DEPARTMENT OF CHEMISTRY
UNIVERSITY OF LUCKNOW
Four Year Undergraduate Course Structure:
Subject: Chemistry Semester VII NEP (Revised)
For Students admitted in 2023-24 onwards

Semester VII						
Paper	**Paper Title**	**Type**	**Credits**	**Internal Assessment**	**Univ Exam**	**Total Marks**
Paper 15	Inorganic, Organic and Physical Chemistry	Theory	4	25	75	100
Paper 16	Bioinorganic, Bioorganic and Biophysical Chemistry	Theory	4	25	75	100
Paper 17	Chemistry Practical 7	Practical	4	-	100	100
Paper 18 x	Supramolecular Chemistry	Chemistry Elective 5	4	25	75	100
Paper 18 y	Chemistry of Analgesics and Antipyretics	Chemistry Elective 6				
Paper 19 x	Science & Tech of cosmetics	Chemistry Elective 7	4	25	75	100
Paper 19 y	Electrochemistry	Chemistry Elective 8				
RM	Research Methodology	Theory	4	25	75	**100**
	Total Credits		24			600

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Inorganic, Organic and Physical Chemistry

Semester VII **Paper 15** **Credits 4**

Course Outcome:

- CO 1. Cover wide area of studies of interdisciplinary area of the three branches of chemistry
- CO 2. Have ideas of catalysis, kinetics and free energy relationship.
- CO 3. Study stereochemical aspects of molecules and understand the spatial arrangements and its importance.

Unit 1

- **Homogeneous Catalysis.:**
  - Basic concepts, Turn Over Number (TON), Turn Over Frequency (TOF). Hydrogenation of alkenes using Wilkinson's catalyst Hydroformylation of alkenes using Co and Rh catalysts
- **Free energy relationship:**
  - Thermodynamics and kinetic requirements, kinetic thermodynamic control, Hammonds postulate, Curtin-hammett principle. The Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation.
- **Theory of reaction rate:**
  - Collision, activated complex and unimolecular reaction i.e. Lindeman and preliminary ideas.
  - The ideas of reaction kinetics in solution with special reference to kinetic salt effects. The fast reaction kinetics, Relaxation methods, flow and flash photolysis. Kinetics of enzyme reaction

Unit 2

- **Boranes:**
  - Higher boranes, carboranes, metalloboranes and metallocarboranes. Wade Rule. Metal carbonyls and halide clusters. Compounds with metal-metal multiple bonds

Unit 3

- **Stereochemistry:**
  - Optical activity in absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape. Stereochemistry of compound containing nitrogen, sulphur and phosphorous

- **Pericyclic**
  - Pericyclic Reactions Molecular orbital Symmetry, Frontier orbital of ethylene, 1,3-butadiene, 1,3,5- hexatriene and allyl system. Classification of pericyclic reactions. Woodward Halfmann correlation diagram, FMO and PMO approach, electrocyclic reaction – conrotatory and disrotatory motion, 4n, 4n+2 and allyl systems. Cycloaddition – antarafacial and suprafacial addition, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 dipolar cycloaddition and chelotropic reactions. Sigmatropic rearrangement – Suprafacial and antarafacial shift of H, sigmatropic shift involving corban moieties, 3,3 and 5,5- sigmatropic rearrangement. Claisen, cope and aza-cope rearrangements. Fluxional tautomerism. Ene reaction

Unit 4

- **Quantum Mechanics:**
  - The variation theorem, linear variation principle. Perturbation theory (first order and non- degenerate). Simple application of variation method in perturbation theory. Huckel theory of conjugated system, bond order and charge density calculation. Application to ethylene, butadiene etc. Ordinary angular momentum, eigen functions for eigen values of angular momentum.
- **Non-Equilibrium Thermodynamics:**
  - Thermodynamic criteria for non – equilibrium state, entropy production and entropy flow, entropy balance equation for different irreversible processes (e.g. heat flow, chemical reaction etc.) transformation of generalized fluxes and forces, nonequilibrium stationary states, phenomenological equation, microscopic reversibility and Onsager's reciprocity relation, electrokinetic phenomena, diffusion, electric conduction.

Recommended Books:

1. Organometallic Chemistry: A Unified Approach, R. C. Mehrotra and A. Singh, New Age International Publisher.
2. Basic Organometallic Chemistry, Concepts, Syntheses and Applications, B. D. Gupta and Anil J. Elias, University Press.
3. Inorganic Chemistry: Principles of Structure and Reactivity, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, Pearson Education
4. Organic Chemistry, Vol. I, I.L. Finar, Pearson Education.
5. Organic Chemistry, M.K. Jain, Shoban Lal& Co.
6. Pradeep's Organic Chemistry, S.N. Dhawan, Pradeep Publication.
7. Organic Chemistry, Morrison and Boyd, Prentice Hall.
8. Organic Chemistry, L.G. Wade Jr. Prentice Hall.
9. Fundamentals of Organic Chemistry, Solomons, John Wiley.

10. Organic Chemistry, Vol. I, II, III S.M. Mukherji, S.P. Singh and R.P. Kapoor, Wiley Eastern Ltd. (New Age International)
11. Organic Chemistry, F.A. Carey, Tata McGraw-Hill publishing company
12. Introduction to Organic Chemistry, Streitwiesser, Hathcock and Kosover, Macmillan.
13. Physical Chemistry, Puri Sharma & Pathania, Vishal Publishing Co
14. Pradeep's Physical Chemistry Vol II, S.C. Khetrapal, Pradeep Publication.
15. Computers and Common Sense, R. Hunt and Shelly, Prentice Hall.
16. Physical Chemistry. G.M. Barrow. International Student Edition, McGrawHill
17. Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
18. The Elements of Physical Chemistry, P.W. Atkins, Oxford.
19. Physical Chemistry Through problems, S.K. Dogra and S. Dogra, Wiley Eastern Ltd, India
20. Basic Programming with Application, V.K. Jain, Tata McGraw Hill, India
21. Textbook of Physical Chemistry, Samuel Glasstone, Ed 2, Macmillian 1942

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Bioinorganic, Bioorganic and Biophysical Chemistry

Semester VII **Paper 16** **Credits 4**

Course Outcome:

- CO 1. Have ideas of metalloenzymes, bioenergetics, transport and storage of dioxygen, electron transfer, metal storage and metals in medicine.
- CO 2. Cover wide area of studies of interdisciplinary area of biology and chemistry.
- CO 3. It includes both natural phenomena such as behaviour of the metalloproteins as well as artificially introduced metals.

Unit 1

- **Metal Storage Transport and Biomineralization**
  - Ferritin, Transferring and Siderophores
- **Electron transfer in biology:**
  - Structure and functions of electron transfer proteins, Cytochromes and respiratory chain, iron sulphur proteins rubredoxin and ferridoxins.
- **Photosynthetic pigments:**
  - Photosynthesis, Chlorophyll molecule, Photosystem-I and Photosystem-II.
- **Metal Nucleic Acid Interactions:**
  - Metal ions and metal complex interactions. Metal complexes-nucleic acid.

Unit 2

- **Transport and Storage of Dioxygen:**
  - Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper.

Unit 3

- **Enzyme and Mechanism of Enzyme Action:**
  - Introduction of enzymes, enzyme action, Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.
- **Co-Enzyme Chemistry:**
  - Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD+, NADP+, FMN, FAD, lipoic acid, vitamin B12. Mechanisms of reactions catalyzed by the above cofactors

- **Bioenergetics:**
  - Standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP, muscular contraction and energy generation in mechanochemical system.
- **Cell Membrane and Transport of Ions:**
  - Structure and functions of cell membrane, ion transport through cell membrane, irreversible thermodynamic treatment of membrane transport. Nerve conduction.
  - it includes the study of both natural phenomena such as the behaviour of metalloproteins as well as artificially introduced metals.
- **Transport of Ions:**
  - Ion transport through cell membrane, irreversible thermodynamic treatment of membrane transport.
- **Biosensors:**
  - Definition, types, sensors for environmental, medical, food safety and biosecurity applications.

Recommended Books:

1. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
2. Understanding Enzymes, Trevor Palmer, Prentice Hall.
3. Enzyme Chemistry: Impact and Applications, Ed. Collin J Suckling, Chapman and Hall.
4. Enzyme Mechanisms Ed, M. I. Page and A. Williams, Royal Society of Chemistry.
5. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
6. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
7. Enzymatic Reaction Mechanisms, C. Walsh, W. H. Freeman.
8. Enzyme Structure and Mechanism, A Fersht, W.H. Freeman.
9. Biochemistry: The Chemical Reactions of Living Cells, D. E. Metzler, Academic Press. Principles of Biochemistry, A. L. Lehninger, Worth Publishers.
10. Biochemistry, L.Stryer, W.H.Freeman.
11. Biochemistry, J. David Rawn, Neil Patterson.
12. Biochemistry, Voet and Voet, John Wiley.
13. Outlines of Biochemistry, E. E. Conn and P. K. Stumpf, John Wiley.
14. Macromolecules: Structure and Function, F. Wold, Prentice Hall.
15. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.

16. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
17. Inorganic Biochemistry volume I and II. ed. G.L. Eichhorn, Elsevier.
18. Progress in Inorganic Chemistry, Volume 18 and 38 ed. J.J. Lippard, Wiley.

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Chemistry Practical 7

Semester VII **Paper 17** **Credits 4**

Course Outcome:

In order to make students understand the theories taught to them in B.Sc. semester vii in different branches of chemistry e.g. Inorganic, Organic, Physical, the following practical are introduced. Students will learn:

- CO-1. Qualitative analysis of inorganic mixtures of 8 radicals
- CO-2. Qualitative analysis and determination of two metal ions volumetrically and gravimetrically.
- CO-3. The preparation of selected inorganic compounds and their characterization.
- CO-4. Qualitative analysis of three component organic mixtures.
- CO-5. students should be able to check the purity of organic molecules by the use of TLC and how to calculate their Rf values.
- CO-6. Two steps synthesis involving different name reactions.
- CO-7. The basic knowledge of conductance, electrochemistry, potentiometry and the kinetics of decomposition of the complexes spectrophotometrically.

INORGANIC CHEMISTRY

- Inorganic: Qualitative analysis of inorganic mixture of 8 radicals containing not more than two of the following less common metals: Tl, Mo, W, Zr, Th, V, U.
- Quantitative analysis Separation and determination of two metal ion Cu-Ni, Cu-Zn etc. involving volumetric and gravimetric methods.
- Preparation and their characterization
    - $VO(acac)_2$
    - cis-$K[Cr(C_2O_4)_2(H_2O)_2]$ • $Na[Cr(NH_3)_2(SCN)_4]$
    - $K_3[Fe(C_2O_4)_3]$
    - $Hg[Co(SCN)_4]$

ORGANIC CHEMISTRY

- Separation, purification, characterization and identification by making suitable derivatives of the three component Organic mixture (three solids or two solids and one liquid or two liquids and one solid) involving all the functional groups. Use TLC for checking the purity of the separated compounds and their derivatives and report their Rf values.
- Two steps organic synthesis involving
    - Acetylation

- Oxidation
- Aldol condensation
- Sandmeyer reaction
- Acetoacetic ester Condensation
- Aromatic Electrophilic Substitution.
- Hydrolysis

PHYSICAL CHEMISTRY

- **Conductance measurement**
  - Determination of cell constant of a given conductivity cell and also find out the equivalent conductance of a strong electrolyte at different concentrations at room temperature and the test the validity of Onsager equation.
  - Determine the solubility of sparingly soluble substance in water at given temperature by conductance method
  - Study hydrolysis of aniline hydrochloride by conductance method.
  - Determination of basicity of a given salt by conductance method.
- **Electrochemistry (EMF – Measurements) – Potentiometry / pH-metry**
  - Determination of EMF of Daniel Cell by Potentiometric method $Zn/ZnSO_4$ (C_1) I I $CuSO_4$ (C_2)/Cu Where C_1 and C_2 (i) same concentration (ii) different concentration and hence to see the effect of dilution.
  - Determination of the solubility of a sparingly soluble salt in water by EMF method.
  - Determination of the strength of strong acid using pH – metric method.
  - Determine the pH a given buffer solution using given quinhydrone electrode.
- **Chemical kinetics**
  - Determination of the rate constant and order of reaction for the hydrolysis of an ester catalyzed by an acid at a given temp.
  - Determine the velocity constant and order of reaction for hydrolysis of ethyl acetate by sodium hydroxide at given temperature (saponification of an ester)
- Spectrophotometer
  - Study the kinetics of decomposition of the complex formed between sodium sulphide and sodium nitroprusside spectrophotometrically, and also find the order and rate constant of the reaction.

Recommended Books:

1. Vogels Text book of Quantitative Analysis revised, J. Bessett, R.C. Denney, G.H. Jellery and J. Mendhan ELBS
2. Experimental Inorganic Chemistry by Mounir A, Malati, Horwood series in Chemical Science (Horwood publishing Chichester) 1999.
3. Inorganic Experiments, J. Derexwoolings VCH
4. Microscale Inorganic Chemistry, Z. Scafran, R.M. Pike and M.M. Singh Wiley.
5. Practical Inorganic Chemistry, G. Marrand, B.W. Rockett, Van Nostrand.
6. The systematic Indentification of Organic Compounds, R.L. Shringer and D.Y. Curlin.
7. Qualitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
8. Basic concept of Analysis chemistry, S.M.Chopkar,WileyBastern.
9. Synthesis and characterization of Inorganic compounds, W.L. Jolly, Prentice Hall.
10. Systematic Qualitative Organic Analysis, H. Middeton, Adward Arnoid.
11. Handbook of Organic Analysis Qualitative and Quantitative, H. Clark, Adward Ar
12. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley.
13. Practical Physical Chemistry, A.M. James and F.E. Prichand,

Distribution of Maximum Marks:

The maximum marks in the evaluation of the practical exercises, viva-voce and records of their class-work are given below.

Chemistry Practical 7						
Class	Inorganic	Organic	Physical	Viva	Class Record	Total
B.Sc. Semester VII	25	25	25	15	10	100

Note: For exempted students, marks of class record will be added to the marks of viva-voce for practical examinations since they do not have the class record.

Supramolecular Chemistry (Chemistry Elective 5)

Semester VII **Paper 18X** **Credits 4**

Course Outcome:

- CO 1. Have understanding of theories behind supramolecular interaction and various classes of host-guest chemistry and its applications.
- CO 2. Develop ideas for further research in the field of supramolecular chemistry.
- CO 3. Molecular recognition, complex formation and host design, templates and self-assembly through various examples and applications.

Unit 1

- **Supramolecules:**
  - Definition, classification of supramolecular host-guest compounds, nature of supramolecular interactions, Chelate and macrocyclic effects, General principles of molecular recognition, complex formation and host design, templates and self-assembly.

Unit 2

- **Host-Guest Chemistry (Cation Binding Hosts):**
  - Crown ethers
  - Cryptands
  - Spherands

Unit 3

- **Host-Guest Chemistry (Anion Binding Hosts):**
  - Expanded porphyrins
  - Guanidinium Based receptors

Unit 4

- **Host-Guest Chemistry (Neutral Molecules Binding Hosts):**
  - Solid State Clatharates
  - Zeolites
- **Selected Applications in:**
  - Catalysis
  - Ion Transport
  - Molecular switches, rectifiers and Molecular wires

Books Recommended

1. Supramolecular Chemistry: concepts and perspectives by J. M. Lehn, 1995
2. Supramolecular Chemistry by JW Steel and JL Atwood, 2004
3. Principles and Methods in Supramolecular Chemistry by H Scheneider and A Yatsimirsky,2000
4. Supramolecular Chemistry: an Introduction by F Vogtle, 1993
5. Perspectives in Supramolecular Chemistry, Vol.2, Crystal Engineering and molecular recognition by Desiraju (Ed.), 2003

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Chemistry of Analgesics and Antipyretics (Chemistry Elective 6)

Semester VII **Paper 18Y** **Credits 4**

Course Objective:

- The objective of this course is to provide students information about the recent development in the area of antipyretics and analgesics and also about the structure activity relationship which play pivotal role in drug development.

Course Outcome:

After completing the course, students shall be able to learn:

- CO-1. The structural activity relationship of different class of drugs.
- CO-2. The synthesis of drug molecules using the reactions of synthetic organic chemistry.
- CO-3. Well acquainted with the synthesis of some important class of drugs.
- CO-4. The mechanism pathways of certain class of medicinal compounds and their modes of action with receptors.
- CO-5. The chemistry of drugs with respect to their pharmacological activity.

Unit 1

- **Narcotic Analgesics**
  - Introduction, classification, mode of action, structural activity relationship of narcotic analgesics and applications of the following:
    - Derivatives of morphine
    - Morphinan
    - Phenylpiperidine
    - Benzazocine
    - Diphenylpropylamine and isosters.

Unit 2

- **Narcotic antagonists**
  - Introduction, classification, mode of action, structural activity relationship of narcotic antagonists and applications of the following:
    - n-allyl-nor morphine
    - Levellorphan
    - Naloxone

Unit 3

- **Analgesics and Antagonists**
  - Synthesis of the following narcotic analgesics and antagonists:
    - Phenylpiperidine

- Benzazocine
- Diphenyl propylamine
- n-allyl-nor morphine
- Levellorphan
- Naloxone

Unit 4

- **Antipyretic analgesics:**
  - Introduction, classification, mode of action, structural activity relationship of antipyretic analgesics and applications and synthesis of the following:
    - Paracetamol
    - Asprin
    - Indomethacin
    - Diclophenac sodium
    - Ibuprofen
    - Piroxicam

Recommended Books:

1. Thomas L. Lemke, David A. Williams, Victoria F. Roche, S. William Zito, Foye's Principles of Medicinal Chemistry, 7th Ed., Lippincott Williams & Wilkins, 2012.
2. Graham L. Patrick, "An Introduction to Medicinal Chemistry", 5th Ed. Oxford University Press 2013.
3. D. Sriram, P. Yogeeswari, Medicinal Chemistry, Pearson Education India, 2009.
4. Ashutosh Kar, Medicinal Chemistry, 4th Edition, New Age Publication Publishers.

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Science and Technology of Cosmetics (Chemistry Elective 7)

Semester VII **Paper 19X** **Credits 4**

Course outcome:

- CO-1. This course allows students to understand and learn about the chemistry of cosmetics.
- CO-2. More specifically, this course aims to introduce the scientific aspects such as chemical, physical and biological functions of different ingredients present in the cosmetics.
- CO-3. This course also gives information about the formulation and technology of cosmetics

Unit 1

- **Basic concept of Cosmetics.**
  - Classification of cosmetic products for skin, hair and oral care.
  - Forms of cosmetics and their suitable examples: Solutions, creams, lotions, ointment, paste, gels, sticks, tablets, capsules, powders and aerosols.

Unit 2

- **Cosmetic Ingredients and Classifications:**
  - Water, Surfactants, Foaming agents,
  - Emulsifiers, and Solubilizers, rheological additives, Antioxidants, Antimicrobial and Chelating agents used as preservatives.

Unit 3

- **Perfume:**
  - Classification of perfumes, Perfume ingredients
- **Colour Cosmetics:**
  - Building block and formulation of Lipsticks, mascara, and nail polish
- **Hair conditioner:**
  - Building blocks and formulation of Hair conditioners, hair oils, hair dye, Herbal cosmetics

Unit 4

- **Nanotechnology in Cosmetics**
  - Use of nanotechnology in cosmetics, suspensions, creaming, cracking and phase inversion

- **Micrometrics:**

- Methods of determining particle size, optical microscopy, sieving, sedimentation measurements

- **Powders:**
  - Porosity, densities, bulkiness and flow properties.

Recommended Books:

1. Harry's Cosmeticology – Wilkinson, Moore, seventh edition, George Godwin.
2. Cosmetics – Formulation, Manufacturing and Quality Control, P.P. Sharma, 4th edition, Vandana Publications Pvt. Ltd., Delhi.
3. Drugs and Cosmetic act/rules by govt. of India Publication
4. Handbook of Cosmetic Science and Technology, 3rd Edition, André O. Barel, Marc Paye, Howard
5. Maibach, Marianne Mahieu Informa Healthcare USA, Inc.

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Electrochemistry (Chemistry Elective 8)

Semester VII **Paper 19Y** **Credits 4**

Unit 1

- **Electrokinetic Phenomenon**
  - Electrokinetic Effects, Electrical double layer, quantitative treatment of electrokinetic phenomena, Electrokinetic potential/Zeta potentials and its determination, influence of ions on electrokinetic phenomena, Electro-Osmosis, Streaming potential, Sedimentation potential, Electrophoretic, Mobility and Bound hydrogen ion.

Unit 2

- **Bioelectrochemistry**
  - Threshold phenomena, Donnan Membrane Equilibrium and its application, Membrane
  - Potential, Hodges Huxley Equation, Core conductor model. Quantum Aspects of Charge transfer at electrode-solution interfaces, quantization of charge transfer tunneling. Theory of double layer semiconductor solution interfaces, Limiting current in semiconductor electrode.

Unit 3

- **Polarography and Voltametry**
  - Electrode polarization, Theories and importance of overvoltage,Principle of polarography, variation of conventional polarographic methods, Pulse Polarography, Oscillographic polarography, Tensammetry, AC polarography, square wave polarography, Anodic stripping and cyclic voltammetry, Qualitative and quantitative application of polarography, Determination of stoichiometry and formation constants of complexes.

Unit 4

- **Solid State Electrochemistry**
  - Solid Fuel Cells and batteries, super Capacitor and semiconductors, Temperature dependence of electrical resistances, Coherent Length, Piezoelectric and pyroelectric materials, Conducting polymers, Fullerenes-Doped conductors. Brief idea of Electrochemistry of molten electrolytes and nonaqueous solvents.

Books Suggested (Theory Courses)

1. Physical Chemistry. G.M. Barrow. International Student Edition, McGraw Hill.
2. Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
3. The Elements of Physical Chemistry, P.W. Atkins, Oxford.
4. Physical Chemistry Through problems, S.K. Dogra and S. Dogra, Wiley Eastern Ltd.
5. Graduate physical Chemistry, VolumeI-III By L.R. Sharma and M.s..Pathania

Research Methodology

Semester VII **RM** **Credits 4**

Course Objective:

To provide students thorough knowledge of the literature and a comprehensive understanding of scientific methods and techniques applicable to their work.To give knowledge of Safety, Hazards and precautions in Laboratory. To introduce Chemistry related software and Databases and Data Analysis as per IUPAC protocol.

Course Outcome:

Student will learn-

- CO-1. Minimize the risk of injury or illness to laboratory workers by ensuring that they have the training, information, support and equipment needed to work safely in the laboratory.
- CO-2. Have understanding of different purification criteria at separation and be able to account for fundamental separation processes and their connection to molecular properties.
- CO-3. IUPAC awareness on the world authority on chemical nomenclature, terminology, standardized methods for measurement, atomic weights and many other critically-evaluated data.
- CO-4. Developing skill for systematic, articulate and orderly presentation of research work in a written form containing relevant information on the research work carried out.

Unit 1

- **Safety, Hazards and Precautions in Laboratory:**
    1. Brief idea about toxicity, explosive nature and ill effects of various chemicals generally used in research and precautions to handle them.

Unit 2

- **Computer Basics and Application**
    - Introduction to basic software
        - MS Word,
        - Power Point
        - Excel
- **Introduction to Chemistry related software**
    - Gaussian,
    - Gaussview

- ChemDraw

- **Introduction to Databases**
  - SciFinder
  - Scopus
  - Cambridge Structural Database

Unit 3

- **Purification Techniques:**
  - A brief knowledge about various techniques such as distillation, fractional distillation, crystallization, fractional crystallization.
  - Chromatography:
    - Column
    - TLC
    - Paper

Unit 4

- **Data Analysis:**
  - Data Analysis as per IUPAC and Association of Analytical Chemists' (AOAC) protocol:
  - Errors in chemical analysis, Repeatability and reproducibility, classification of errors, determination of accuracy of methods, improving accuracy of analysis, significant figures, mean, mode, median, standard deviation, comparison of results: T-test, F-test and Chi-square test, Rejection of results, presentation of data.