Fergusson College (Autonomous) Pune

Learning Outcomes-Based Curriculum

for

M.Sc. II- Analytical Chemistry

With effect from June 2024

Programme Structure

Semester	Paper Code	Paper Title	Credits
III	CHA -601	Advanced Analytical Techniques	4
	CHA -602	Separation Techniques	4
	CHA -603	Nanotechnology	4
	CHA -604 OR	Pharmaceutical Chemistry	4
	CHA -605	Industrial material analysis-I	
	CHA -620	Analytical Chemistry Practical - V	2
	CHA -621	Analytical Chemistry Practical - VI	2
		Total Semester Credits	20
IV	CHA -651	Forensic science and Toxicology	4
	CHA -652 OR	Spectroscopic Techniques	4
	CHA -654	Industrial material analysis-II	
	CHA -610	Research Project I	4
	CHA -660	Research Project II	6
	CHA -670	Analytical Chemistry Practical - VII	2
		Total Semester Credits	20
		Total PG-II Credits	40

	S.Y. M.Sc. Semester III	
Title of the Course and Course Code	**Advanced Analytical Techniques CHA -601**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Recall and describe the basic concepts in analytical chemistry and different analytical techniques.	
CO2	Explain the working principles and instrumentation of electro analytical, thermal, luminescence techniques.	
CO3	Illustrate the applications of advanced analytical techniques for various types of chemical analysis.	
CO4	Identify and interpret experimental/spectral data and apply knowledge to solve numericals.	
CO5	Compare electroanalytical, thermal, luminescence based techniques based on their principles and applications.	
CO6	Develop ability to apply different techniques to assess physicochemical properties.	

Unit. No.	Title of Unit and Contents
I	**Concepts in Analytical Chemistry (15 L)** Sample preparation: acid digestion and flux method, dry and wet ashing methods. Calibration of apparatus, Calibration curve method, standard addition and internal standard methods and numericals, Statistical treatment.

II	**Electro-analytical technique (15 L)** **a. Coulometry:** Principle, Instrumentations, Coulometric titrations – Apparatus, Specific Applications of Coulometry., advantages and limitations, problems. **b. Polarography:** Principle, Instrumentation, Ilkovic Equation, advantages and disadvantages of dropping mercury electrode, applications and numericals. **c. Cyclic Voltammetry and Amperometry:** Principle, instrumentation and applications (cyclic voltamogram of $K_3[Fe(CN)_6]$) and numericals.
III	**Thermal Methods of Analysis (15 L)** **a. Thermo gravimetric methods of analysis:** Instrumentation, thermogram and information from thermogram, factors affecting thermogram, applications TGA for quantitative analysis and problems based TGA. **b. Differential Thermal Analysis (DTA):** Principle, instrumentation, differential thermogram, simultaneous TG-DTA, Applications **c. Differential Scanning Calorimetry (DSC):** Principle, Instrumentation, and Applications. **d. Thermometric titrations and evolved gas analysis(EGA):** Principle, Instrumentation, and Applications
IV	**Chemiluminescence, Fluorescence and phosphorescence: (15 L)** Introduction, principle, types, instrumentation, quantitative chemiluminescence, gas phase chemiluminescence analysis, chemiluminescence titrations, electro-chemiluminescence**,** Photo luminescent (theory and instrumentation), photo luminescent spectra, photo luminescent analysis, analysis of non-photoluminating compounds specific examples of analysis using photoluminescence, application of Fluorescence-Polarization Assays in Small Molecule Screening.

Reference Books:

1. Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987).
2. Instrumental methods of chemical analysis by H. Willard, L. Merrit, J.A. Dean and F.A. Settle. Sixth edition CBS (1986).
3. Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992).
4. Principles of Instrumental Analysis Skoog, West, Niemann.
5. Thermal analysis by W.W. Wendlandt, John Wiley, (1986).
6. Cyclic Voltammetry and frontiers of electrochemistry by N.Noel and K.I. Vasu IBH, New Delhi (1990).

7. Electrochemical Methods: Fundamentals and Applications by Allen J. Bard and Larry R. Faulkn.

Title of the Course and Course Code	**Separation Techniques CHA -602**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Define terminologies involved in extraction process, chromatographic techniques and method validation	
CO2	Distinguish between different types of extraction techniques and chromatographic techniques.	
CO3	Solve numericals based on concepts involved in separation techniques.	
CO4	Outline several applications of advanced extraction and chromatography.	
CO5	Explain various separation techniques and processes involved.	
CO6	Develop knowledge related to important theoretical principles of chromatographic methods, which will enable them to select, implement and optimize a chromatographic separation technique in their future work.	

Unit. No.	**Title of Unit and Contents**
I	**Classical Approach to Extraction Techniques: (5L)** Introduction, Liquid-Liquid extraction (selection of solvents, solvent extraction, limitations), purge and trap for volatile organics in aqueous samples.
II	**Solid Phase Extraction (SPE): (10L)** Introduction, Types of SPE media and apparatus, method for SPE operation, solvent selection, factors affecting SPE, Automation and On-Line SPE. Introduction to Solid phase micro-extraction, New development in micro extraction (liquid micro extraction, membrane micro extraction).

III	**Microwave Assisted and Supercritical Fluid Extraction (5L)** MAE (Introduction, instrumentation with Applications), Supercritical fluid extraction (concept of critical state of matter and super critical state, types of super critical fluids, apparatus and applications).
IV	**Concepts in chromatographic techniques: (10L)** System parameter: chromatogram, column performance, retention time, retention volume, dead volume, capacity factor, selectivity factor, resolution, The plate theory, Height equivalent to a theoretical plate (HETP), Van-Demeter equation and its applications, optimization of a chromatographic analysis and numericals.
V	**High Performance Liquid Chromatography: (10L)** Theory and instrumentation (solvents, Mobile phase delivery system, Pumps, Injectors, Columns, Stationary phases, Mobile phases, Paired-ion chromatography, Types of detectors). Types of liquid Chromatography, LC-MS, Applications, Calibration, Troubleshooting and numericals. Impurity profiling: Types of impurities in drugs. method development for impurity analysis, identification and quantitation. isolation of drug impurities by preparative HPLC.
VI	**Gas Chromatography: (10L)** Theory and Instrumentation, Carrier gas system, Sample injectors, Stationary Phase, Columns, Solid/Liquid Stationary phases, , programmed temperature gas chromatography, Types of detectors, GC-MS, Applications, Calibration, troubleshooting and numericals.
VII	**Method Development in chromatography: (5L)** Introduction, steps in method development, parameters for method development. (column, stationary phase, mobile phase, pH range, solvent composition, detectors, temperature).
VIII	**Method validation: (5L)** Method validation process: Types of analytical procedures to be validated, role of validation within quality assurance, Evolution of a new method, Identification, Assay, Impurities, Precision, Accuracy, Specificity, Linearity, Range, Limit of Detection, Ruggedness, Robustness, Stability.

Reference

1. Modern analytical techniques in the pharmaceutical and bio analysis by Dr. Istvan Bak (Book Available Online).
2. Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (free e-book available on internet).
3. Extraction technique in analytical science, John R. Dean, Wiley (2009).
4. Practical HPLC method Development, Snyder, Kirki and Glajch, Wiley India Pvt. Ltd.
5. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
6. Analytical chemistry principles by John H. Kenedey- Second edition, Saunders college publishing.
7. Instrumental analysis by Skoog and Holler.
8. Instrumental methods of chemical analysis by Willard, Dean and Merittee- Sixth edition.

Title of the Course and Course Code	**Nanotechnology CHA-603**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Outline the basic terminologies and concepts in nanotechnology.	
CO2	Summarize different applications of nanomaterials in various sectors	
CO3	Illustrate different techniques for synthesis of nanomaterials	
CO4	Explain various characterization techniques to study different properties of nanomaterials.	
CO5	Review environmental impacts and toxicological health effects of nanotechnology.	

CO6	Compile investigations of nanomaterials using various characterization techniques, analyze and interpret data to draw valid conclusions.

Unit.No.	Title of Unit and Contents
I	**Introduction to Nanomaterials: (15 L)** Fundamental concepts of nanomaterials, synthesis routes (Bottom-Up Approaches, Top-Down Approaches), Nanostructured Materials with High Application Potential.
II	**Analytical Techniques for Characterization of Nanomaterial (25 L)** a. **Electron Microscopy:** Introduction, principle of Ultraviolet photoelectron spectroscopy (UPS) and X-ray photoelectron spectroscopy (XPS), Scanning Transmission Electron Microscope (STM), Scanning electron microscopy (SEM) and Transmission Electron Microscopy (TEM), Analytical Electron Microscopy, Scanning-Probe Microscopes – principle, instrumentation and applications. b. **X- ray Methods of Analysis:** Principle, Theory, instrumentation, Powder XRD and Single crystal XRD, Chemical analysis using X-ray absorption, X-ray Fluorescence- instrumentation and chemical analysis, X-ray Diffraction, Chemical analysis with X-ray diffraction, numericals. c. **XRF:** Principle, instrumentation and application d. **BET:** Principle, instrumentation and application
III	**Applications of Nanotechnology: (15 L)** Electronics, Sensors, Medicinal, Agriculture, Food, Renewable energy, Industrial material
IV	**Environmental Impacts of Nanotechnology: (5 L)** Introduction, routes of entry, toxic mechanisms, environmental implications of nanoparticles, toxicological health effects, relevant parameters in nanoparticle toxicology, integrated concept of risk assessment of nanoparticles.

Reference

1. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition
2. Analytical chemistry principles by John H. Kenedey- Second edition, Saunders college publishing.
3. Electron microscopy in the study of material, P. J Grundy and G. A Jones, Edward Arnold.
4. Instrumental analysis by Skoog and Holler.
5. Instrumental methods of chemical analysis by Willard, Dean and Merittee- Sixth edition.
6. An Introduction to Nanoscience and Nanotechnology by Alain Nouailhat, John Wiley & Sons, Inc.
7. Nanotechnologies: Principles, Applications, Implications and Hands-on Activities by Luisa Filipponi and Duncan Sutherland, European Union, 2012
8. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni.

Title of the Course and Course Code	**Pharmaceutical Chemistry CHA -604**	**Number of Credits : 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	List the importance of FDA in pharmaceutical industries. Define basic concepts related to pharmaceutical chemistry.	
CO2	Discuss and explain various pharmaceutical concepts and techniques of analysis.	
CO3	Illustrate the role of drug activity in pharmaco-kinetics and dynamics. Solve the numericals based on pharmaceutical concepts.	
CO4	Analyze different pharmaceutical samples using different analytical techniques.	
CO5	Compare different dosage forms, route of administration, pattern of drug release and explain the importance in drug administration.	

CO6	Propose method for analyzing pharmaceutical samples based on their properties.

Unit. No.	Title of Unit and Contents
I	**Role of FDA in Pharmaceutical Industries: (10L)** Definitions of Drug & Cosmetics, Substandard Drugs, Role of FDA in , introduction of New Drug, Phase I, Phase II, Phase III and Phase IV clinical trials, drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP, documentation as per FDA guidelines.
II	**Dosage form and route of administration: (10L)** Introduction, dosage and their types. Route of administration, factors affecting on dosage, **Dosage form analysis:** Tablets, different types of tablets, additives used in tablet manufacture. Analysis of aspirin tablet, Capsules, types of capsules, (Rifampicin), Powders (Sodium benzoate), Solutions (saline NaCl), Suspensions (barium sulphate), (Ointments (salicylic acid) and creams Dimethicone by IR) Injections (Mannitol), Aerosols (salbutamol), Problems based on assay of these materials.
III	**Evaluation of solid dosage Forms-Tablets and capsule (10L)** **Quality:** Hardness, Friability, Tablet thickness, Weight variation test, Content uniformity test, Viscosity and pH Measurement, disintegration, dissolution, stability, Disintegration and Dissolution, rate of dissolution and types dissolution apparatus, **ii. Moisture / water content by Karl-Fischer titration**- Principle, types of Karl Fischer titration, preparation and standardization of Karl Fischer reagent. iii. **Sterilization:** Methods for Sterilization (Physical and chemical method), Applications.
IV	**Biological Tests & Assay: (5 L)** Introduction to biological assay, Biological assay of Heparin sodium, Determination of Amylase activity, Determination of Photolytic Activity, Test for Insulin in solution, Biological Assay of Tetanus Antitoxin, Test for Undue Toxicity **Microbiological Tests and Assays: (5L)**

	Microbiological test for Antibiotics Standard preparation and units of activity, Test organisms and Inoculums, Cylinder-plate assay receptacles, Turbidimetric assay receptacles, Assay Designs, Cylinder plate or Cup-plate method, Two level fractional assay, Test for Sterility
V	**Pharmacology: Pharmacokinetics and dynamics (10L)** **Pharmacokinetics**: Introduction, ADME process, pharmacokinetics models bioavailability, Constant-rate infusion- administration rate, kinetics of elimination. **Pharmacodynamics:** Introduction, principle of drug action, mechanism of drug action, enzymes-enzyme inhibition, Receptors- Agonists, Antagonism, Partial agonists, function of receptors, dose-response relationship, drug potency and efficiency, therapeutic efficiency, drug selectivity and specificity, Non-receptor mechanisms.
VI	**Sources of Impurities in Pharmaceutical Raw Materials & Finished Products: (10L)** **a.** Raw materials, Method of manufacture, Atmospheric contaminations, Cross contamination, Microbial contamination, Container contamination, Packaging errors, Chemical instability, Temperature effect and Physical changes. **b.** Shelf Life of Pharmaceutical Product: shelf life of Pharmaceutical product and determination of shelf life. Water for pharmaceutical use. **c.** Limit test: Limit tests for aluminum, arsenic, iron, lead, potassium, sulphate, chloride, heavy metals, **d.**Ash value: acid soluble ash, acid insoluble ash, sulphated ash, Loss on drying loss on ignition.

References

1. Indian Pharmacopeia Volume I and II.
2. Practical Pharmaceutical chemistry third edition volume 1. By A. H. Beckett & J. B. Stenlake.
3. Remington‘s Pharmaceutical sciences.
4. Ansel’s Pharmaceutical Analysis.
5. Aymanns C, Keller F, Maus S, et al. Review of pharmacokinetics and pharmaco dynamic and the aging kidney. Clin J Am SocNephrol.
6. Pharmaceutical Analysis by Ashutosh Kar.

Title of the Course and Course Code	**Industrial material analysis-I CHA -605**	**Number of Credits: 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	State composition, types and functions of various industrial material.	
CO2	Explain types of ores and alloys, disintegration of ore, concentration of ore, metal extraction and refining techniques.	
CO3	Solve numericals to determine various components of industrial materials.	
CO4	Analyze components from various industrial samples using chemical methods.	
CO5	Identify different properties of polymers and select testing methods.	
CO6	Review properties of ores, alloys, soil and fertilizers, relate with their applications and environmental effects. Compile different steps in metallurgy.	

Unit.No.	**Title of Unit and Contents**
I	**Analysis of Ores and Alloys: (15L)** **a. Ores:** Introduction, Dolomite (For silicate, Mg and Ca), Ilmenite (for silicate, Ti and Fe), Monazite (for rare earth metals), Hematite (silicate and Fe), Pyrolusite (for silicate and Mn) and bauxite (for Al and Silicate). **b. Alloy:** Types, composition and analysis of Copper based alloy like cupronickel (Cu, Ni), bronze (Cu, Sn) and brass (Cu, Zn), Aluminum based alloy Duralumin and Magnalium, stainless steel (Fe, Cr, Ni, Co, Cu, Mn), and Solder (Pb and Sn).
III	**Analysis of Cement: (10)** Types of cement, sampling, Analysis of cement and building materials: Silicon dioxide, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide, sulphur- trioxide, sulphide- sulphur, loss on ignition, insoluble residue, sodium and potassium oxide.

II	**Analysis of Soil: (10 L)** Chemical and mineralogical composition of soil, classification of soil, macro and micronutrients (functions and deficiency) for plant growth, Sampling, determination of Moisture Content, Water Holding Capacity. Analysis of Carbonate, Organic carbon, and organic matter, Total nitrogen, ammonia and nitrates, Total determination of major soil constituents by fusion analysis, silica and total combined oxides of iron, aluminium, and titanium, Determination Ca, Mg, Na, K, phosphate, Exchangeable cations, Cation exchange capacity.
III	**Analysis of Fertilizers: (10 L)** Sampling and sample preparation, water, total nitrogen: Kjeldahl method, total nitrogen by reduced iron method, urea nitrogen, total nitrogen by spectrophotometric method, Ammonia nitrogen. Phosphorus: total phosphorus, available and non-available, alkali metric ammonium molybdophosphate method, water soluble phosphorous, citrate insoluble phosphate, Potassium: potassium by sodium tetra phenyl borate method, flame photometric methods
VI	**Analysis and Testing of Polymers: (15 L)** Introduction, classification, concept of average molecular weight **a.** Thermal analysis (TGA, DTA and DSC) of polymers **b.** Physical testing of polymers: Mechanical properties, Fatigue testing, impact testing, tear resistance, hardness, abrasion resistance. **c.** Thermal Testing: flammability, Heat deflection temperature, Vicat softening temperature, torsion pendulum test, thermal conductivity, thermal expansion. **d.** Optical properties: transmittance, colour, gloss, haze and transparency. **e.** Electrical properties: dielectric constant and loss factor, resistively, dielectric strength, electronic properties. **f.** Chemical Test: Immersion test, vapor permeability, staining resistance, solvent stress cracking resistance, environmental stress cracking.

References

1. Standard methods of chemical analysis, Sixth Edition, F.J. Welcher.
2. Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Vogel, 3ed, ELBS, 1964.

3. Chemical analysis of metals; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering
4. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines, 1979.
5. Hand Book of Water, Air and Soil Analysis (A Lab Manual) by Sadhana Chaurasia.
6. Manual for analysis of pesticide residue for food by FSSAI government of India 2012.
7. Textbook of polymer science 3rd edition by F. W. Billmeyer (1994).
8. Principles of polymer systems by P. J. Flory, Cornell University press, New York.
9. Polymer chemistry-an introduction Seymour-Carraher-Marcel Dekker. Inc. New York.
10. Polymer Science by V.R. Gowarikar, N. B. Vishvanathane, New Age International Ltd. Publisher (1998).
11. Principle of polymer science, Bahadhur and Sastri, Narosa publishing house.
12. Textbook of Polymer Chemistry by M.S. Bhatnagar, S. Chand publication.

Title of the Course and Course Code	**Analytical Chemistry Practical V CHA-620**	**Number of Credits : 02**
Course Outcome (CO) **On completion of the course, the students will be able to:**		
CO1	Recall basic concepts regarding lab safety, chemical handling and protocols followed in analysis.	
CO2	Represent the results of experimental work in oral, written, graphical and electronic formats.	
CO3	Articulate problem solving, critical thinking, statistical knowledge and analytical reasoning skills to given scientific problems.	
CO4	Analyze given inorganic, pharmaceutical and biological samples.	
CO5	Standardize different chemical reagents and procedures to analyze different samples.	
CO6	Compile experimental findings in a scientific manner.	

Practical No	**Title of Experiment**

I	**Ore and alloy analysis** 1. Dolomite 2. Magnalium
II	**Analysis of industrial material** 1. Cement 2. Fertilizer (N) 3. Fertilizer (P) 4. Assay of Detergent 5. Fe from detergent 6. Urea 7. Loss on Drying of $CuSO_4$ and LOI of Zn
III	**Analysis of soil and water** 1. Water parameters: COD, BOD, hardness, TS, DS, SS, chlorides and sulfates 2. Soil parameters: Organic carbon, cation exchange capacity, pH. and micronutrients.
IV	**Analysis of pharmaceutical product** 1. Limit tests for acid and basic radicals 2. Milk of Magnesia 3. Sulpha drug (non-aqueous titration method) 4. Strength of carboxylic acid
V	**Analysis of Blood** 1. Ketone bodies 2. Cholesterol
VI	**Isolation and Analysis of plant materials** 1. Lycopene 2. Citric acid 3. Ascorbic Acid (Vit. C) 4. Resin (Ginger sample) 5. Water soluble ash in Ginger 6. Volatile oils (Bitter Almond or Thujone oil) 7. Acid value from oil 8. Rancidity of oil

Note: Any other equivalent practical

Title of the Course and Course Code	**Analytical Chemistry Practical VI CHA 621**	**Number of Credits : 02**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	Recall concepts of analytical instrumentation.	
CO2	Represent the results of scientific work in oral, written, graphical and electronic formats.	
CO3	Carry out analysis of various samples using different instrumentation techniques.	
CO4	Analyze and interpret experimental data using standard statistical methods and computational methods.	
CO5	Standardize/calibrate the instruments.	
CO6	Plan and perform experiments using correct procedure for different samples.	

Practical No	Title of Experiment
I	**Conductometry** 1. Estimation of aspirin content from tablet. 2. Determination of concentration of acid mixture and copper sulphate. 3. Compare relative strengths of different acids. 4. Determination of the basicity.
II	**pH metry** 1. Determination of strength of acid in a mixture 2. Determination of strength of ammonia solution.
III	**Potentiometry** 1. Potentiometric titration of iron

III	**Flame photometer** 1. Estimation of sodium 2. Estimation of potassium 3. Estimation Na and K from mixture
IV	**Nephelometry** 1. Determination of sulphate ion 2. Determination chloride from water sample
V	**Polarimeter** 1. Lactose in Milk 2. Specific rotation of glucose
VI	**Spectrophotometer** 1. Estimation of Amino acid. 2. Estimation of reducing sugar. 3. Determination of Iron from pharmaceutical dosage form 4. Estimation of chlorophylls in leaf pigments. 5. Determination of phosphorous. 6. Equilibrium constant of Ni complex.
VII	**Atomic absorption spectroscopy** 1. Analysis of metal ions
VIII	**Chromatographic techniques (HPLC/GC)** 1. Estimation of alcohol content 2. Pesticide residue
IX	**Miscellaneous techniques** 1. Hardness of tablet 2. Dissolution test for tablet **3.** Determination of moisture content using Karl-Fischer titrator

Note: Any other equivalent practical

	S.Y. M.Sc. Semester IV	
Title of the Course and Course Code	**Forensic science and Toxicology CHA -651**	**Number of Credits : 04**

Course Outcome (COs) On completion of the course, the students will be able to:	
CO1	Understand basic concepts and terms involved in forensic science and toxicology.
CO2	Discuss the types of crime scene, physical evidences, methods of collection and preservation of samples.
CO3	Identify and individualize different evidences, drugs and poisons and establish its origin.
CO4	Compare various physical evidences and classify it into respective classes.
CO5	Review various techniques involved in crime scene investigation and methods of identification, isolation of toxic substances.
CO6	Propose steps for analyzing various samples obtained at crime scenes and develop critical thinking and investigate in a stepwise manner.

Unit.No.	Title of Unit and Contents
I	**Forensic Science: (15 L)** **a. Introduction:** History, role of forensic science in crime investigation, collection and preservation of biological materials. **b. Physical Evidence**: Common Types of Physical Evidences and its Significance. **c. Trace evidence:** Introduction, principle, Hair, fiber , glass, soil and paints analysis.
II	**a. Fingerprint Analysis: (10 L)** Introduction, types of fingerprint, developing of Latent fingerprints; **b. Document Analysis:** Principle and application
III	**a. Bloodstain Pattern Analysis**: (10 L) Blood and blood grouping, type of bloodstain pattern and application. **b. DNA Profiling:** Introduction, principle, DNA and its polymorphism, DNA typing procedures-RFLP, PCR, AFLP, STR, other methods, paternity testing, applications, interpretation and practical use**,** southern blotting technique. **c. Other body fluids:** saliva, Semen, Urine

IV	**a. Firearms and Ammunitions: (10L)** History, Types of firearms, propellants, bullets and its types, components of ammunitions **b. Forensic Psychology:** Defination, Importance of Forensic Psychology, **c. Criminal psychological profiling:** nature, definition, Psychological test – Narco analysis, polygraph.
V	**Forensic Toxicology: (15)** **a.** Introduction, clinical and practical aspects of analytical toxicology. **b. Poisons:** Type of poisons, detection of poison in biological fluid- physical and chemical method. **c. Drugs:** Classification of drugs, isolation, identification and determination of Narcotics- heroin and cocaine, Stimulants- caffeine, amphetamines, Depressants- Barbiturates, Benzodiazepines. **d. Alcohol in body fluids:** Legal background, Sampling and sample preservation, analysis-GC, IR, enzymatic and other methods.

References

1. Basic Analytical Toxicology Published by WHO, By R. J. Flanagan, R. A. Braithwaite, S. S. Brown Available Online
2. http://www.forensicsciencesimplified.org/
3. Textbook of Medicinal Jurisprudence, Forensic Medicine and Toxicology, 6th edition By Dr. C. K Parikh.
4. Forensic Chemistry, 1st edition, By Suzanne Bell, Person Education Ltd.
5. Shreves' Chemical Process Industries fifth edition by George Austin MgGraw Hill Practical Pharmceutical Chemistry by Becket
6. Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; NEW AGE International (P) limited, Publication, Pearson's chemical analysis of food.
7. Practical Biochemistry in Clinical Medicine, R. L Nath, Academic Publishers 2nd Edn (1990).

Title of the Course and Course Code	**Spectroscopic Techniques CHA -652**	**Number of Credits: 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		

CO1	Recall the basic terminologies in different spectroscopic techniques.
CO2	Summarize the principles and applications of spectroscopic techniques
CO3	Illustrate theoretical and instrumental aspects of various spectroscopic techniques.
CO4	Relate different concepts and apply them to identify, interpret and compute the spectral data.
CO5	Review the concepts involved in different spectroscopic techniques.
CO6	Develop knowledge related to important theoretical concepts of spectroscopic techniques and comprehend their applications in industries and research.

Unit.No.	Title of Unit and Contents
I	**Introduction to atomic spectroscopy: (5L)** electromagnetic spectrum, atomic and molecular spectra, emission process, radiative and nonradioactive relaxation, absorption and transmittance, line, band and continuum spectra, atomic line width, factors affecting spectral width (uncertainty effect, Doppler shift, pressure and collisional effect, temperature effect).
II	**Atomic Absorption Spectroscopy: (10 L)** Continuum radiation sources, Line sources, sample introduction system, atomizers, wavelength selectors, detectors. chemical and spectral interferences, quantitative analysis and numericals.
III	**Atomic Emission Spectroscopy: (10 L)** flame emission spectrophotometer, inductively coupled plasma and direct current plasma, ICP-AES, AES with electric arc discharges, electrodes in AES, DC Arc, AC Arc and Spark sources, Stallwood jet apparatus, comparison of atomic absorption and emission methods, Applications of AES.
IV	**Laser Based Techniques: (10 L)** Concept of LASER, spontaneous and stimulated emission, components of lasers, mechanism of lasing action, comparison of 3L and 4L laser system, properties of laser, solid state laser (Ruby laser, Nd:YAG laser), gaseous

	laser (He:Ne laser, CO_2 laser), dye laser, Resonant Ionization Spectroscopy, Laser-enhanced ionization spectroscopy.
VI	**Mass Spectrometry (15 L)** **a. Atomic Mass spectrometry:** steps in AMS process, atomic mass spectra, ionization sources, types of AMS, mass analyzer, transducers, Instrumentation of Inductively coupled mass spectrometry (ICPMS), interferences in AMS, applications. **b. Molecular Mass spectrometry:** molecular mass spectra, ion sources, electron impact source, electron impact spectra, chemical ionization source, matrix assisted laser desorption ionization (MALDI), electron spray ionization, fast atom bombardment sources (FAB), tandem mass spectrometry, hyphenated MS, applications.
VII	**Nuclear magnetic resonance spectroscopy (5L)** Recapitulation of ^{1}HNMR, 2D NMR,- FID signal generation mechanism, Techniques in 2D NMR- homo nuclear correlation spectroscopy (COSY), total correlation spectroscopy (TOCSY), heteronuclear, correlation (HETCOR).
VIII	**Electron Paramagnetic Resonance Spectroscopy (5L)** Theory and Instrumentation, Spin Hamiltonian, Isotropic and anisotropic EPR spectra, Magic Pentagon rule. Applications of EPR spectroscopy.

References:

1. Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987)
2. Instrumental methods of chemical analysis by H. Willard, L. Merrit, J.A. Dean and F.A. Settle. Sixth edition CBS (1986)
3. Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992)
4. Principles of Instrumental Analysis Skoog, West, Niemann.
5. Thermal analysis by W.W. Wendlandt, John Wiley, (1986)
6. Cyclic Voltammetry and frontiers of electrochemistry by N.Noel and K.I. Vasu IBH, New Delhi (1990)
7. Electrochemical Methods: Fundamentals and Applications by Allen J. Bard and Larry R. Faulkn

8. Nuclear Magnetic Resonance –Basic Principles-Atta-Ur-Rehman, Springer-Verlag (1986).
9. One and Two dimensional NMR Spectroscopy –Atta-Ur-Rehman, Elsevier (1989).
10. Practical NMR spectroscopy - ML Martin, J J Delpench, and D J Martyin
11. NMR –Basic principle and application - H Guntur

Title of the Course and Course Code	**Industrial material analysis-II CHA653**	**Number of Credits: 04**
Course Outcome (COs) **On completion of the course, the students will be able to:**		
CO1	State composition, types and functions of various industrial material and food nutrients.	
CO2	Outline the basic techniques used to determine carbohydrates, proteins and lipids.	
CO3	Discuss different sampling methods of industrial materials.	
CO4	Explain various food processing methods in food preservation techniques.	
CO5	Identify and analyze components from various industrial samples.	
CO6	Formulate and solve numericals to determine different components present in industrial material.	

Unit.No.	Title of Unit and Contents
I	**Analysis of soaps and detergents: (15 L)** General scheme of analysis, sampling, alcohol soluble materials, moisture and volatile matter, active ingredient and equivalent combined SO_3^{3-}, Tests for soaps and detergents: total fatty acids, fatty anhydride combined alkali, and anhydrous soap, Unsponified and unsaponifiable matter, Free alkali or free acid, titer test, Iodine value, saponification value, free glycerol, alkalinity, chlorides, silicate, phosphate, borates, UV spectroscopic analysis

	of detergents, Determination of sodium alkyl benzene sulfonate, sodium toluene sulfonate, sodium xylene sulfonate, germicides
II	**Analysis of Paints and Pigment (15L)** Introduction, test on the total coating, water content, separation of pigment binder, and thinner of solvent type coating, separation of pigment binder, and thinner of latex paints, Identification of the binder, polymer resins and oils, plasticizer, Analysis of the vehicle, Identification and Analysis of pigments, outline of general procedure, HCL insoluble, Titanium dioxide, total lead, acid soluble Al and Fe, acid soluble calcium, total zinc, antimony oxide, total sulfate, total carbonate), identification and analysis of thinners.
III	**Food analysis (15L)** **a. Carbohydrates: Introduction,** Analysis of carbohydrates from food sample by different method i) Fehling's solution, ii) Wu method iii) total Anthrone method, iv) Estimation of pectic substances. **b. Proteins:** Definitions and functions, Analysis of proteins by Kjedahl's method, Lowry method, ninhydrin method, Estimation of food grain for methionine content. **c. Lipids**: Estimation of oil, free fatty acids, Saponification value, iodine value, acid value of oil, peroxide value of oil and rancidity.
IV	**Analysis of food products:** (5L) Milk and milk products, tea, coffee and beverages. flour, starch, honey, jams and edible oils.
V	**Food processing and Preservation:** (10 L) a. **ood processing:** Refining milling, canning, concentration, freezing Drying, irradiation, pasteurization, and sterilization. b. **etermination of food preservatives:** Analysis of inorganic and organic preservatives, such as SO_2 by Tanners method, Nitrate and nitrites, boric acid , Benzoic acid, 4-hydroxybenzoate,ascorbic acid, Analysis of food additives: sweeteners and colors.

References:

1. Standard methods of chemical analysis, volume 3, Part-B, F.J. Welcher
2. Practical Clinical Biochemistry, Gowenlock, CBS published, 6th Ed.

3. Chemical analysis of food by Pearson.
4. Practical Pharmaceutical Chemistry by Beckett.
5. Biochemical methods of analysis S. Sadasivam and A. Manickam, Narosa Publication

Title of the Course and Course Code	**Research Project I CHA-610**	**Number of Credits : 04**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Identify the area of research considering possible applications	
CO2	Discuss the novelty of the research problem through literature survey	
CO3	Outline the plan of research work	
CO4	Categorize various budget heads	
CO5	Justify the execution plan for the proposed project work	
CO6	Prepare the project proposal	

Title of the Course and Course Code	**Research Project II CHA-660**	**Number of Credits : 06**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	State the plan for experimental work, using different methods	
CO2	Execute the experimental work	
CO3	Interpret results and draw conclusions	
CO4	Compare and justify findings of the experimental results based on scientific literature.	
CO5	Review the results considering aspects of plagiarism .	

CO6	Prepare the dissertation and presentations.

Title of the Course and Course Code	**Analytical Chemistry Practical VII CHA 670**	**Number of Credits : 02**
Course Outcome (COs) On completion of the course, the students will be able to:		
CO1	Recall calibration of instruments and standardization reagents.	
CO2	Demonstrate technical skills in preparation of reagents, handling of instruments.	
CO3	Apply the laboratory skills and theoretical concepts to carry out the various experiments using analytical methods.	
CO4	Compare and justify the results with literature.	
CO5	Interpret and convey results of experimental work effectively in the form of oral, writing, graphs and electronic formats.	
CO6	Build ability to work and learn both independently and collaboratively to incorporate diverse skills.	

Practical No	Title of Experiment
I	**Conductometry** 1. Determination of strength of commercial vinegar 2. Determination of strength of borax
II	**pH metry** 1. Analysis of mixture of carbonate and bicarbonate using pH meter.
III	**Spectrophotometer** 1. Determination of the amount of carbohydrate in potato by Anthrone method. 2. Determination of ionization constant of indicator 3. Determination of isobestic point of indicator

IV	**Spectroflurometry** 1. Analysis of Thiamine 2. Analysis of Riboflavin
V	**Polymer** 1. Determination of molecular weight by viscosity measurement. 2. Determination of K value and polymer chain linkage
VI	**TGA** 1. Thermo gravimetric analysis of commercial sample..
VII	**Ore and alloy analysis** 1. Bronze 2. Brass
VIII	**Analysis of industrial material** 1. Plaster of Paris 2. Talcum powder 3. Pigment (Ti) 4. Pigment (zinchrome) 5. Adsorption study of Oxalic acid
IX	**Analysis of food sample** 1. Caffeine/Tannin 2. HMF 3. Saponification value from oil 4. Iodine Value of oil
X	**Analysis of Blood** 1. Creatinine 2. Glucose
XI	**Forensic Science** 1. Nicotine 2. Comparison of two presumptive tests for blood. 3. Identification of drugs and poisons by chemical method (Ba, aniline, antimony, CCl_4 etc.). 4. Fingerprint analysis

XII	**Nanomaterial:** 1. Synthesis and characterization of Nanomaterial

Note: Any other equivalent practical