Indrashil University

Department of Chemistry
School of Science

M.Sc. 2024-2026 Sem I-IV

Analytical Chemistry

Course Profile
Academic Year: 2024 – 2025

Course Structure M.Sc. Analytical Chemistry Semesters I to IV

SEMESTER: I	MINIMUM SEMESTER CREDIT REQUIRED: 20 CUMULATIVE SEMESTER CREDITS REQUIRED: 20		
SUBJECT NO.	**SUBJECT NAME**	**L-T-P**	**CREDITS**
CH4 101	ORGANIC CHEMISTRY - I	3-0-0	3
CH4 102	INORGANIC CHEMISTRY - I	3-0-0	3
CH4 103	PHYSICAL CHEMISTRY -I	3-0-0	3
CH4 104	ANALYTICAL CHEMISTRY - I	3-0-0	3
CH4 105	ORGANIC CHEMISTRY LABORATORY	0-0-8	4
CH4 106	INORGANIC CHEMISTRY LABORATORY	0-0-8	4
Total		12L-16P	20

SEMESTER: II	MINIMUM SEMESTER CREDIT REQUIRED: 43 CUMULATIVE SEMESTER CREDITS REQUIRED: 23		
SUBJECT CODES	**SUBJECT NAME**	**L-T-P**	**CREDITS**
CH4 201	ORGANIC CHEMISTRY – II	3-0-0	3
CH4 202	INORGANIC CHEMISTRY – II	3-0-0	3
CH4 203	PHYSICAL CHEMISTRY – II	3-0-0	3
CH4 204	BIO-ORGANIC CHEMISTRY	3-0-0	3
CH4 205	SPECTROSCOPY - I	3-0-0	3
CH4 206	ANALYTICAL TECHNIQUES LABORATORY	0-0-8	4
CH4 207	PHYSICAL CHEMISTRY LABORATORY	0-0-8	4
Total		16L-16P	23

SEMESTER: III	MINIMUM SEMESTER CREDIT REQUIRED: 24 CUMULATIVE SEMESTER CREDITS REQUIRED: 67		
SUBJECT CODES	**SUBJECT NAMES**	**L-T-P**	**CREDITS**
CH5 AN101	ANALYTICAL CHEMISTRY - II: PHARMACEUTICAL ANALYSIS AND MEASUREMENTS	3-0-0	3
CH5 AN102	ANALYTICAL CHEMISTRY - III: ELECTROANALYTICAL TECHNIQUES	3-0-0	3
CH5 AN103	ANALYTICAL CHEMISTRY-IV: QA QC VALIDATION	3-0-0	3
CH5 104	SPECTROSCOPY-II	3-0-0	3
CH5 105	CHEMICAL DATA ANALYSIS LABORATORY	0-0-8	4
CH5 AN106	ANALYTICAL CHEMISTRY LABORATORY	0-0-8	4
	ELECTIVE-I	2-0-0	2
	ELECTIVE-II	2-0-0	2
Total		19L-16P	24

SEMESTER: IV	MINIMUM SEMESTER CREDIT REQUIRED: 15 CUMULATIVE SEMESTER CREDITS REQUIRED: 82		
SUBJECT CODES	**SUBJECT NAMES**	**L-T-P**	**CREDITS**
CH5 AN201	RESEARCH OR INDUSTRIAL PROJECT	0-0-20	10
CH5 AN202	PROJECT REPORT	3-0-0	3
CH5 AN203	PROJECT PRESENTATION	2-0-0	2
Total		5L-20P	15

Semester 3: LIST OF AVAILABLE SUBJECTS FOR ELECTIVE I, II

SUBJECT CODES	SUBJECT NAMES	L-T-P	CREDIT
CH5 EAN1	SEPARATION METHODS	2-0-0	2
CH5 EAN2	APPLICATIONS OF COMPUTER IN CHEMISTRY	2-0-0	2
CH5 EAN3	SUPRAMOLECULAR CHEMISTRY	2-0-0	2
CH5 EAN4	APPLIED ANALYSIS AND GREEN ANALYTICAL CHEMISTRY	2-0-0	2

SEMESTER I

SYLLABUS WITH COURSE LEARNING OUTCOME (CLO)

CH4 101: ORGANIC CHEMISTRY I (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 101	**Course name:** Organic Chemistry I

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
3	-	3	45	Lecture	CCE, ESE	100	35

Course Description: Unit I of this course deals with types of reactions and their mechanisms, Generation, structure, stability, and reactivity of organic reactive intermediates, Chemical bonding, Hammett equation, Hammond's postulate, Curtin-Hammett principle, HSAB Principle. Unit II of the course consists, SN1, SN2, SNi, SNAr, SRN1, and benzyne mechanism, the NGP, anchimeric assistance, classical and non-classical carbocations. Aromatic electrophilic substitution reactions, arenium ion mechanism, the ortho/para ratio, ipso attack, Unit-III of the course explains about the Basic principles of Stereochemistry, chirality, enantiomers, diastereomers, threo and erythro isomers, R, S, and E, Z nomenclature, Prochiral relationship, optical activity in biphenyls, spiranes, allenes and helical structures. Stereochemistry of compounds containing Nitrogen, Sulphur and Phosphorous.

CLO1: Familiarize with types of reactions, their mechanisms, and reactivity of organic reactive intermediates
CLO2: Understand the Hammett equation, Hammond's postulate, Curtin-Hammett principle, and HSAB Principle.
CLO3: Get an idea about SNAr, SRN1 and benzyne mechanism, the NGP, and anchimeric assistance.
CLO4: Be able to understand Classical and non-classical carbocations. Aromatic electrophilic substitution reactions, arenium ion mechanism, the ortho/para ratio, ipso attack,
CLO5: Knowledge of Basic principles of Stereochemistry, chirality, Prochiral relationship, and optical activity in biphenyls, spiranes, allenes, and helical structures. Stereochemistry of compounds containing Nitrogen, Sulphur, and Phosphorous.

Detailed Syllabus

Units	Contents	Hours
I	**Structure and Reactivity** Chemical bonding, Resonance, hyperconjugation, delocalization, tautomerism, inductive effect, Types of reactions, mechanisms, thermodynamic and kinetic requirements, Hammett equation, Hammond's postulate, Curtin-Hammett principle, Potential energy diagram, transition states and intermediates, methods of determining mechanism, isotopic effects, solvent effects, substituent effects, Hard and soft acids and bases. Generation, structure, stability, and reactivity of organic reactive intermediates such as carbocations, carbanions, free radicals, carbenes, and nitrenes. Introduction to Retrosynthetic Analysis, synthons, and synthetic equivalents, functional group inter-conversion (FGI), Principles and applications of protective groups for -OH, -NH_2, -C=O, -COOH groups	15

II	**Organic Reaction Mechanism** **Aliphatic nucleophilic substitution reactions:** SN^1, SN^2, SN^i with suitable examples & mechanisms. **Aromatic nucleophilic substitution reactions**, SN^{Ar}, SN^1, benzyne, and SRN1 with suitable examples, and mechanisms. Reactivity – effect of substrate structure, leaving group and attacking nucleophiles, ambident nucleophilicity. Nucleophilic substitution at an allylic, aliphatic, trigonal, and vinylic carbon. Neighboring group participation, anchimeric assistance. Classical and nonclassical carbocations, phase transfer catalysis, **Aromatic electrophilic substitution reactions:** Arenium ion mechanism, orientation, and reactivity, energy profile diagram, the ortho/para ratio, ipso attack with suitable examples.	**15**
III	**Stereochemistry** Basic principles, elements of symmetry, chirality, molecules with more than one chiral centre, enantiomers, diastereomers, threo and erythro isomers, Re and Si faces, CIP rule, absolute configurations at carbon (R, S, E and Z). Interconversion of Fischer, Newman and Sawhorse projections, Molecules with more than one chiral center, Methods of resolution, Stereospecific and stereoselective reactions. Prochiral relationship, optical activity in biphenyls, spiranes, allenes and helical structures. Stereochemistry of compounds containing Nitrogen, Sulphur and Phosphorous. Conformation and reactivity in acyclic and cyclic compounds. Conformational analysis of Cycloalkanes and Decalins, Effect of conformation on reactivity.	**15**

Reading references:

1. E.L. Eliel. Stereochemistry of Carbon Compounds. TATA McGraw-Hill Edition. 1962.
2. D. Nasipuri. Stereochemistry of Organic Compounds. New Age International (P) Limited, Publishers. 1994, 2nd Ed.
3. P.S. Kalsi. Stereochemistry: Conformation and Mechanism. New Age International (P) Limited, Publishers. 2019, 10th Ed.
4. Jerry March. March's Advanced Organic. Chemistry: Reactions, Mechanisms, and Structure. WILEY-INTERSCIENCE A JOHN WILEY & SONS, INC., PUBLICATION. 2006, 6th Ed.
5. Peter Sykes. A Guidebook to Reaction Mechanisms in Organic Chemistry. Longman scientific & technical. 1986, 6th Ed.
6. S.M. Mukherji & S.P.Singh. Reaction Mechanism in Organic Chemistry. McMillan India Ltd. 1976, Revised Ed.
7. L. G. Wade Jr. Organic Chemistry. Pearson. 2011, 8th Ed.
8. Francis A. Carey and Richard J. Sundberg. Advanced Organic Chemistry, Part A and Part B: Structure and Mechanisms. Springer. 2007, 5th Ed.
9. Greeves, Warren, and Wothers Clayden. Organic Chemistry. Oxford University Press. 2014, 2nd Ed.

CH4 102: INORGANIC CHEMISTRY I (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 102	**Course name:** Inorganic Chemistry I

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
3	-	3	45	Lecture	CCE, ESE	100	35

Course Description: This course deals with understanding of different types of isomers, coordination polyhedral, and molecular symmetry. This course also teaches the idea of inorganic reaction mechanisms. This course also explains redox reaction, the Nernst equation.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Identify different coordination isomers.
CLO2: Compare different strengths of acids and bases.
CLO3: Classify the molecular symmetry by using the group theory concept.
CLO4: Develop the concept of a redox reaction, Nernst equation, and Inorganic reaction mechanisms.

Detailed Syllabus

Units	Content	Hours
I	**Principles of Inorganic Chemistry**: Isomerism, Structural and stereoisomerism of tetrahedral, square planar and octahedral complexes, the concept of ligand- ambidentate, chelating, innocent, non-innocent and bridging ligand, flexidentate behavior of polydentate ligand, Chelate complex, EDTA, Coordination polyhedra - Enumeration of geometrical and optical isomers, Theory of Acids and Bases: Bronsted and Lewis acids and bases, gas phase versus solution acidity- solvent leveling effects, Hardness and softness- Surface acidity. SHAB principle, Super acids.	15
II	**Structure and Reactivity:** *Symmetry and Group Theory*: Definitions and theorems of group theory, subgroups, Classes Molecular symmetry and symmetry groups – symmetry elements and operations. Symmetry planes, reflections, inversion centre, proper/ improper axes of rotation, products of symmetry operations, equivalent symmetry elements and atoms, symmetry elements and optical isomerism, symmetry point groups, classes of symmetry operations, classification of molecular point groups. Representations of groups. Great orthogonality theorem, character tables, properties of characters of representations. (No mathematical part.) Group theory and quantum mechanics, wave function as basis for irreducible representations. **Inorganic Reaction Mechanisms:** Substitution reactions - Dissociative and associative interchange - trans-effect - Linear free energy relations - Rearrangements - Berry pseudo rotation - Electron transfer reactions - Photo- dissociation, -substitution and -redox reactions, Fluxional molecules.	15
III	**Magnetic Properties:** Classification of magnetic materials; Langevin diamagnetism; Quantum theory of para magnetism; Cooperative phenomena - ferro, anti-ferro and ferrimagnetism - magnetic domains and hysteresis; Super paramagnetism. **Optical Properties:** Optical reflectance - plasmon frequency; Raman scattering in crystals; Photoconduction; Photo and electroluminescence; Lasers; Photovoltaic and photo electro chemical effects.	15

Reading references:

1. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong: Shriver and Atkins' Inorganic Chemistry. W. H. Freeman and Company New York. 2009, 5th Ed. or D. F. Shriver and P. W. Atkins. Inorganic Chemistry. W. H. Freeman and Company New York. 1999, 3rd Ed.
2. C. Housecroft, A. G. Sharpe. Inorganic Chemistry. Prentice Hall/Pearson. 2008, 3rd Ed. or 2012, 4th Ed.
3. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry. John Wiley. 1988, 5th Ed. (or F. A. Cotton, C. A. Murillo, M. Bochmann and R. N. Grimes. Advanced Inorganic Chemistry. John Wiley. 1999, 6th Ed.)
4. J. E. Huheey, E. A. Keiter, R. L. Keiter. Inorganic Chemistry: Principles of Structure and Reactivity. Prentice Hall. 1997, 4th Ed. (or a previous edition).
5. G. L. Miessler, D. A. Tarr. Inorganic Chemistry. Pearson Education. 2004, 3rd Ed.
6. G. Wulfsberg. Inorganic Chemistry. University Science Books. 2000, 2nd Ed.

CH4 103: PHYSICAL CHEMISTRY I (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 103	**Course name:** Physical Chemistry I

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
3	-	3	45	Lecture	CCE, ESE	100	35

Course Description: This course involves some fundamental aspects of Physical Chemistry. The statistical thermodynamics part connects the macroscopic and microscopic worlds; whereas the chemical kinetics part will help in understanding and modifying the rate of a chemical reaction under a laboratory setup. Unit III exposes the students to solid-state chemistry that involves the concept of crystallography and lattice.

In brief, through this course, the students will be able to

CLO1: Connect statistics and thermodynamics. Build the fundamental understanding of the computational world.
CLO2: Understand the rate laws of complex reactions.
CLO3: Analyze the scientific study of chemical kinetics of complex reactions.
CLO4: Demonstrate the ability to identify different bonding contributions in the solid state.
CLO5: Acquire the knowledge of polymorphism which will help them in pharma industry.

Detailed Syllabus

Units	Content	Hours
I	**Statistical Thermodynamics:** Limitations of classical thermodynamics. Introduction to terms like ensemble, population, equipartition of energy, degeneracy. Boltzmann's distribution law, Evaluation of β, partition function, Distinguishable and indistinguishable particles, molar partition function, Electronic, Translational, Rotational, and Vibrational partition functions. Sackur-Tetrode equation. Derivation of Fermi-Dirac statistics and Bose-Einstein statistics distribution law and their application. Applications of statistical thermodynamics- Heat capacity behavior of solid and calculation of equilibrium constant.	15
II	**Chemical Kinetics:** Revision and basics of simple chemical kinetics. *Complex Reactions:* Reactions approaching equilibrium, steady state approximation, Rate laws for consecutive, opposing, parallel reactions, and explosive reactions. Chain reactions Comparison between gas phase and solution reactions, factors determining rates in solution. Reaction between ions, reactions involving dipoles, and reactions in solution. *Fast reactions*: Relaxation, stop flow, and flash photolysis. Kinetics of enzyme reactions, Harpoon mechanism (Molecular Beam method). Basics of simple collision theory**.** *Activated complex theory*: Reaction coordinate and the transition state theory, potential energy surface, concentration of activated complex and rate constant, experimental observation of activated complex. *Theories of uni-molecular reactions*: Perrin, Lindemann, Hinshelwood	15
III	**Solid State Chemistry: Crystallography**- Recapitulation, diffraction properties of crystals. Symmetry elements, space groups. Concept of crystal planes, Miller indices. Ionic crystals. Determination of crystal structure. Imperfection in crystals- point defects (Thermodynamic treatment) and line defects. Crystal growth, Crystal engineering, and polymorphism, regulatory issues regarding drug polymorphism. **Thermal Properties:** Lattice vibrations - phonon spectrum; Lattice heat capacity; Thermal expansion; Thermal conductivity. **Electrical Properties:** Free electron theory - electrical conductivity and Ohm's law - Hall effect; Band theory - band gap - metals and semiconductors - intrinsic and extrinsic semiconductors; Hopping semiconductors; Semiconductor/metal transition; p-n junctions; Superconductors - Meissner effect - type I and II superconductors - isotope effect - basic concepts of BCS theory - manifestations of the energy gap - Josephson devices.	15

Reading references:

1. M. C. Gupta. Statistical Thermodynamics. New Age Int. Ed. 1998, Revised printing.
2. T. L. Hill. An Introduction to Statistical Thermodynamics. Dover Publication. 1986.
3. B. N. Roy. Fundamental of Classical and Statistical thermodynamics. Wiley. 2002, 1st Ed.
4. K. J. Laidler. Chemical Kinetics. Pearson Education, Noida. 1987, 3rd Ed.
5. R. D. Levine. Molecular reaction Dynamics. Cambridge University Press, NY. 2009, Paperback Edition.
6. Raja Ram and J. C. Kuriacose. Kinetics and Mechanism of Chemical Transformations. MacMillan Indian Ltd. 1993, 1st Ed.
7. Samuel Glasstone. Text Book of Physical Chemistry. Macmillan Publishers. 1942, 2nd Ed.
8. Atkins. Physical Chemistry. Oxford publishers. 2018, 8th Ed.
9. M. M. Woolfson. An Introduction to X-ray Crystallography. Cambridge University Press-Vikas Publishing House, New Delhi. 1980, 2nd Ed.
10. W. Cochran. Dynamics of Atoms in Crystals. Edward Arnold, London. 1973. (pages 24-37).
11. P. M. A. Sherwood. Vibrational Spectroscopy of Solids. University Press, Cambridge. 1972. (pages 1-45).
12. C. N. R. Rao and K. J. Rao. Phase Transitions. Cambridge University Press.
13. George H Stout and Lyle H Jenson. X-ray Structure determination: A practical guide. Macmillan Publishing Co. Inc and Collier Macmillan Publishers. 1989, 2nd Ed.
14. Gurdeep Raj. Advanced Physical Chemistry. Krishna Prakashan. 2022.

CH4 104: ANALYTICAL CHEMISTRY-I (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** I
Course code: CH4 104	**Course name:** Analytical Chemistry-I

Lect.	Practical (Hours/week)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing Marks
3	0	3	45	Lecture	CCE, ESE	100	35

Course Description: This course deals with basics of Analytical Chemistry. From this course students will learn several fundamental instrumental techniques used in different industry as well as research institutes. Gradually they come to know the importance of analytical science. Also, they get chance to have some hands-on experience on analyzing different compounds using various instruments. More importantly they will learn fundamentals of various spectrophotometric techniques along with practical knowledge. This will help them to explore their scientific knowledge and make them fit for any industry. They will also learn most of the Chromatographic techniques.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Know the importance of Analytical science in Research & Development of an industry.
CLO2: Operate several analytical instruments within a very short span of time.
CLO3: Understand several analytical data representation techniques.
CLO4: Learn the techniques to analyze unknown samples.
CLO5: Be familiarized with several computer-based data plots.

Detailed Syllabus

Units	Content	Hours
I	**Data Handling, Good Laboratory Practice (GLP) and Calibration Methods:** Scope of analytical science and its literature, qualitative and quantitative analysis, ways to express accuracy and precision, types of errors and their causes; significant figures, control charts, confidence limit, test of significance, rejection of a result- the Q-test. GLP- standard operating procedures, quality assurance and quality control, validation of analytical methods. Finding the best straight line-least square regression, correlation coefficient; Calibration curves, standard addition technique and internal standards, Chemical concentrations.	**15**
II	**Fundamentals of Spectrophotometry:** Properties of light, absorption of light, interaction of light with matter and origin of spectra. The spectrophotometer- calibration, sources of light, monochromators and detectors. Beer's law in chemical analysis, optical rotatory dispersion, and circular dichroism. Analysis of mixture-resolved and unresolved spectra, measurement of equilibrium constant: Stoichiometry-method of continuous variation- the Jobs plot, Photometric titrations. Atomic absorption spectroscopy	**15**
III	**Chromatography, GC and HPLC Techniques:** Chromatographic Principles and applications of Paper, Thin layer & HPTLC, column chromatography, Gas and Gas-liquid chromatography, HPLC (normal and reverse phase) and FPLC.	**15**

Self-learning topics:

Unit-I Scope of analytical science and its literature, ways to express accuracy and precision
Unit-II sources of light.
Unit-III Basic Chromatographic Principles

Reading references:

1. D.A. Skoog, D. M. West, F. J Hooller & S. R. Crouch. Fundamental of Analytical Chemistry. Brooks /Cole Publication. 2013, 9th Ed.
2. Elizabeth Prichard and Vicki Barwick. Analytical Chemistry by Open Learning, A Series of 34 Titles(set). Wiley India. 2008.
3. D. A. Ray and Underwood. Quantitative Analysis. Prentice-Hall International Ltd. New Delhi. 1991, 6th Ed.
4. G.H. Jeffory, J. Busseff, J. Mendham, R. C. Denny. Vogel's Text Book of Inorganic Quantitative Chemical Analysis. Longman Science & Technical. 1989, 5th Ed.
5. Gary D. Christian. Analytical Chemistry. John Wiley and Sons Inc. New York. 1994, 6th Ed.
6. Gurdeep R. Chatwal & Sham K. Anand. Instrumental Methods of Chemical Analysis. Himalaya Publishing House. 2016, 5th revised Ed. And Enlarged Edition.
7. H. H. Willard, L. L. Merrit, J. A. Dean. Instrumental Methods of Analysis. Van Nostrand. 1974, 5th Ed. And CBS. 1986, 6th Ed.
8. H. Kaur. Analytical Chemistry. Pragati Prakashan Meerut. 2021, Paperback Ed.
9. Daniel C. Harris. Quantitative Chemical Analysis. W.H. Freeman and Company, New York. 1998, 5th Ed.
10. Gary D. Christian. Analytical Chemistry. John Wiley and Sons Inc. New Jersey. 6th Ed.
11. Douglas A. Skoog. Principles of Instrumental Analysis. Holt Saunders International Edition. 1016, 7rd Ed.
12. Galen W. Ewing. Instrumental Methods of Chemical Analysis. International Student Edition. 4th Ed.

CH4 105: ORGANIC CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

1. Qualitative analysis
   Separation of mixtures containing three components. The mixtures should also involve the separation of nitrophenols, amines, neutral compounds, low-boiling substances, and water-soluble substances.
2. One-step or two-step Organic Synthesis: (Minimum 9 preparations)

1. Preparation of m-dinitrobenzene (Nitration).
2. Preparation of Tribromo aniline (Bromination)
3. Preparation of Benzanilide (Benzoylation).
4. Methyl orange preparation (Diazotization)
5. Preparation of 2,4-dihydroxyacetophenone. (Friedel-crafts acylation).
6. Preparation of dibenzalacetone (Claisen-Schmidt reaction).
7. Cyclohexanol to cyclohexanone (Oxidation).
8. Benzophenone to diphenylmethane (Reduction or Nagai method).
9. Benzyl cyanide to phenylacetic acid (hydrolysis of nitriles).
10. Nitrobenzene to m-nitroaniline (Nitration and Selective Reduction)
11. Benzoic acid to ethyl benzoate (Esterification)
12. Diel's Alder Adduct of anthracene and maleic anhydride (Diel's Alder Reaction)

Reading references:

1. Israel Vogel and B. S. Furniss. Vogel's textbook of practical organic chemistry. 1989, 5th Ed.
2. Frederick George Mann and Bernard Charles Saunders. Practical Organic Chemistry. Longman Scientific & Technical. 1960, 4th Ed.
3. N. K. Vishnoi. Advanced Practical Organic Chemistry. Vikas publishing. 2010, 3rd Ed.
4. R. K. Bansal. Laboratory Manual of Organic Chemistry. New Age International Publishers. 1983, 5th Ed.

CH4 106: INORGANIC CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

1. Estimation of Fe (II) in a given solution (Permanganometry).
2. Estimation of Fe(II) with K_2Cr_2O7 (dichromatometry/dichrometry).
3. Estimation of Cu(II) in a solution (Iodometry).
4. Estimate the amount of magnesium present per liter of the given solution of magnesium sulfate.
5. Estimation of total hardness of water using EDTA by complexometric method
6. To determine the percentage of iron in hematite ore.
7. To estimate the mass of nickel in the whole of the given nickel ammonium sulfate solution.
8. Synthesis and analysis of 3d metal complexes.
9. Synthesis and analysis of rare earth metal complexes.
10. Gravimetric estimation of Cu in Cu and Fe solution.
11. Total gravimetric estimation of Fe and Al.
12. Gravimetric determination of Fe in Fe and Cr solution.
13. Gravimetric determination of Ni in Cu and Ni solution.
14. Volumetric estimation of Cu in Cu and Ni (German silver).
15. Volumetric estimation of Ca and Mg in Dolomite solution.
16. Volumetric estimation of Fe in Cu and Fe solution.
17. Volumetric estimation of Zn in Cu and Zn solution.
18. Volumetric estimation of Ni in Ni and Zn solution.

Reading references:

1. Orient Longman. Vogel's Textbook of Quantitative Chemical Analysis. Longman Scientific & Technical. 1989, 5th Ed.
2. Orient Longman. Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis. Orient Longman. 1982, 5th Ed.

SEMESTER II

CH4 201: ORGANIC CHEMISTRY-II (L-T-P-C: 3-0-0-3)

Unit I: Organic Reaction Mechanism (15 h)

Reactions of multiple bonds, mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles, and free radicals. Regio- and Chemoselectivity. Addition to carbon-heteroatom multiple bonds. Addition of organometallic reagents containing lithium, magnesium, copper, zinc, mercury, and cadmium. Ylides and Wittig reaction, mechanism of alkylation and condensation reactions involving enolates. Elimination reactions. E_2, E_1 and E_{1cB} mechanism, Oxidation reactions, application using Cr, Mn, Ce, Pb, Pd, Pt, Os based reagents, m-CPBA, O_3, $NaIO_4$, etc. Reduction reactions involving hydrogen and metal catalysts, Wilkinson catalyst, borane and reagents thereof, $LiAlH_4$, and DIBAL-H. R_3SnH.

Unit II: Reactions and Rearrangements (15 h)

Molecular Rearrangements. Mechanism of molecular rearrangements involving nucleophilic, electrophilic and free radical. Carbon-carbon rearrangements: Wagner–Meerwein, Tiffeneau–Demyanov, Favorskii, Wolff, Benzil–Benzilic acid, Neber, Benzidine rearrangements, Carbon–nitrogen rearrangements: Hoffmann, Curtius, Lossen Schmidt and Beckmann rearrangements. Carbon–oxygen rearrangements: Bayer–Villiger, Dakin and Wittig rearrangements. Fries, Claisen, Cope reactions. Reactions involving P, N, and S Ylides.

Unit III: Heterocyclic Chemistry (15 h)

Heterocyclic Chemistry: Nomenclature of heterocyclic compounds (three, four, five, six, two or more heteroatom compounds and Fused heterocycles), Hantzsch-Widman rules for fused and bridge ring systems. Preparation, Chemical Reactions, and properties of 3, 4, 5, 6 and Fused Heterocycles.
Three membered heterocycles: Aziridine, Oxiranes, and Thiiranes.
Four membered ring heterocycles: Azetidine, Azetines, and Oxetanes.
Five membered heterocyclic compounds: Pyrrole, Furan, Thiophene.
Six membered heterocyclic compounds: Pyrylium salts, α and ϒ-Pyrones.
Bicyclic ring system heterocyclic compounds: Indole, Benzofuran, Benzthiophenes, Quinolines, isoquinolines.

Reading references:

1. R. K. Meckie, D. M. Smith, R. A. Atken. Guidebook to Organic Synthesis. Addison-Wesley Longman Ltd. 1990, 2nd Ed.
2. O. House. Modern Synthetic Reactions 1972, 2nd Ed.
3. M. B. Smith. Organic Synthesis. Editorial Staff. 2016, 4th Ed.
4. S. N. Sanyal. Reactions, Rearrangements, and Reagents. Bharti Bhawan Publishers. 2020, 4th Ed.
5. Francis A. Corey and Richard J. Sundberg. Advanced Organic Chemistry: Part A Structure & Mechanism. Springer. 2007, 5th Ed.
6. R.K. Bansal. Heterocycles. New Age International Publishers. 2022,7th Ed.
7. I. L. Finar. Organic Chemistry Vol. I & II. ELBS Publication.2002, 5th Ed.
8. Ray Mukul C. Reaction Mechanisms in Organic Chemistry. MTG Learning Media. 2021, Revised Ed.
9. Li Jie Jack. Name Reactions. Springer. 2018, 4th Ed.
10. Christian M. Rojas. Molecular Rearrangements in Organic Synthesis. Wiley. 2015.
11. Raj K Bansal. Organic Reaction Mechanisms. New Age International. 2012, 4th Ed.
12. Jerry March. Advanced Organic Chemistry. Wiley India Pvt. Ltd. 2007, 6th Ed.
13. Laurence M. Harwood. Advanced Organic Chemistry. Oxford University Press. 1992.
14. P S Kalsi. Organic Reactions and Their Mechanisms. New Age International. 2020, 3rd Ed.

15. R.M. Acheson. An Introduction to the Chemistry of Heterocyclic Compounds. Wiley student edition. 2008, 3rd Ed.
16. John A. Joule and Keith Mills. Heterocyclic Chemistry. Wiley. 2010, 5th Ed.
17. Thomas. L. Gilchrist. Heterocyclic Chemistry. Pearson. 2005, 3rd Ed.
18. R.R. Gupta, Kumar, and V. Gupta. Heterocyclic Chemistry. Springer. 1998.

CH4 202: INORGANIC CHEMISTRY II (L-T-P-C: 3-0-0-3)

Unit I: Main Group Chemistry (15 h)

Perspectives, periodicity & periodic anomalies – Relativistic effects on chemical properties. *Hydrogen and its compounds*: H-bond and its influence on the structure and properties of crystals Hydrides→classification: electron deficient, electron precise and electron rich hydrides.

Alkali and alkaline earth metals: Solutions in liquid ammonia - Synthesis, properties, uses and structures of crown ether complexes, cryptands and organometallic compounds.

Group 13 elements: Borides, borates, boron halides, boranes, carboranes and metallocarboranes, BN compounds, transition-metal stabilized borylene and boryllithium, organoaluminum compounds, Lewis Base adducts of AlR_3 compounds, Subvalent organo-Al compounds, Organo-gallium, -indium, and –thallium compounds.

***Group 14 elements*:** Allotropes of Carbon- C60 and its compounds (fullerenes) - carbon nanotubes: synthesis ***Group 14 elements*:** and properties -Intercalation compounds of graphite - Pure Silicon, silica and silicates, Silicones - Low coordinated and hypervalent Silicon compounds - Brief survey of Ge, Sn, and Pb chemistry- Organo-germanium, -tin, and -lead compounds.

***Group 15 elements*:** P(V) compounds (structure, bonding, reactivity) - P(III) compounds: diphosphenes, phosphaalkenes, iminophosphanes - P-containing ring systems (phosphabenzene, phosphole), phosphazenes, P-S compounds.

***Group 16 elements*:** Sulfurpolycationic and anionic species - SN compounds.

Unit II: Halogens and Nobel gases and Inner transition elements (15 h)

Group 17 elements: Charge-transfer complexes of halogens, inter-halogen compounds, halogen oxides and oxygen fluorides, pseudo halogens. **Group 18 elements:** Noble gas clathrates and compounds. Inner transition elements: Chemistry of f-block elements - Binary compounds –Organometallic compounds - Relation to p-block and d-block chemistry – Tran'sactinides (super-heavy elements).

Unit III: Organometallic Chemistry and Catalysis (15 h)

Organometallic Chemistry: Complexes with pi-acceptor and sigma-donor ligands - 16 electron and 18 electron rules – Stability and Reactivity - Isolobal analogy - Structure and bonding - Agnostic interaction. back bonding carbonyl, σ-Organyls, Metal carbenes and metal carbynes, Ferrocene. **Homogeneous and Heterogeneous Catalysis**: Hydrogenation, carbonylation, polymerization, Wacker oxidation and other reactions catalyzed by transition metal complexes. Metal Cluster Compounds: Metal-metal bond - Carbonyl and non-carbonyl clusters - Structure and bonding - Low-dimensional solids - Clusters in catalysis.

Reading references:

1. A G. Massey. Main group chemistry. Wiley. 2000, 2nd Ed.
2. N. N. Greenwood and A. Earnshaw. Chemistry of the Elements. Pergamon Press. 1989. 1st Ed.
3. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong: Shriver and Atkins' Inorganic Chemistry. W. H. Freeman and Company New York. 2009, 5th Ed. or D. F. Shriver and P. W. Atkins. Inorganic Chemistry. W. H. Freeman and Company New York. 1999, 3rd Ed.

4. C. Housecroft, A. G. Sharpe. Inorganic Chemistry. Prentice Hall/Pearson. 2008, 3rd Ed. (or 2012, 4th Ed.)
5. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry. John Wiley. 1988, 5th Ed.
6. or F. A. Cotton, C. A. Murillo, M. Bochmann and R. N. Grimes. Advanced Inorganic Chemistry. John Wiley. 1999, 6th Ed.
7. J. E. Huheey, E. A. Keiter, R. L. Keiter. Inorganic Chemistry: Principles of Structure and Reactivity. Prentice Hall. 1997, 4th Ed. (or a previous edition).

CH4 203: PHYSICAL CHEMISTRY II (L-T-P-C: 3-0-0-3)

Unit I: Surface Sciences (15 h)

Adsorption – surface tension, capillary action pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), Catalytic activity at surfaces. Micelles- Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micellar concentration (CMC), factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization-phase separation, solubilisation, micro emulsion, reverse micelles

Unit II: Electrochemistry (15 h)

Electrochemistry of solutions. Debye-Hückel-Onsager treatment and its extension, ion-solvent interactions, Debye-Hückel-Jerum model. Thermodynamics of electrified interface equations, derivation of electro-capillarity, Lippmann equations (surface excess), methods of determination. Structure of electrified interfaces- Guoy-Chappman, Stern, Graham-Devanathan-Mottwatts models. Polarography theory- Ilkovic equation, half-wave potential, and its significance. Introduction to corrosion, homogeneous theory, forms of corrosion monitoring, and prevention methods.

Unit III: Catalysis (15 h)

Mechanism of surface reactions. Surface heterogeneity, activity and selectivity, deactivation, and regeneration. Theories of promotion and poisoning of catalysts. Catalyst Synthesis: supports and supported catalysts. Zeolites and zeolite-like materials, precipitation, and impregnation methods. Characterization of catalysts: Surface area, pore size distribution (mercury porosimetry) Thermal methods (DTA, TG, TPD, and TPR), Surface acidity, Photoelectron spectroscopy (XPS, AES, XRF, LEED, Mossbauer spectroscopy, IR, SIMS, Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM).

Reading references:

1. M. J. Schick. Non-ionic surfactants. Surfactant Science Series. 1985, Volume 72.
2. P. Ghosh. Colloids and Interface Science. PHI Learning Pvt. Ltd. New Delhi. 2009.
3. M. J. Rosen. Surfactants and Interfacial Phenomena. John Wiley, New Jersey. 2004, 3rd Ed.
4. M. R. Porter. Handbook of surfactants. Chapman and Hall, London. 1994, 2nd Ed.
5. A.W. Adamson. Physical Chemistry of Surface. John Wiley. 1997, 6th Ed.
6. John O'M. Bockris and Amulya K. N. Reddy. Modern electrochemistry Vol-II. 2018, 2nd Ed.
7. A Tager. Physical chemistry of Polymer. Mir. Pub. Russia. 1978.
8. H. S. Harned and B. B. Owen. Physical Chemistry of Electrolytic Solution. Reinhold. 1950.
9. Samuel Glasstone. Text Book of Physical Chemistry. Macmillan Publishers. 1948.

CH4 204: BIOORGANIC CHEMISTRY (L-T-P-C: 3-0-0-3)

Unit I: Peptides, Proteins, and Carbohydrates (15 h)

Peptides and Proteins**:** Primary and secondary structures of proteins are forces responsible for holding secondary structures. α-helix, β-sheets, superb secondary structures, triple helix structure of collagen. Tertiary structure of protein-folding and domain structure, Quaternary structure. Sequence determination; chemical/enzymatic/mass spectral, racemization/detection.

Carbohydrates: Structural polysaccharides-cellulose and chitin. Storage polysaccharides-starch and glycogen. Structure and biological function of glucosamine glycans or mucopolysaccharides. Carbohydrates of glycoproteins and glycolipids.

Unit II: Lipids and Nucleic Acids (15 h)

Lipids: structure and function of triacylglycerols, glycerol phospholipids, sphingo lipids, cholesterol, bile acids, prostaglandins eicosanoids, leukotriene. Lipoproteins-composition and function, role in atherosclerosis. Properties of lipid aggregates-micelles, bilayers, liposomes and their possible biological function.

Nucleic Acids: Structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA, and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. Chemical synthesis of mono and tri-nucleoside. The chemical basis for heredity, an overview of replication of DNA, transcription, translation, and genetic code. Introduction regarding peptide nucleic acids. Gene therapy, antigene/antisense therapy.

Unit III: Enzymes (15 h)

Enzymes, Coenzymes, enzyme-kinetics, mechanism, metalloenzymes, applications of enzymes in organic synthesis, enzyme-models and applications. Nucleophilic displacement on phosphorus atom, multiple displacement reactions, and the coupling of ATP cleavage to endergonic processes. Transfer of sulfate, addition and elimination reactions, enolic intermediates in isomerization reactions, β-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme-catalyzed carboxylation and decarboxylation. Catalytic triad, Enzyme inhibition, and drug design. Molecular recognition, chiral recognition, crown ethers, cryptands, host-guest chemistry. ~~Cyclodextrins, Porphyrins applications in Stereo, regio selective organic transformations, cyclodextrin based models, micelles and reverse micelles, Self-assembling systems, and hydrogen bonding in molecular organization. Chemoselective reduction of β-ketoesters with Bakers yeast. Self-immulative chirality, Synthesis of Biotin.~~

Reading references:

1. L. Lehninger. Principles of Biochemistry. worth publishers. 2007, 7th Ed.
2. L. Stryer, W. H. Freeman. Biochemistry. 2019, 5th Ed.
3. Voet and Voet. Biochemistry. Wiley. 2010, 3rd Ed.
4. J. David and Rawn. Biochemistry. Neil Patterson. 1989, International Ed.
5. E. E. Conn and P. K. Stumpf. Outlines of Biochemistry. John wiley. 2006, 5th Ed.
6. Trevor Palmer. Understanding Enzymes. Prentice Hall. 1995, 2nd Ed.
7. E. d. Collins and J. Suckling. Enzyme Chemistry: Impact and Applications. Chapman and Hall. 1990, 2nd Ed.
8. U. Satyanarayana and U. Chakrapani. Essentials of Biochemistry, Elsevier Health Sciences. 2021, 3rd Ed.
9. Robert K. Murray, Victor W. Rodwell, David Bender, Kathleen M. Botham, P. Anthony Weil, Peter J. Kennelly. Harper's Illustrated Biochemistry. McGraw Hill Professional. 2009, 28th Ed.

CH4 205: SPECTROSCOPY-I (L-T-P-C: 3-0-0-3)

Unit I: Vibrational, UV, and IR Spectroscopy (15 h)

Vibrational Spectroscopy: Rotational and vibrational spectra. Moment of inertia and rotational spectra of rigid and non-rigid diatomic molecules. Vibrational excitation effect. Rotational spectra of symmetric - top molecules. Trak effect. Vibrational energy of diatomic molecules. Anharmonic oscillator, overtones and hot bands. Diatomic vibrator rotator (P, Q and R branches of diatomic vibrator rotator). Rotational vibrational spectra of symmetric top molecules.

UV Spectroscopy: Origin of electronic spectra, Lambert-Beer's absorption law, Types of electronic transitions. Effect of solvent, substituent, conjugation on electronic transitions. Benzene and its substituted derivatives. Applications of UV-visible spectroscopy in analysis (qualitative/quantitative) of polyenes/aromatic (hetero & homo) systems, geometrical isomers, keto-enol tautomer's, components of a mixture, ionization constants of acids and bases. Woodward-Fieser rules for calculating absorption maximum in dienes, trienes and α, β-unsaturated carbonyl compounds.

IR Spectroscopy: Instrumentation–sources-sampling techniques. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of hydrogen bonding and solvent effect on vibrational frequencies, overtones, combination bands and Fermi resonance.

Unit II: NMR Spectroscopy (15 h)

Introduction, Definition, Chemical shift, spin-spin interaction, shielding mechanism, mechanism of measurement, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, carbonyl and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), effect of deuteration, complex spin-spin interaction between two, three nuclei. Stereochemistry, hindered rotation, Karplus curve variation of coupling constant with dihedral angle. nuclear Over Hauser effect (NOE).

Unit III: Mass Spectroscopy (15 h)

Origin of mass spectrum, principles of EI mass spectrometer- Instrumentation. Preliminary account of chemical ionization, Types of fragments: odd electron and even electron containing neutral and charged species (even electron rule, Nitrogen rule, isotopic peaks, metastable ion peaks, determination of molecular formula and High-resolution mass spectrometry. Salient features of fragmentation pattern of organic compounds- α-cleavage, β-cleavage, McLafferty rearrangement, Fragmentation pattern of individual heterocyclic systems viz., Furan, Pyrrole, Thiophene and Pyridine.

Reading references:

1. C. N. Banwell and E. M. McCash. Fundamentals of Molecular Spectroscopy. Mc Grew Hill. 2011, 4th Ed.
2. Aruldhas. Molecular structure and Spectroscopy. Prentice Hall. 2004, 2nd Ed.
3. Silverstein, Basseler and Morril. Spectroscopic identification of organic compounds. Wiley. 2014, 8th Ed.
4. Y. R. Sharma. Elementary Organic Spectroscopy. S Chand Publishers. 2007, Revised Ed.
5. Rita Kakkar. Atomic and Molecular Spectroscopy. Cambridge University Press. 2015.
6. Willam Kemp. Organic Spectroscopy 3rd Ed. 1990 Reprint
7. William Kemp. Organic Spectroscopy. MACMILLAN. 1994, 3rd Ed.
8. DH Williams and I Fleming. Spectroscopic methods in Organic chemistry. McGraw-Hill Education. 1995, 5th Ed.
9. Andrew B Derome. Modern NMR techniques for chemistry research. Pergamon. 1987, Reprinted Ed.
10. Pavia. Introduction to organic spectroscopy. Cengage India Private Limited. 2015, 5th Ed.
11. G. C. Levy and O. L. Nelson. Carbon-13 NMR for organic chemists. Wiley. 1980, 2nd Ed.
12. Atta-Ur-Rahman. Nuclear Magnetic Resonance Basic principles. Springer-Verlag New York Inc. 2011.
13. P. S. Kalsi. Spectroscopy of organic compounds. New Age International Private Limited. 2020, 8th Ed.

14. R.V. Parish. NMR, NOR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry. Ellis Horwood. 1990.
15. M.L. Martin, J. J. Delpeuch and G. J. IV Brtin, Heyden. Practical NMR Spectroscopy. Heyden. 1979.
16. R.J. Abraham, J. Fisher and P. Loftus. Introduction to NMR Spectroscopy. Wiley. 1992, 1nd Ed.
17. J. R. Dyer. Application of Spectroscopy of Organic Compounds. Prentice Hall. 1998.
18. D. H. Williams and I. Fleming. Spectroscopic Methods in Organic Chemistry. Tata McGraw-Hill. 2011, 6th Ed.

CH4 207: PHYSICAL CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

1. To determine the percentage composition of strong acid and weak acid in a given mixture using the Conductometric method. (Conductometry)
2. To determine the rate constant and energy of activation of hydrolysis of methyl acetate at two different temperatures. (Conductometry)
3. To determine the relative strengths of the given strong acids by studying the kinetics of inversion of cane sugar using the polarimetric method. (Conductometry)
4. To determine the Critical Micelle Concentration of a given surfactant (SDS) by conductometric method. (Potentiometry)
5. To determine the viscosity average molecular weight of a given polymer sample using Ostwald's viscometer. (pH metry)
6. To determine the Redox potential of Fe^{2+}/ Fe^{3+} system by potentiometric method. (pH metry)
7. To determine the strength of a given unknown $AgNO_3$ using the potentiometric method. (pH metry)
8. To determine the dissociation constants (pK_1 and pK_2) of a given dibasic acid using the pH-metric method. (pH metry)
9. To determine the K_{sp} of Barium Sulphate, Silver Chloride, and Silver Chromate using the conductometric method. (Colorimetry)
10. To determine the dissociation constant of monobasic acids (acetic acid, benzoic acid and Salicylic acid) by potentiometric method. (Viscometry)
11. Kinetic study of the esterification of an alcohol by NMR Spectroscopy. (Chemical kinetics)
12. Thermodynamics of Denaturation of Bovine Serum Albumin. (Thermodynamics)
13. Determination of Critical Micelle Concentration of Some Surfactants by Electrochemistry. (Electrochemistry)
14. Determination of the equilibrium constant for the formation of tri-iodide ion. (Chemical equilibrium)
15. Determination of the chain linkage in poly (vinyl alcohol) from viscosity measurements. (Viscometry)

Reading references:

1. B. D. Kholsa, V. C. Garg, Senior Practical Physical Chemistry Delhi: R. Chand, 2018, 18th Edition
2. B. Viswanathan, P. S. Raghavan Practical Physical Chemistry Navi Mumbai Viva Books Private Limited 2017, 1st Edition
3. A. K. Nad, B. Mahapatra, A. Ghoshal. An Advanced Course in Practical Chemistry Paperback, l New Central Book Agency P LTD 2012, 3rd Edition
4. J. N. Gurtu and Amit Gurtu Advanced Physical Chemistry Experiments Pragati Prakashan 2008,

CH4 208: ANALYTICAL TECHNIQUES LABORATORY (L-T-P-C: 0-0-8-4)

1. Determination of PI of Amino acid by titration method.
2. Identification of monosaccharides and di-saccharides by recrystallization.
3. Separation of amino acids by TLC.
4. Estimation of total sugar by the Anthrone method.
5. Estimation of amino acid by Anthrone method.
6. Estimation of protein by Lowery's method.
7. Determination of Iodine number and acetyl number of Lipid molecules.

8. Separation of amino acids by paper chromatography.
9. Determination of Bathochromic shift in alkaline medium of p-Nitro phenol compared to p-Nitro phenol.
10. Determination Hypsochromic shift in the acidic medium of Aniline compared to Aniline
11. Recording the I.R Spectrum of Different Organic compounds:
12. Aliphatic and aromatic alcohols. b) Aliphatic and aromatic carbonyl compounds (aldehydes, ketones, esters and acids, etc.
13. Aromatic and aliphatic Nitro, Amines, Nitriles, alkenes, alkynes, and Amides.

Reading references:

1. R. Katoch. Analytical techniques in Biochemistry and Molecular Biology. Springer. 2011.
2. H. Martin. Basic methods for the Biochemical Lab. Springer. 2007.
3. K. Wilson. And J. Walker. Principles and Techniques in Biochemistry and Molecular Biology. Cambridge University Press. 2010, 7th Ed.
4. J. A. A. Chambers and D. Rickwood. Biochemistry Lab fax Ed. Blackwell Science. 1993.
5. T. S. Work and E. Work. Laboratory Techniques in Biochemistry and molecular biology Vol. I & II. North-Holland. 1970.
6. R. K. Bansal. Practical Organic Chemistry Practical Organic Chemistry. New Age International Private Limited. 2008, 5th Ed.
7. D. Field, S. Sternhell, J. R. Kalman. Organic Structures from Spectra. Wiley & Sons, Ltd. 2008, 4th Ed.
8. Mann and Saunders. Practical Organic Chemistry. Pearson Education India. 2009, 4th Ed.
9. William. Kemp. Organic Spectroscopy. MacMillan. 1994, 3rd Ed.
10. P. S. Kalsi. Spectroscopy of Organic Compounds. New age international publishers. 2007, 6th Ed.
11. Y. R. Sharma. Elementary Organic Spectroscopy – Principles and Chemical applications. S. Chand. 1992, 5th Ed.

SEMESTER III

SYLLABUS WITH COURSE LEARNING OUTCOME (CLO)

CH5 AN101: ANALYTICAL CHEMISTRY II: PHARMACEUTICAL ANALYSIS AND MEASUREMENTS (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry (**Analytical**)	**Semester:** III
Course code: CH5 AN101	**Course name:** ANALYTICAL CHEMISTRY II: PHARMACEUTICAL ANALYSIS AND MEASUREMENTS

Lect.	Practical (Hours/week)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing Marks
3	0	3	45	Lecture	CCE, ESE	100	35

Course Description: This course deals with the basics of Analytical Chemistry. From this course, students will learn several instrumental techniques used in different industries as well as research institutes. The students will also get the opportunity to gain hands-on experience in analyzing different compounds using various instruments with various spectrophotometric techniques along with practical knowledge. This course also deals with various chromatographic techniques.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Explain the importance of Analytical techniques in Research & Development processes.
CLO2: Operate several analytical instruments for characterizations.
CLO3: Analyze several analytical data representation techniques.
CLO4: Demonstrate instruments standard operating procedures and data plots.

Detailed Syllabus

Units	Content	Hours
I	**Automation in Measurements:** Principles of automation, automatic and automated devices, Process control: off-line, at-line, and on-line analysis. Continuous and discrete analyzer's, feedback mechanism. Flow injection analysis, principles, dispersion coefficient, factors affecting peak height-sample volume, channel length, flow rate, and channel geometry. Applications of FIA, stopped-flow measurements, and gradient FIA.	**15**
II	**Food Analysis and Pharmaceutical Analysis:** Introduction to food analysis, regulations and international standards related to food analysis, nutritional labelling, sample and sample preparation. Compositional analysis of foods for moisture, proteins, fat, fibres, ash, vitamins and minerals. Adulteration of fats and oils; milk and milk products. Instrumental and titrimetric assays for anti-diabetic, anti-cancer, anti-tuberculosis, antimalarial, anti-hypertensive and anti-HIV drugs based on USP/BP/IP. Heavy metal ion analysis in pharmaceuticals. Importance of UV-Visible spectrophotometry, IR spectroscopy and HPLC with UV, fluorescence and photodiode array detection in pharmaceutical industry.	**15**

III	**Analysis of pesticides, soaps and detergents, fertilizers:** Classification of pesticides. Analysis of different pesticides by classical and instrumental methods. Classification of soaps and detergents with suitable examples. Characterization of soaps and detergents. Types of fertilizers and analysis of different elements like, nitrogen, phosphates, calcium, sodium, potassium and ammonia.	**15**

Self-learning topics:
Unit-I Several instrumental detail with their working principle
Unit-II Heavy metal ion analysis in pharmaceuticals
Unit-III Soap and detergents

Reference Books:

1. Gary D. Christian. Analytical Chemistry. John Wiley and Sons Inc. New Jersey. 2007, 6th Ed.
2. Douglas A. Skoog. Principles of Instrumental Analysis. HoltSaunders International Edition. 1016, 7rd Ed.
3. Jose Martinez Calatayud. Flow injection analysis of pharmaceuticals: automation in the laboratory. Taylor and Francis. 1996. 1st Ed.
4. S. Suzanne Nielsen. Food Analysis. Springer. 2003, 3rd Ed.
5. S. Suzanne Nielsen. Food Analysis Laboratory Manual. Springer. 2003, 3rd Ed.
6. P. D. Sethi. Quantitative Analysis of Drugs in Pharmaceutical Formulation. CBS Publishers. 2008, 3rd Ed.
7. Satinder Ahuja and Stephen Scypinski. Handbook of Modern Pharmaceutical Analysis. Academic Press. 2001, Volume 3.
8. F.J. Welcher. Standard Method of Chemical Analysis, volume1,2&3, Part two. Van Nostr and Reinhold Company. 1917, 6th Ed.

CH5 102: ANALYTICAL CHEMISTRY III: ELECTROANALYTICAL TECHNIQUES (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 AN102	**Course name:** ANALYTICAL CHEMISTRY-III: ELECTROANALYTICAL TECHNIQUES

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
3	-	3	45	Lecture	CCE, ESE	100	35

Course Description: This course deals with understanding different electro gravimetric analyses. This course also explains the principles of potentiometry, voltammetry, Polarography, and Cyclic Voltammetry. This course also delivers the idea about different kinds of electrodes used in different techniques.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: State different techniques used for electrogravimetry analysis
CLO2: Summarize the working principle of different techniques.
CLO3: Identify the different types of electrodes used in different techniques
CLO4: Analyze different electroanalytical titration used for the separation method.

Detailed Syllabus

Units	Content	Hours
I	**Electroanalytical Measurements and Voltammetry:** Voltage, Impedance, The electric double layer, Electro capillarity, Current, Diffusion transport. Fundamentals, conventional or DC polarography, theoretical principles, complex ions, quantitative techniques, the effect of oxygen, simple polarography and classical DC polarography, the three electrode polarograph: potentiostatic control, modified voltammetry, cyclic voltammetry, quantitative applications of polarography.	**15**
II	**Potentiometry, Polarography, and Coulometry:** Fundamentals, reference electrode, indicator and ion-selective electrodes, Instrumentation and measurement of cell emf Polarography: Theory, apparatus: derivative polarography, modified polarographic techniques, sinusoidal AC polarography, pulse polarography, chronopotentiometry and their application in qualitative and quantitative analysis. Coulometry: Introduction: principles, technique, coulometry at constant current and controlled potential coulometry, applications, and stripping analysis. Unit-III: High-frequency titration Introduction: theory and instrumentation, high frequency titrimetric, types of cells. Advantages of high-frequency methods, applications.	**15**
III	**Electrochemical and Bio-sensors:** Potentiometric sensors, Potentiometric biosensors, Amperometry sensors, Conductometric sensors, Applications of Field-Effect Transistors sensors such as chemorestive sensors. Fluorescence-based biosensors.	**15**

Reading references:

1. Peter T. Kissinger and William R. Heineman. Laboratory Techniques in Electroanalytical Chemistry. Marcel Dekker Inc., New York. 1996, 2nd Ed.
2. Basil H. Vassos and Galen W. Ewing. Electroanalytical Chemistry. John Wiley & Sons, New York. 1983.
3. Allen J. Bard and Larry R. Faulkner. Electrochemical Methods–Fundamentals and Applications. John Wiley & Sons, New York. 2001, 2nd Ed.
4. Daniel C. Harris. Quantitative Chemical Analysis. W. H. Freemanan d Company, New York. 2015, 9th ed.
5. I. M. Kolthoff and P.J. Elving. Treatiseon Analytical Chemistry. Wiley Interscience, NewYork. 1968.
6. Brian R. Eggins. Chemical Sensors and Biosensors. John Wiley & Sons, NewYork. 2002, 1st Ed.

CH5 AN103: ANALYTICAL CHEMISTRY IV: QA QC VALIDATION (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 AN103	**Course name:** ANALYTICAL CHEMISTRY-IV: QA QC VALIDATION

Lect.	Practical	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing Marks
3	0	3	45	Lecture	CCE, ESE	100	35

Course Description: This course deals with the detail understanding of quality assurance and quality control in chemical and material analysis. From this course, students will learn various aspects of quality assurance and quality control for industry. This course also explains the importance of accuracy, precision, quality control in analysis. The

students will also learn the importance of reference material and basics of development and validation of analytical methods in chemical or pharmaceutical industry.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Explain the significance of quality control and assurance.
CLO2: Understand the operating procedures of analytical
CLO3: Analyze analytical data and their interpretation.
CLO4: Demonstrate quantitative determination of the given sample using various techniques.

Detailed Syllabus

Units	Content	Hours
I	**Quality Assurance and Quality Control:** Industrial Analysis: Quality characteristics of chemical analysis, errors occurring at the start, during or by the end of the analysis, Shewhart Chart, CUSUM chart and EWMA chart; Batch and process evaluation, QA schemes, experimental designs for optimization studies and ruggedness testing, system management. Clinical Analysis: Introduction, analytical responsibilities, Managerial responsibilities, practical approaches to QA, characterization of a method, Results, and preparation of reports. Internal QC, Accuracy and external quality assessment, near-patient testing, and QC. Water Industry: Water quality field sampling QA/QC program, QA/QC documentation, QA project plan, designing a water quality monitoring plan, Site selection, sampling frequency and sample size, cost considerations, training of field personnel, field trip preparations, Water quality sampling, toxic chemicals in bottom sampling and biota, bacterial sample collection, sequential triplicate sampling, sample handling, preservation, storage and transport, chain of custody, field safety, field audit program.	**15**
II	**Reference Materials:** Analytical standards, primary and secondary standards, high purity substances, reference materials, use of RMs in statistical control schemes and in intercomparisons, the role of certified reference materials (CRMs), production and requirements, obtaining reference value and certified value.	**15**
III	**Development and validation of Analytical Methods:** Analytical method development: Theory and factors affecting resolution separation factor (selectivity), retention factor (capacity factor), and column efficiency). Selecting the HPLC separation mode (reversed phase, normal phase etc.) Selecting the most appropriate detector Gradient/isocratic operation, selecting the column for analysis, Selecting and optimizing the mobile phase, the effect of pH, considering pKa of the analytic Requirements for a stability-indicating analytical method, Anticipation of likely degradation products, From experience with the compound, From forced degradation (stress testing) of drug substance, as per ICH guidance, Note findings of stress-testing industry comparison, Calculation of mass balance and its significance Validation of methods Introduction to ICH guidelines: ICH Q2(R1).	**15**

Self-learning topics:
Unit-I Shewhart Chart, CUSUM chart, and EWMA chart
Unit-II High-purity substances
Unit-III Introduction to ICH guidelines: ICH Q2(R1)

Reading references

1. D. A. Skoog, D. M. West and F. J. Holler. Fundamentals of Analytical Chemistry. Saunders College Publishing. 1991, 2nd Ed.
2. R. A. Day and A. L. Underwood. Quantitative Analysis. Prentice-Hall of India Pvt. Ltd. 1993, 6th Ed.
3. Ian A. Fowlis. Gas Chromatography. Analytical chemistry. Open Book Learning. 1995, 2nd Ed.
4. Larry Hargis. Analytical Chemistry: Principles and techniques. Pearson. 1988, Facsimile Ed.

5. Satinder Ahuja and Stephen Scypinski, Handbook of Modern Pharmaceutical Analysis, Volume 3, Academic Press, 2001.
6. F.J. Welcher, Standard Method of Chemical Analysis 6th edition, volume1,2&3, Van Nostr and Reinhold Company.

CH5 104: Spectroscopy II (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 104	**Course name:** Spectroscopy II

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
3	-	3	45	Lecture	CCE, ESE	100	35

Course Description: This course deals with understanding of concept of NMR, 13C, Raman and Mossbauer spectroscopy. Which cover first and second order spectra, method of simplification of second order spectra. From this course, students will learn the analysis and structure elucidation of organic compounds using 2D NMR. This course also covers the Rotational and Vibrational Raman spectra and application of Mossbauer spectroscopy.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Remember the basic concept of 1H and 13C, Raman and Mossbauer spectroscopy
CLO2: Understand the concept of first and second order spectra
CLO3: Apply the knowledge for structure elucidation of organic compound.
CLO4: Analyze the ^{1}H, ^{13}C NMR and IR spectra of organic compounds

Detailed Syllabus

Units	Content	Hours
I	**NMR Spectroscopy** -Differences between first order and Second order effects, examples of AB, AX, A2X2, AX2, AA'XX', AMC and ABX systems, simplification of second order spectrum, selective decoupling, use of chemical shift reagents for stereochemical assignments. Study of dynamic processes by VT NMR, restricted rotation (DMF, DMA, biphenyls, annulenes), cyclohexane ring inversion, degenerate rearrangements (bullvalene and related systems).	**15**
II	**Carbon-13 NMR Spectroscopy**- 13C NMR, introduction to FT technique, relaxation phenomena, NOE effects, 1H and 13C chemical shifts to structure correlations. Editing techniques: INEPT and DEPT methods, Chemical shift and (Aliphatic, olefinic, Alkyne, Aromatic, Heteroaromatic and carbonyl carbon), Coupling constants. Introduction to two-dimension NMR spectroscopy. COSY, HMBC, HMQC, NOESY. Time scale- Multinuclear	**15**
III	**Raman spectroscopy-** Quantum theory of Raman effect, Classical theory of Raman effect, Pure rotational Raman spectra, Raman activity of vibrations, Vibrational Raman spectra, polarization of light and Raman effect, applications., Mutual exclusion principle **Mossbauer Spectroscopy:** Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe+2 and Fe+3 compounds including those of intermediate spin, (2) Sn+2 and Sn+4 compounds- nature of M-L bond, coordination number, structure and detection of oxidation state and in equivalent MB atoms.	**15**

Reading references:

1. R. M. Silverstein, G. C. Bassler and T. C. Morrill, Spectrometric Identification of Organic Compounds, 1991, John Wiley. 5th Ed.
2. R.J. Abraham, J. Fisher and P. Loftus. Introduction to NMR Spectroscopy. Wiley. 1992, 1nd Ed.
3. J. R. Dyer, Prentice Hall, Application of Spectroscopy of Organic Compounds. Englewood Cliffs, N. J., Prentice-Hall. 1965.
4. D. H. Williams, I. Fleming. Spectroscopic Methods in Organic Chemistry. Tata McGraw-Hill. 1968, 7th Ed.
5. J. L. Mchale. Molecular Spectroscopy. CRC Press. 2017, 2nd Ed.
6. Pavia. Introduction to organic spectroscopy. Cengage India Private Limited. 2015, 5th Ed.
7. D. N. Sartya Narayana. Handbook of Molecular Spectroscopy. J. K. Inter publishers. 2015, 1st Ed.
8. Y. R. Sharma. Elementary Organic Spectroscopy. S Chand Publishers. 2007, Revised Ed.
9. Douglas A. Skoog. Principles of Instrumental Analysis. HoltSaunders International Edition. 2016, 7rd Ed.
10. Rita Kakkar. Atomic and Molecular Spectroscopy. Cambridge University Press. 2015.

CH5 105: SPECTROSCOPY DATA ANALYSIS LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry (Analytical)	**Semester:** III
Course code: CH5 105	**Course name:** SPECTROSCOPY DATA ANALYSIS LABORATORY

Lect.	Practical	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing Marks
--	8	4	120	Lab	ESE	100	35

Course Description: This is a practical course which deals with spectral analysis of various organic compounds which are synthesized in laboratory and chemical industries. This course also explains the various software used in analysis of data in NMR and IR spectroscopy. This course also delivers the learning of structural prediction and confirmation.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Understand the analysis of ^{1}H and ^{13}C-NMR spectra with analysis
CLO2: Explain the IR spectra analysis for functional group determination
CLO3: Apply the knowledge of spectral analysis in structural characterization
CLO4: Demonstrate the application of software for NMR analysis

Detailed Syllabus

Content	Hours
Solving structure elucidation problems using multiple spectroscopic data sheets (NMR, 2D-NMR, MS, IR, GC, HPLC, and UV-Vis) at least 20 examples. (A student will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may	**40**
Determination Bathochromic shift in Alkaline medium of p-Nitro phenol Compared to p-Nitro phenol. Determination Hypsochromic shift in acidic medium of Aniline compared to Aniline.	**20**
Recording the I.R Spectrum Different Organic compounds i. Aliphatic and aromatic alcohols. ii. Aliphatic and aromatic carbonyl compounds (aldehydes, ketones, esters and acids etc.)	**30**

iii. Aromatic and aliphatic Nitro, Amines, Nitriles, alkenes, alkynes and Amides.	
Use of Computer techniques iv. Chem Draw, Chemsketch, ISIS Draw, Pymol calculations, MestrecSoftwares operations. v. Draw the Structure of Simple aliphatic, aromatic and heterocyclic compounds in ChemDraw with different substituents. Get the correct IUPAC Name and predict the ^{1}H-NMR Spectra.	**30**

Reading references:

1. R. K. Bansal. Practical Organic Chemistry Practical Organic Chemistry. New Age International Private Limited. 2008, 5th Ed.
2. D. Field, S. Sternhell, J. R. Kalman. Organic Structures from Spectra. Wiley & Sons, Ltd. 2008, 4th Ed.
3. Mann and Saunders. Practical Organic Chemistry. Pearson Education India. 2009, 4th Ed.
4. William. Kemp. Organic Spectroscopy. MacMillan. 1994, 3rd Ed.
5. P. S. Kalsi. Spectroscopy of organic compounds. New Age International Private Limited. 2020, 8th Ed.
6. Y. R. Sharma. Elementary Organic Spectroscopy – Principles and Chemical Applications. S. Chand. 1992, 5th Ed.

CH5 AN106: ANALYTICAL CHEMISTRY LABORATORY (L-T-P-C: 0-0-8-4)

Program: M. Sc. Chemistry (Analytical)	**Semester:** III
Course code: CH5 AN106	**Course name:** ANALYTICAL CHEMISTRY LABORATORY

Lect.	Practical	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Passing Marks
--	8	4	120	Lab	ESE	100	35

Course Description: This is a practical course which deals with physical analysis of various compounds and materials which are synthesized in laboratory and chemical industries. This course also explains the various data analysis used in potentiometry and conductometry.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Understand the potentiometric analysis of chemical compounds
CLO2: Explain the use of pH meter in sample analysis of acid and base
CLO3: Apply the knowledge of conductometry in analysis of metal complexes
CLO4: Demonstrate the application of polarography and electrogravimetry

Detailed Syllabus

Content	Hours (h)
Potentiometry: Potentiometric Titrations and Calculation of End Point Potentials for the following systems: i) $Fe^{2+}$and VO^{2+} Mixture vs Ce^{4+} ii) Assay of sulphanilamide iii) Silver electrode for silver assay iv) Mixture of halide anions using Silver electrode	**30**
pH-metry:	**30**

1. Determination of CO_3 and HCO_3 in a mixture 2. Determination of the dissociation constants of Ethylene diamine (en)(H_2L) (ii) Glycine (HL) (iii) Histidine mono hydrochloride (H_2L) 3. Determination of binary constants of i) Cu(II) -en and (ii) Ni(II) -His iii) Ni(II) – Gly Systems 4. Determination of stability constant of ternary (o-Phen-Ni(II)-His) system - Calculation of Log K.	
Conductometry: 1. Determination of the Composition of Cu(II)-oxine and Cu(II)-EDTA Complexes 2. Interaction of Pyrophosphate with Mg^{2+}, Ca^{2+}, Mn^{2+} and Cu^{2+} 3. Determination of Aspirin with KOH	**20**
Ion selective electrodes method (Ionimetry): 1. Estimation of fluoride ion in water 2. Estimation of nitrate ion in water 3. Estimation of ammonia in water **Polarography:** 1. Determination of E½ of Cd^{2+} and Pb^{2+} 2. Verification of Ilkovic equation by using Cd^{2+} solution 3. Determination of Stability Constants of Cd^{2+} and Pb^{2+} complexes **Electrogravimetry:** 1. Determination of Copper and Nickel individually and in a Mixture	**40**

Reading references:

1. John H. Kennedy. Analytical Chemistry Practice. Saunders College Publishing. 1990, 2nd Ed.
2. J. Mendham. Vogels Textbook of Quantitative Chemical Analysis, Pearson Education. 2002, 6th Ed.
3. A. I. Vogel. A Text Book of Quantitative Inorganic Analysis. Elbs Publication. 1969, 3rd Ed.
4. Arthur E. Martell and Ramunas J. Motekaitis. Determination and use of Stability Constants. VCH Publishers INC. 1988, 2nd Ed.
5. A. E. Martell and R.D. Handcock. Metal Complexes in Aqueous Solutions. Plenum Press, New York. 1996.
6. Gary D. Christian. Analytical Chemistry.John Wiley & Sons Inc New York. 1994, 6th Ed.

CH5 EAN1: SEPARATION METHODS (L-T-P-C: 2-0-0-2)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 EAN1	**Course name:** SEPARATION METHODS

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
2	--	2	30	Lecture	CCE, ESE	50	18

Course Description: This is an elective course which deals with understanding of various solvent extraction processes used in laboratory and chemical industries. This course explains the details of supercritical fluid extraction (SCF). This course also delivers the working principle and application of chromatographic techniques used in R & D laboratory and chemical industry.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Explain the role of partition coefficient in solvent extraction
CLO2: Classify various solvent systems for extraction of natural and synthetic products
CLO3: Apply the knowledge in recovery and recycling of solvents
CLO4: Demonstrate the working principle of supercritical fluid extraction

Detailed Syllabus

Units	Content	Hours
I	**Solvent Extractions:** The distribution coefficient, distribution ratio, relation between KD& D, and the percent extracted. Solvent extraction of metals – ion association complexes, metal chelates, the effect of pH and reagent concentration, the extraction process, separation efficiency of metal chelates, analytical separations – multiple counter current distribution, solid phase extraction, solvent extraction of flow injection analysis. Supercritical fluid extraction. Organic reagents in Inorganic analysis: Theoretical basis for the use of organic reagents in inorganic analysis. Extraction of metal ions by the use of organic reagents – acetylacetone, thionyl-trifluoro acetone, tri-n-octyl phosphine oxide. Applications to extractions of metal ions by chelating agent (Dithizone, 8-hydroxy quinoline, and cupferron) Determination of salts of organic acids and bases, determination of alkaloids in crude drugs	15
II	**Supercritical Fluid chromatography (SFC) and Electrophoresis:** Instrumentation of SFC stationary and mobile phases used in SFC, Detectors, Advantages of SFC. Technique and applications of SFC. Size Exclusion Chromatography: Principle of Gel Chromatography, Filtration Chromatography, Instrumentation, retention behavior, resolution, selection of gel type – applications. Ion Exclusion – Principle and applications. Ultra-Performance Liquid Chromatography: Principle, Instrumentation **Electrophoresis:** Introduction, Definition Paper Electrophoresis: Principle, Experimental Requirements, Technique, Factors governing the migration of ions, Applications Capillary Electrophoresis: Electro osmotic flow, migration in CE, instrumentation, control of separation, applications Gel Electrophoresis: Principle, technique, applications Immuno electrophoresis: Principle, technique, applications.	15

Reading references:

1. M. N. Sastri. Separation Methods. Himalaya Publishers. 1991, 1st Ed.
2. Skoog, Holler and Nieman. Principles of Instrumental Analysis. Harcourt College Publishers. 1998, 5th Ed.
3. Gary D. Christian. Analytical Chemistry. John Wiley and sons. Inc., New York. 1994, 6th Ed.
4. Robert A. W. Johnstone and Macolm. Mass spectrometry for Chemists and Biochemists. Cambridge University Press. 1996, 2nd Ed.
5. E.A.V. Ebsworth, et al. Structural methods in Inorganic chemistry. ELBS Publications. 1988, 2nd Ed.
6. Raymond PW Scott. Introduction to analytical Gas Chromatography. Marcel Dekker, Inc. New York. 1988, 2nd Ed.

CH5 EAN4: APPLIED ANALYSIS AND GREEN ANALYTICAL CHEMISTRY (L-T-P-C: 2-0-0-2)

Program: M. Sc. Chemistry	**Semester:** III
Course code: CH5 EAN4	**Course name:** APPLIED ANALYSIS AND GREEN ANALYTICAL CHEMISTRY

Lectures	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
2	-	2	30	Lecture	Internal, external	50	18

Course Description: This course involves the applications of analytical chemistry in forensic toxicology, drug analysis, and trace evidence. Through this course, the students will learn the role and importance of analytical chemistry in the identification of trace amounts of chemicals in a crime scene.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Describe the scope of chemical analysis in Forensic Science
CLO2: Understand the necessity of the Green analytical technique and its utility
CLO3: Explain the technical instruments used in chemical analysis in trace amount
CLO4: Demonstrate the knowledge of analytical chemistry in the analysis of crime scene.

Detailed Syllabus

Units	Content	Hours
I	**Forensic Chemical Analysis:** Contact traces – Analysis of soil, fibers and paint evidence in forensic work. Analysis of narcotic drugs and psychotropic substances (opiates, cannabinoids, barbiturates, benzodiazepines, amphetamines with one example each and LSD) by colour/micro crystal tests, chromatographic methods (TLC, GC, and LC) and spectroscopic methods (UV-Vis, IR, MS and GC-MS). chromatographic methods (TLC, GC AND GCMS)and spectroscopic methods (UV-Vis, IR, MS and GC-MS). Analytical toxicology – extraction techniques for dugs and pesticides – analytical techniques in forensic toxicology for alcohols, drugs and pesticides involving spot tests (TLC, GC & LCMS). Interpretation of analytical data – court testimony.	**15**
II	**Green Analytical Chemistry** Green Analytical Chemistry: Concepts and trends "Greening" Sample Treatment: Reduced and solvent- free sample preparation methodologies, alternative solvents, energy saving procedures. Green Instrumental Analysis: Assessment of analytical methods for "Greenness", greening flow injection analysis, chemical sensors, liquid green chromatography.	**15**

Reading references

1. Gary D. Christian. Analytical Chemistry. John Wiley and sons. Inc, New York. 1994, 6th Ed.
2. Marck and Rekniz. Kinetics Methods of Analysis. Volume 25.
3. A. H. Beckett et al. Practical Pharmaceutical Chemistry. Vol. 1 & Vol. 2. CBS Publishers & Distributors. 1986, 3rd Ed.
4. Miguel De La Guardia and Sergio Armenta. Green Analytical Chemistry: Theory & Practice. Elsevier. 2010, 1st Ed.
5. Mihkel Koel and Mihkel Kaljurand. Green Analytical Chemistry. RSC Publishing. 2010.

SEMESTER IV

CH5 AN201: RESEARCH OR INDUSTRIAL PROJECT (L-T-P-C: 0-0-20-10)

Program: M. Sc. Chemistry	**Semester:** IV
Course code: CH5 AN201	**Course name:** RESEARCH OR INDUSTRIAL PROJECT

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
0	20	10	150	Lab	ESE	100	35

Course Description: This is a compulsory course performed in the final semester where the students get a semester-long exposure to research. Students who work on research and industrial projects gain valuable training and experience that can help them in their future careers. Students can work on real-world research projects proposed by industry or public sector sponsors. This course helps to train individuals who contribute to human resources required in the chemical/pharmaceutical industry. The research work may lead to academic research articles as well. They also learn about patents, scientific publications, and literature search tools

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Understand the real-world academic/industrial research problems
CLO2: Apply the knowledge gained during various theoretical and practical courses
CLO3: Design different projects with the knowledge of chemistry to solve existing problems in society
CLO4: Understand data interpretation and data analysis
CLO5: Learn to reboot any experimental problems.

Detailed syllabus: Lab-specific research topics.

CH5 AN202: PROJECT REPORT (L-T-P-C: 2-0-0-2)

Program: M. Sc. Chemistry	**Semester:** IV
Course code: CH5 AN202	**Course name:** PROJECT REPORT

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
2	0	2	30	Lecture	ESE	100	35

Course Description: In this course, the students learn to summarise their learning experiences. They learn the proper ways to write a 'project thesis'. This contains a comprehensive overview of a project's objectives, progress, team performance, and milestone accomplishments. It also gives an account of the challenges faced during a project's execution, solutions devised to tackle them, and the lessons learned during the process. They also learn about different communication medium like Microsoft word, chemdraw etc.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Understand how to report a practical work into a thesis
CLO2: Learn to publish their research results after the program
CLO3: Learn the art of written scientific communications

Detailed syllabus: Depends on the research performed in respective labs.

CH5 AN203: PROJECT PRESENTATION (L-T-P-C: 3-0-0-3)

Program: M. Sc. Chemistry	**Semester:** IV
Course code: CH5 AN203	**Course name:** PROJECT PRESENTATION

Lect.	Practical (Hours)	Credits	Total Hours	Evaluation Scheme			
				Component	Exam	Max. Marks	Pass
3	0	3	45	Lecture	ESE	100	35

Course Description: In this course, the students mainly learn to communicate their work performed to the audience. They learn to use different communication mediums (for example Microsoft PowerPoint) and convince their audience about the research findings. This course helps students to increase confidence, presence, and enjoyment of public speaking. The students also learn to use vocal techniques; use tone, range, articulation, power, pace, and pausing to make an impact. The students learn the use of body language and gestures to create credibility.

Course Learning Outcomes: At the end of this course students will be able to

CLO1: Develop proper communication skills.
CLO2: Defend their accomplished research in front of experts.
CLO3: Gain confidence in facing job interviews.

Detailed syllabus: Depends on the research performed in respective labs.

~:The End:~