. **1 Lecture**

**Kinematics:** Motion in a straight line: Position-time graph, speed and velocity. Uniform and non-uniform motion, average speed and instantaneous velocity.Uniformly accelerated motion, velocity time and position-time graphs, and relations for uniformly accelerated motion (graphical treatment), Scalar and Vector products of Vectors. **3 Lectures**

**Laws of Motion:**Intuitive concept of force. Inertia, Newton's first law of motion; momentum and Newton's second law of motion; impulse; Newton's third law of motion.Law of conservation of linear momentum and its applications.

**3 Lectures**

**Work, Energy and Power:** Work done by a constant force and a variable force; kinetic energy, work-energy theorem, power. Notion of potential energy, potential energy of a spring, conservative forces; conservation of mechanical energy (kinetic and potential energies); non-conservative forces. **4 Lectures**

**Gravitation:** Kepler's laws of planetary motion. The universal law of gravitation.Acceleration due to gravity and itsvariation with altitude and depth.Gravitational potential energy; gravitational potential. Escape velocity.

**5 Lectures**

**Reference:**


1. *"Organic Chemistry"*, **I. L. Finar,** Vol. I & II, 5th Edition (1975), Reprinted in1996, ELBS and Longman Ltd., New Delhi.
2. "Biochemistry" **L. Stryer**, 5th edition (2002) Freeman & Co New York.
3. "Principles of Biochemistry" **D. L. Nelson M.M. Cox, Lehninger,** 3rd edition (2002) McMillan North Publication.
4. R. Cremlyn: *Pesticides*, John Wiley
5. Mechanics, J.C. Upadhyaya, 2017, Ram Prasad Publications, Agra.
6. Classical Mechanics, 2014 J.C. Upadhyaya, Himalaya Publishing House.
7. NCERT, Physics Part-1

## Paper Name: Ancient Indian Chemistry in Modern Perspective

**Credit 02**

**AEC**

**Unit- I**

Keywords/Tags: Metallurgy, Dyes, Cosmetics, Charak Sanhita

(a) Chemical Techniques in ancient India: general Introduction

(b) Contribution of ancient Indian Scientists in chemistry and Ethnomedicine e.g., metallurgy, dyes, pigments,

cosmetics, Ayurveda, Charak Sanhita.

**Unit II**

Knowledge Tradition of lndian 'Chemistry

Ancient Indian chemists and their works: Nagarjuna, Vagbhata, Govindacharyn, Yashodhara,

Ramchandra, Somadeva, etc.

**Unit III**

Introductory idea about rasas

Main rasa:Maharas,Uparas,Commonras;Ratna,dhatu,poison,alkali,acid,salt,lauhabhasma..

Maharasas:Abram,Vaikrant,Bhasik Vimala.Shilaiatu.Sasak,Chapala.

Uprasas: Gandhak, Garik, Kashis, Suvari, Lalak,Manah,Shila, Anjana, Kankushtha

Common rasas:Koyala, Gouripashan, Navasara, Vartaka, Agnijar,Lajavarta, Giri Sindur, Hingur, Murdad, Shrangakam

**Unit IV**

Life history and scientific contribution of Aacharya Prafulla Chandra Ray, Shanti Swaroop Bhatnagar, Asima Chatterjee, Prof. Nilratan Dhar, Prof. Baba Kartar Singh, Prof. J. C. Ghosh, J. N. Mukherjee.

References:

1. Scientific Knowledge in Sanskrit Literature – NirmalTrikha

2. Indian Astronomy: An Introduction – S. Balachandra Rao

3. Ancient Indian Sciences – B. Seal

4. Science in Ancient India (Science of the Past) – Melissa Stewert

5. A History of Hindu Chemistry: from the Earliest Times to the Middle of the Sixteenth Century

A.D. Hardcover – 1 December 2010 by P. C. Ray (Author)

6. Concise History of Science in India,S N Sen B V Subbarayappa (Eds.) D M Bose (Chf.Ed), S.N. Sen (Editor), B.V. Subbarayappa (Editor)

भारतीय रसायन की ज्ञान परंपरा

प्राचीन भारत के रसायनज्ञ एवं उनकी कृतियां: नागार्जुन, वाग्भट्ट, गोविंदाचार्य, यशोधर, रामचन्द्र, सोमदेव, आदि।

रस के विषय में परिचयात्मक ज्ञान

मुख्य रस: महारस, उपरस, सामान्यरस, रत्न, धातु, विष, क्षार, अम्ल, लवण, लौहभस्म।

महारस: अभ्रं, वैक्रान्त, भाषिक, विमला, शिलाजतु, सास्यक, चपला, रसक।

उपरस: गंधक, गैरिक, काशिस, सुवरि, लालक, मन:, शिला, अंजन, कंकुष्ठ।

सामान्य रस: कोयिला, गौरीपाषाण, नवसार, वराटक, अग्निजार, लाजवर्त, गिरि, सिंदूर, हिंगुल, मुर्दाड श्रंगकम्।

| Semester | Course | Name of the course | Credits |
|---|---|---|---|
| V,VI | DSE11 | **Bioinorganic Chemistry** | Theory: 3 |
| | | | Practical: 2 |

**Learning Objectives:**

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

- Chemistry of coordination compounds.
- Characteristics of organometallic compounds.
- Structures and characterizations of organometallic compounds.
- Applications of organometallic compounds.
- Role of metals in biological systems.

**Unit 1:Chemistry of 3d metals**

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$,$Na_3[Co(NO_2)_6]$.

**Unit 2: Organometallic Compounds**

Definition and classification of organometallic compounds on the basis of bond type.Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT.pi-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding.

**Zeise's salt:** Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.

**Metal Alkyls:** Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium.

**Ferrocene:** Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity.Comparison of aromaticity and reactivity with that of benzene.

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals.p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

**Unit 3: A brief introduction to bio-inorganic chemistry**

A brief introduction to bio-inorganic chemistry. Metals in medicine; Role of Cobalt ion, Role of lithium, Role of $Mg^{2+}$ ions in energy production and chlorophyll. Role of $Ca^{2+}$ in blood clotting. Primary, secondary and tertiary structure of protein and

stabilization of protein structures and structural role (bones).

**Recommended books/reference books**


1. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
2. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH,1999
3. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley & Sons, NY, 1967.
4. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann,1997


**List of Laboratory experiments**

1. Rection of metal with halide – preparation of Grignard reagent.
2. Grignard preparation of dye (malachite green (using methylbenoate)/crystal violet (using diethylcarbonate) (starting material as p-bromo N, N-dimethyl aniline)
3. Preparation of various Schiff base-metal complexes and their identification using spectroscopy.
4. Preparation of any two of the following complexes and measurement of their conductivity measurement:
   a. tetraamminecarbonatocobalt (III)nitrate
   b. tetraamminecopper (II)sulphate
   c. potassium trioxalatoferrate (III)trihydrate

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

**Recommended books/reference books**


1. Synthesis of organometallic compounds: A practical guide, S. Komiya,Wiley.
2. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7thEdn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*,Prentice-Hall.

## SYLLABUS OF Ev.C. for M.Sc-IV Sem: DSC-6: CYPDTD9

I. Introduction: Concepts and scope of Environmental Chemistry. Environmental terminologies and nomenclatures, Environmental Segments, Solar Energy, The natural cycles of environment ( Hydrological, Oxygen, Nitrogen, Phosphorus and Sulphur cycles) and their importance.

II. Atmospheric Pollution: Classification of air pollutants and their monitoring( VOS, Ions, radicals , various spm), Chemistry of Ozone layer, Role of chemistry in Ozone layer destruction, Temperature Inversion and its effects, Chemistry of Smogs and its harmful effects, The Green House Effects and Global worming. El Nino phenomenon, Plumes and its effects. Radiation effects (gamma rays and X-rays). Ways to minimise/protect/rejuvenate this segment.

III. Hydrosphere Pollution: Classification of water pollutants and their monitoring, Unique characteristic of water, water - the living and the non-living environment, Pollution indicators (DO,BOD,CODand colours etc), Waste water: Constituents- Microorganisms, Solids, Inorganic and Organic matters, pH value, suspended solids and TDS. Ways to minimise/protect/rejuvenate this segment.

IV. Lithosphere Pollution: Classification of Land Pollution and their monitoring ( solid & liquid pollutants) Chemistry of Soil formation, Role of Insecticides and fertilizers in soil pollution, Classification of solid wastes, $R^3$, pH effects. Ways to minimise/protect/rejuvenate this segment.

V. Basic Principles of Sustainable Chemistry: What is Green Chemistry, What are its postulates, how does it help avoiding pollution in the different segments of the Environment, absorption Vs adsorption, Eco-friendly protocols for speciation of heavy metals from water, Biodegradable polymeric composite sorbents

Outcome:

1. The students will be well versed with the concepts and scope of the subject along with some natural cycles of the environment. Environmental segments and their importance.
2. The students will have learnt about the Atmospheric Segment their Pollution and Pollutants. Acid Rain, Global Worming, Plumes & Smog etc. Ways to minimise/protect/rejuvenate this segment.
3. The students will have learnt about the Segment Hydrosphere & its importance. They will be well versed with the various phenomenon occurring in this segment including the pollutants. Point source and Diffused sources of pollution. Ways to minimise/protect/rejuvenate this segment.
4. The students will have learnt about the Segment Hydrosphere & its importance. They will be knowing about the Soil and its formation. They will know about the classification of soil pollutants, solid soil pollutants, three Rs and the structure of soil. Ways to minimise/protect/rejuvenate this segment.
5. The students will have learnt about the Sustainable Chemistry along with the different ways to meet the sustainability. The students will also know about the Protocols for heavy metals speciation from hydrosphere.

CBCS-PG

# SEM I

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

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

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

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, regression analysis (least square method for linear and non-linear plots).

3. **Quality control in Analytical chemistry:** Elements of quality assurance, quality assurance in design, development, production and services, quality and quantity management system, ISO 9000 and ISO 14000 series-meaning of quality, quality process model, customer requirement of quality calibration and testing, statistical process control, process control tools, control chart, statistical quality control, acceptance sampling, quality control-principles of Ruggedness test.

4. **Treatment of Equilibria:** Solvents and solutions, levelling 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, Calculation of pH, Constructing titration curves from charge balance and mass balance equations, Acid-base titrations and theory of redox and pH indicators, Complexation equilibria and complexometric titrations, Redox equilibria and redox titration, precipitation titrations.

**OUTCOMES:** *Students will learn :*

1. *be able to select the appropriate analytical methods to evaluate a sample, critically evaluate data from a variety of analytical chemistry techniques.*
2. *how to do statistical analysis in analytical chemistry for different data analysis,*
3. *Knowledge regarding quality assurance*
4. *solving problems related to pH and theory of redox indicators*

**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. Technical methods of analysis – Griffin, McGraw Hill Book Co
5. Quality Assurance and Good Laboratory Practices, Prof. Y. Anjaneyulu, In Now Publication, New York

6. Quality Assurance in Analytical Chemistry – G.Kateman and F.W Pijpers, John Wiley and Sons, New York
7. K.V.S.G Murali Krishna, An Introduction ISO 9000, ISO 1400 Series, Environmental Management

## 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 total hardness by EDTA titrations method using Eriochrome Black T
5. Determination of chloride by Argentometric method
6. Determination of the concentration of calcium in milk powder by complexometric titration (EDTA)
7. Spectrophotometric determination of iron using thiocyanate method
8. Spectrophotometric determination of iron using phenanthroline method
9. 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 accurately present and interpret data
- statistical methods of data analysis including error distributions, hypothesis testing, confidence intervals, and the method of maximum likelihood or least-squares analysis.

# SEM II

## CC-6: CYPBTT1-Analytical Chemistry – II (Credit-3)

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

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

2. **Spectroscopic Techniques:** Theory, Instrumentation and applications of 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 completed this module, student will be able to:

- understand theoretical approach towards different types of chromatographic separations.
- understand the underlying theoretical basis of spectroscopic methods including absorption, emission and Fluorescence phenomenon
- understand the underlying theoretical basis of spectrophotometricstudies including UV-visible, Fluorescence, and calculation of stochiometric ratio for complexes.
- Understand instrumantaion, principle and applications of different thermal analysis ;
- be aware of current developments in the field of analytical chemistry such as automation

**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.

## DSE-1: CYPBTD1- Instrumental Analytical Techniques (Credit-3)

**OBJECTIVE AND LEARNING:** This module will provide theory, instrumentation, and applications of different analytical instrumental techniques of Fourier Transform Infra-Red (FTIR), Raman, 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) in sample analysis

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

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

4. **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) and applications in sample analysis

5. **Mass Spectroscopy:** Theory, Instrumentation, and applications

**OUTCOMES:** Student will get the knowledge of

- principles and instrumentation of different analytical techniques
- how to do the analysis using FTIR, Raman, ESR, SEM, TEM, Mass spectroscopy.
- How to select a particular instrumentation for sample analysis
- How special nanlytes/materials should be analysed with above mentioned knowledge.

**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: CYPBLD1- Analytical Chemistry Practical-II (Credit-2)

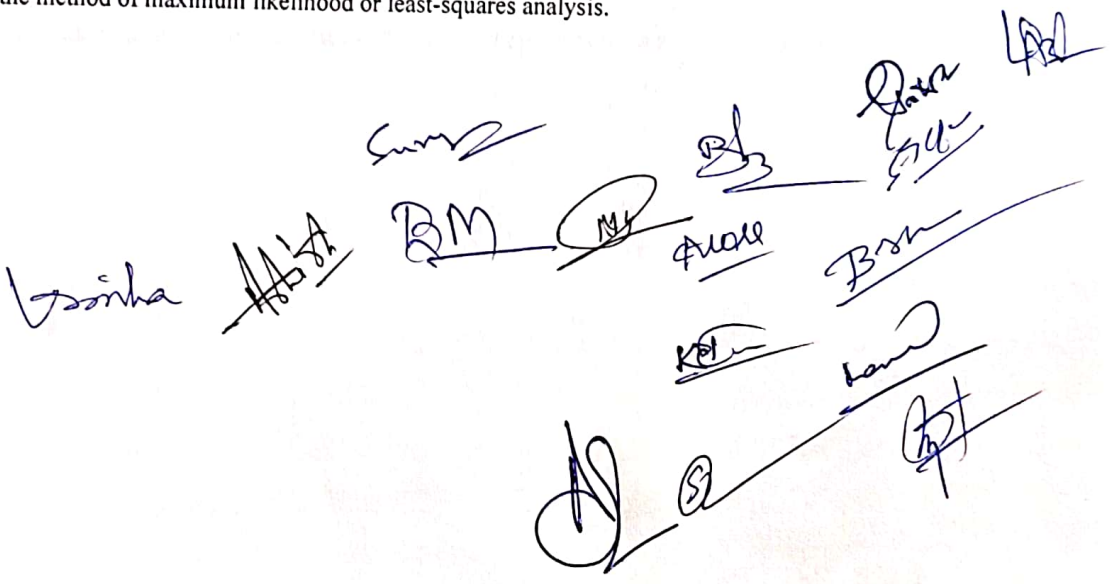
**OBJECTIVE AND LEARNING:** Understanding of term standard solution, titration, back titration, equivalence point, end point, primary and secondary standard, solving volumetric calculations based on performing different types of experiments.

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. Paper chromatography: Separation of organic dyes from given mixture and calculation of $R_f$ value
5. Thin layer chromatography: Separation of amino acids from given mixture and calculation of $R_f$ value
6. Potentiometric titration: Determination of concentration of halide ion(s) in given solution
7. Spectrophotometric: Determination of phosphate in fertilizer and cola drinks by Molybdenum blue method
8. Sectrophotometric/colorimeteric: Determination of the composition of the metal complexes by Jobs continuous variation method
9. Spectrophotometric/colorimetric: Determination of composition of the metal complexes by mole ratio 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.



# SEM III

## 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.
7. Determination of dissolved oxygen (DO) of drinking water and sewage water
8. Determination of dissolved oxygen (DO), Chemical oxygen demand (COD) and Biological oxygen demand (BOD) of drinking water, pond water and sewage water
9. Analysis of Soil: Sampling, Total N and P.

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

**OUTCOMES:** The module will provide

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

# SEM IV

## DSE-5: CYPDTD5- Electroanalytical Methods (Credit-3)

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

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

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

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

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

5. **Electroactive layers and modified electrodes:** chemically modified electrodes, Types, preparation and properties of films and modified electrodes: monolayers, polymers, inorganic films, biologically related materials, composites and multilayers assemblies, role of cyclic voltammetry in sensing, oxygen evolution reaction (OER) and hydrogen evolution reaction (HER).

**OUTCOMES:** Students will learn

1. principles, instrumentation and applications of Polarography
2. Detail study of different modern electroanalytical techniques,
3. preparation methods of modified electrodes&study of different electrochemical sensors.
4. How to do the analysis using these analytical techniques.

## Books Recommended:


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


## Additional References:


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


## 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, Tempkin 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.

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. **Irreversible thermodynamics:** Phenomenological laws, Onsager's reciprocal relations, conservation of masss and energy, entropy production due to heat flow, entropy production in chemical reactions, transformation properties of Fluxes and forces, Verification of Onsager relations, Applications of Irreversible thermodynamic to the biological System.

3. **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

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 Chemistry: Elements of radiation chemistry, units for measuring radiation absorbed, Radiation detection & measurements--Proportional, Geiger-Muller and Scintillation counters, Applications of radioisotopes as tracers: activation analysis, isotope dilution technique, age determination, medical applications: Therapeutic applications, Use of radiochemistry (labelling) in the investigation of mechanism of reaction.

**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.

PRE Ph. D. Course Work

**Paper II** **Credit 6**

**CH-R1 Modern Techniques in Chemical Sciences**

1. Basic theory, instrumentation and analytical applications: Spectroscopic techniques [NMR, ESR, MS (EI, FAB, MALDI-TOF), IR, UV-Vis, Fluorescence and Phosphorescence, Atomic Absorption, Biosensors.

2. **Techniques for Materials Characterization**

   Basic theory and analytical applications of the following physical methods: X-ray diffraction methods (single crystal and powder method), Thermoanalytical methods (TGA, DSC, DTA), Microscopic methods (SEM, TEM, AFM), Surface Properties (BET), Cyclic Voltammetry.

3. **Separation Techniques:**
   Introduction, classification of chromatographic methods, terms and relationships in chromatography, sample characterization High performance liquid chromatography (HPLC), Gas chromatography (GC) and ion exchange chromatography, GPC.

   Principle, Instrumentation and Application of :
   Reverse Osmosis (RO), Nanofiltration (NF), Ultra Filtration (UF) and Micro Filtration (MF), gel electrophoresis, chiral separations.

4. **Computational Chemistry:** Theoretical Chemistry a quantum approach, MO theory, Ab initio calculation, Geometry optimization, basis set, electronic structure calculations.

**Books Recommended**


1. F.W Fifield & D.Keal, Principles and Practice of Analytical chemistry Blackwell Publishing Company, (2004)
2. Pradyot Patnaik, (2004), Dean's Analytical chemistry, Hand Book Second edition McGraw- Hill Hand Books
3. J. D Seader /Ernest J. Henley, Separation Processes Principles; John Wiley & Sons Inc. N.Y. (1998)
4. Skoog, Holler, Nieman, H.B Principles of Instrumental Analysis Fifth edition College publishers.
5. G.H. and H. Freiser, Solvent Extraction in Analytical Chemistry, 1st edition (1958), John Wiley, New York.
6. B. L. Karger, L.R. Snyder and C. Howarth, An Introduction to Separation Science, 2nd Edition (1973) John Wiley, New York.
7. E.W. Berg, Chemical Methods of Separation, 1st edition (1963), McGrw

Paper III

**CH-R2: Thrust Area in Chemical Sciences** Credit 6

1. **Emerging Green Chemistry**: Green chemistry, introduction, 12 principles, Solvent-free synthesis; Environmentally benign solvents: Water and Ionic liquids as green solvents and catalysts in organic synthesis. Microwave in chemical synthesis: Basic principles, advantages and examples. Sonochemistry and green aspects;

2. **Nano-Chemistry**: Introduction, Nucleation and growth, heterogeneous nucleation, Size effect, Synthesis and assembly, techniques, General methods of preparation and synthesis. Types of nano materials, their Properties and applications. Carbon nanotube, micro- and mesoporous materials.

3. **Formation of Carbon-Carbon bonds *via* organometallic reagents:** (i) Palladium-Catalyzed Coupling Reactions, (ii) Organoboron Reagents, (iii) Organozinc Reagents, (iv) Organocopper Reagents.

4. **Multicomponent reactions (MCRs):** Definition, Advantages and examples particularly, Ugi reaction, Biginelli reactions, Strecker amio acid synthesis, Passerini synthesis, Mannich reaction,

5. **The chemistry of molecular recognition:** Host and Guest Chemistry. Supramolecular interactions and their characterization, Supramolecular catalysis and transport processes, Cyclodextrin- a naturally occurring cyclic host, calixarene- a versatile host; Chemosensor, Electrochemical sensors, Origin and source of chirality, chiral ligands, chiral drugs, asymmetric epoxidation

6. **Polymers**: Mechanism and kinetics of radical, condensation and living radical polymerizations. Spectroscopic characterization and testing of polymers. Measurement of molecular weights: viscosity, light scattering, osmotic and size exclusion chromatographic method. Properties and applications of commercial polymers: polyamides, polyesters, phenolic resins, epoxy resins and silicones. Fire retarding polymers, conducting polymers, and biocompatible polymers.

**Books Recommended**


1. Mike Lancaster, Green Chemistry: An Introductory Text, Royal Society of Chemistry, 2002.
2. Nina Hall( Editor-in-chief), The new Chemistry, Cambridge university Press, 2000.
3. CNR Rao, Muller and Cheetham, The Chemistry of Nano Materials, Vol.I & II, Wiley-VCH (2005)