Abeda Inamdar Senior College of Arts, Science and Commerce, Pune 411001

(Autonomous)

Affiliated to Savitribai Phule Pune University

Syllabus for

M. Sc. Part-II

(M.Sc. Analytical Chemistry)

Choice Based Credit System [CBCS]

From Academic Year 2022-23

Board of Studies (Chemistry)

Post Graduate Department of Chemistry and Research Center

Abeda Inamdar Senior College of Arts, Science and Commerce, Pune – 411001.

Syllabus of Autonomous M. Sc. Part-II Analytical Chemistry

Choice Based Credit System [CBCS]

[2022-23]

Structure of the Course:

Basic Framework of the syllabus for M. Sc. Part-II Analytical Chemistry at the Abeda Inamdar Senior College of Arts, Science and Commerce, (Autonomous), Pune affiliated to Savitribai Phule Pune University, Pune.

Sr. No.	Paper No.	Subject	Credit
SEMEMSTER-III			
1	21SMAC231	Advanced Analytical Spectroscopic Techniques	4
2	21SMAC232	Bioanalytical Chemistry and Analysis of Food	4
3	21SMAC233	Physical methods of chemical analysis and Analytical Extraction Techniques	4
(Any One from Following 21SMAC234)			
4	21SMAC234A	Metallurgy and Environmental Analytical Chemistry	2
	21SMAC234B	Analysis of Controlled Substances	2
5	21SMAC235	Practical: Basic Instrumental Analysis	2
6	21SMAC236	Practical: Analysis of Food and Bio analytical Samples	2
7	21SMAC237	Practical: Geochemical and Water Analysis	2
SEMESTER-IV			
8	21SMAC241	Advanced Methods of Chemical Analysis	4
9	21SMAC242	Pharmaceutical chemistry and Pharmaceutical Analysis	4
10	21SMAC243	Analytical Method validation and Drug Development	4
(Any One from Following 21SMAC244)			
11	21SMAC244A	Analytical Chemistry of agriculture, Soil and Detergents	
	21SMAC244B	Polymer Analysis	2
12	21SMAC245	Practical: Advanced Instrumental Analysis	2
13	21SMAC246	Practical: Analysis of Pharmaceutical Products	2
(Any One from Following 21SMAC247)			
14	21SMAC247A	Practical: Analysis of polymers and complex materials	2
	21SMAC247B	Project/Industrial Training	2

***N.B.:**1. One Credit Theory Paper = 15 Hours lectures per semester and 1 Hour per week.

2. Two Credit Practical Paper = 60 Hours practical per semester and 4 hours per week.

M. Sc. II Analytical Chemistry Program Objectives and Outcomes

Program Objectives:

1. To develop conscience towards social responsibility, human values and sustainable development through curriculum delivery and extra-curricular activities.
2. To develop scientific temperament with strong fundamental knowledge of the subject.
3. To develop analytical thinking and problem-solving skills needed for various entrance and competitive examinations and Post Graduate Studies.
4. To train students in laboratory skills and handling equipment along with soft skills needed for placement.
5. To mold a generation of youth which can apply the chemistry in their life and careers?
6. To inculcate scientific attitude enriched with a multidisciplinary perspective in the students.
7. To update the students with the needs of the industry and society with respect to chemistry.

Program Outcomes: After completing the M. Sc. Program, the students shall:

1. Know the basics and applied aspects of the chemistry.
2. Be in a position to apply their knowledge in their professional, social and personal life.
3. Be competent to pursue research or a career in the chemistry.
4. Have the knowledge and confidence to pursue higher studies in Chemistry
5. Have skills in laboratory techniques and experience in instrument handling
6. Develop sensitivity towards social issues and become productive citizens of the nation.
7. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
8. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
9. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
10. Have a thorough understanding of the principles and theory behind chemical equilibria,

quantitative analyses, and the laboratory equipment used to do real-world analytical chemistry.

Program Specific Outcome:

M.Sc. Analytical Chemistry:

1. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
2. Students will be skilled in problem solving, critical thinking and analytical reasoning as applied to scientific problems.
3. Students will be able to clearly communicate the results of scientific work in oral, written and electronic formats to both scientists and the public at large.
4. Explain the fundamentals of analytical chemistry and steps of a characteristic analysis, expresses the role of analytical chemistry in science, compare qualitative and quantitative analyses, expresses the quantitative analysis methods and the qualitative analysis methods.
5. Explain the theoretical principles and important applications of classical analytical methods within titration (acid/base titration, complexometric titration, redox titration, precipitation titration), and various techniques within gravimetric and coulometric methods.
6. Explain the theoretical principles of selected instrumental methods within electroanalytical, spectrometric/spectrophotometric and mass spectrometry methods, and main components in such analytical instruments.
7. Explain the theoretical principles of various separation techniques in chromatography, and typical applications of chromatographic techniques.
8. Assess and suggest a suitable analytical method for a specific purpose, and evaluate sensitivity, important sources of interferences and errors, and also suggest alternative analytical methods for quality assurance.
9. Be familiar with calculations in analytical chemistry and method evaluation, and perform statistical evaluation of results from classical and instrumental chemical experiments and analyses.
10. Be able to plan for sampling and understand how different sampling methods and instrumental analytical methods can be used in speciation studies.
11. Describe and compare a range of analytical chemistry methods and explain the underlying

theoretical principles.

12. As part of a team or individually, conduct, analyze and interpret results of a chemical analysis and effectively communicate these in written reports and other formats.

Evaluation Pattern:

For each Theory and Practical Course, 50-50 pattern will be followed. Internal assessment will be of 50 marks for a paper of 100 Marks. Internal assessment will be of 25 marks for a paper of 50 Marks.

For Continuous Internal Evaluation (CIE), evaluations of theory courses will be done continuously. The 50 marks of Internal Evaluation shall be divided into the following:

a) One Mid Semester Exams of 15 Marks each.
b) Two Class Tests of 15 marks each converted to 15 Marks.
c) One Presentation/Seminar/MCQ Test of 5 Marks.
d) One Group Discussion/Open Book Test of 5 or 10 Marks.
e) Class Assignments of 10 or 5 Marks.
f) A compulsory Mock Practical Examination and Viva Voce of practical subjects.
g) Internal marks for Journal / project report/ dissertation report completion and certification.

SEMESER-III

Course/ Paper Title	**Advanced Analytical Spectroscopic Techniques**
Course Code	21SMAC231
Semester	III
No. of Credits	4 Credits, (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. Know how nuclear spins are affected by a magnetic field, and be able to explain what happens when radiofrequency radiation is absorbed. 2. Be able to use NMR spectra to determine the structures of compounds, given other information such as a molecular formula. 3. Understand and have a basic knowledge of the methods of x-ray absorption and fluorescence spectroscopy.

Expected Course Specific Learning Outcomes

Learning Outcome
On successful completion of the course students will be able to:– 1. Explain the basic principles of NMR at an advanced level. 2. Show and explain function of the main units of an NMR instrument. 3. Explain the fundamental physical mechanisms involved in the generation of fluorescence and phosphorescence. 4. Analyse and interpret spectroscopic data collected by the methods discussed in the course.

Section I: Atomic Spectroscopic Methods [24 L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Basic concepts (Ref-1,2):** Introduction: Electromagnetic radiation, properties, Interaction of radiations with matter, classification of analytical method based on EMR spectrum. Instrumentation: Sources of radiations, monochromators, sample containers, detectors for various types of radiations. Electron Microscopy: Introduction, Principles, Instrumentation, Applications.	**02**
II	**Atomic Absorption and Emission Spectroscopy (Ref-1,2,3):** Introduction, Atomic spectra, Instrumentation of AAS: Sample introduction system: Nebulizers, Laser Ablation technique, hydride vapour generators, automizers: Flame atomizer - premix burner, fuel gases and oxidants, graphite furnace, hydride generator, cold vapour technique, Hollow cathode lamps, spectrophotometers, detectors, Interferences in AAS (spectral and chemical), Quantitative analysis (calibration curve method, standard addition method, internal standard addition method), Practical applications of AAS. Inductively Coupled Plasma AES: Introduction to Atomic emission spectroscopy, inductively coupled plasma, Direct current plasma, microwave induced plasma, glow discharge, plasma spectroscopy, spectrometers, Detectors, interferences, Atomic fluorescence, Apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasmas- ICP and DCP, Detectors, theory of AFS, Analysis with AFS, Interferences with AFS, Resonant ionization Spectroscopy, LASER enhanced ionization spectroscopy.	**10**
III	**Electron Paramagnetic Resonance Spectroscopy (Ref. 4, 5):** Basic Theory: general remarks, electron spin and magnetic moment, ESR transitions, Selection rules, g-factor, presentation of spectra, interaction of magnetic dipole with microwave radiations, Larmor precision, resonance phenomenon, relaxation process, transition	**10**

	probability. Hyperfine Structure: Nuclear hyperfine splitting, radical containing one proton, spin Hamiltonian, selection rules, radical containing a set of equivalent protons, radical containing a set of multiple protons, radical containing multiple sets of protons (I = ½), radical containing multiple sets of proton (I > ½), Atomic radicals, Origin of hyperfine interaction, sigma radicals, assignments of spectra using Huckel MOs, alternant hydrocarbons, hyperfine splitting constants, second order splitting, Applications.	
IV	**Elemental Analysis (Ref. 7):** Particular analyses, Elemental organic microanalysis, Total nitrogen analysers (TN), Total sulphur analysers, Total carbon analysers, problems on empirical and molecular formula on CHONS analysis.	**02**

References Books:

1. Standard methods for the examination of water and waste water, 23rd Ed. Jointly published by American Public Health Association, American Water Work Association, Water Environment Federation. 2017
2. Practical Inductively Coupled Plasma spectroscopy, John R. Dean, Wiley India Pvt. Ltd.
3. Introduction to instrumental analysis by R. D. Braun, MC-Graw Hill- International edition.
4. Introduction to Magnetic Resonance of Spectroscopy ESR, NMR, NQR, D.N. Sathyanarayana, I. K. International Publishing House Pvt. Ltd.
5. Chemical Analysis Modern Instrumentation Methods and Techniques, Francis Rouessac and AnnickRouessac, Second Edition, John Wiley & Sons Ltd.

Section II: Molecular Spectroscopic Methods [24 L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Nuclear magnetic resonance spectroscopy (Ref. 1, 2 and 3):** ^{1}H-NMR: Introduction, theory, Instrumentation, Chemical shifts, spin-spin splitting, protons on heteroatom's, coupling protons with other nuclei,	**08**

	solvents, qualitative and quantitative analysis, problems. ^{13}C NMR: Introduction, interpretation ^{13}C NMR spectra, Chemical shifts, Spin coupling, quantitative analysis, problems. 2-D NMR: introduction, ^{1}H-^{1}H connectivity, ^{1}H-^{13}C connectivity, ^{13}C-^{13}C connectivity, through space ^{1}H-^{1}H proximity, option and how to use them, problems.	
II	**Molecular Luminescence spectrometry (Ref. 1 and 4):** Introduction, theory of fluorescence and phosphorescence: excited state producing fluorescence and phosphorescence, energy level diagram, rate of absorption and emission, deactivation process, variables affecting fluorescence and phosphorescence, Emission and excitation spectra; Instruments for measuring fluorescence and phosphorescence: Components of Fluorometers and Spectrofluorometers, Instrument Design, Applications of Photoluminescence Methods: Methods for Organic and Biochemical Species, Phosphorometric method, **Chemiluminescence:** The Chemiluminescence phenomenon, measurement of chemiluminescence, analytical applications, problems.	**08**
III	**X- ray Methods of Analysis (Ref. 1 and 3):** Principle, Theory- X-ray spectral lines, X-ray tube, X-ray emission, Absorptive apparatus: Sources, Collimation, sample handling, wavelength dispersive devices, Energy dispersive devices, detectors, readout device, Chemical analysis using X-ray absorption, X-ray Fluorescence- instrumentation and chemical analysis, X-ray Diffraction, Chemical analysis with X-ray diffraction, numerical problems.	**08**

Reference Books:

1. Introduction to instrumental analysis by R. D. Braun, M. C. Graw Hill-International edition.
2. Spectroscopic identification of organic compounds Fifth Ed., Silvestrine, Bassler, Morrill, John Wiley and sons.
3. Analytical Chemistry, Edited by Kellner, Mermet, otto, Valcarcel, Widmer, Second Ed. Wiley –VCH.

4. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
5. Materials Characterization, introduction to microscopic and spectroscopic techniques, Yang Leng, 2nd Wiley-VCH.
6. Fundamentals of Light Microscopy, Spencer, Michael, Cambridge University Press, 1982.
7. Transmission Electron Microscopy: A Textbook for Materials Science, David B. Williams, C. Barry Carter, Springer, 2009.
8. Practical Electron Microscopy in Materials Science, J. W. Edington, 1976, 4 volumes reprinted by Tech Books, Herndon, USA.
9. Transmission Electron Microscopy and Diffractometry of Materials, B. Fultz, and J. M. Howe, Second Edition, 2002,Springer, Germany.
10. Instrumental Methods of Analysis, Hobart. H. Williard, Lyne. L. Merrit, John. A. Dean, Frank. A. Settle. Jr., CBS Publisher.
11. Principles of analytical, 6th edition, Douglas. A. Skoog, F. James Holler, Stanley R Crouch, Thomson/Brooks/Cole.

Course/ Paper Title	**Bioanalytical Chemistry and Analysis of Food**
Course Code	21SMAC232
Semester	III
No. of Credits	4 Credits, (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. Develop the skills to understand the theory and practice of bio analytical techniques. 2. Explain and interpret the principles of different bioanalytical methods for their appropriate application. 3. To provide scientific understanding of analytical techniques and detail interpretation of results. 4. Providing knowledge on the specificities of sampling and preparing biological samples, as well as about methods of bioanalytical chemistry. 5. To provide the students with knowledge on the key food safety issues, including the food safety hazards, their methods of sampling methods, detection and the key food quality properties. 6. Be familiar with the current state of knowledge on food composition. Identify reasons for determining composition and characteristics of food and describe the role of food analysis in relation to food standards and regulations. 7. Describe principles and relevant theory used to determine moisture, carbohydrate, lipid, proteins, and ash content of a food. 8. This course will allow students to learn basic food chemistry and will enhance understanding of the composition of foods and to learn how to analyze food composition and how to prepare and design food nutrition labels.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Select bioanalytical techniques and be familiar with working principals, tools and techniques of bioanalytical techniques. 2. Understand the strengths, limitations and creative use of techniques for problem-solving and design experiments and understand the instrumentation. 3. To understand and identify food hazards, adulteration and traceability and perform laboratory analyses for routine chemical testing, in the framework of an accredited laboratory. 4. Identify and critically evaluate food analysis method and techniques to ensure quality control and select the most appropriate analytical method to solve a given analytical question, to apply an analytical protocol and to analyze and interpret analytical results. 5. Take-up career in research organizations and to pursue higher studies in bioanalytical and food chemistry with high regard for ethical values, environmental and social issues. 6. Understand the quality attributes, their measurement principle and instrumentation of various instruments used in food quality analysis. 7. Thoroughly understand various types of additives to be added and their role in respective food items. 8. Understand the working principle and instrumentation of various instruments used in food analysis. The students will know the importance of various methods to identify any malfunction aspect of food.

Section I: Bioanalytical Chemistry [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Collection of Specimens (Ref. 1,2):** Blood: Collection of Blood specimens, storage and preservation, Urine: Collection of Urine, physical characteristics of urea, preservation and storage, Faeces: Collection and preservation.	**02**
II	**Analysis of Blood and urine (Ref. 1, 2):** Determination of blood and	**08**

	plasma glucose by glucose oxidase method, Determination of urine for glucose, Determination of ketone bodies in blood, Oral Glucose tolerance test, Determination of serum creatinine, estimation of serum bilirubin, Estimation of serum cholesterol, determination of blood haemoglobin, Urate: determination of serum urate, Determination of urea in urine by urease method and by direct colorimetry, Estimation of Na, K, Ca by flame photometry, inorganic phosphate by colorimetry.	
III	**Determination of vitamins in body fluid (Ref. 1, 2):** Classification of vitamins with example, Each vitamin must be explained with respect of functions, deficiency diseases, daily requirement, and analytical method of Vit D3 (cholecalciferol), Vitamin E (Tocopherols, Determination of serum tocopherol by spectrophotometry by dipyridyl method), Vitamin B1 (thiamine determination by flurometry), Vitamin B2 (riboflavin, Photofluorometric method), Vitamin B6 (Pyidoxine, Fluorometric determination of Xanthuric acid), Nicotinic acid and Niacin: determination by fluorometry, Ascorbic acid (vitamin C) Volumetric method using 2,6-dichlorophenol method, colorimetric determination of leucocyte ascorbate.	**04**
IV	**Organ function tests (Ref. 1, 2):** Structure and functions of the liver. Liver diseases-jaundice, hepatitis, cirrhosis. Liver function tests-conjugated and total bilurubin in serum, albumin: globulin ratio, hippuric acid and bromsulphthalein test, Kidney structure of nephron, urine formation, normal and abnormal constituents of urine. Renal function tests- creatinine and urea clearance tests, phenol red test.	**04**
V	**Microbiological and Biological Assays (Ref. 5, 6):** 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. Introduction, Introduction to biological assay, Biological assay of Heparin sodium, Determination ofAmylase activity, Determination of Photolytic Activity, Test for Insulin in solution,	**06**

	Determination of ABO group and Rh group.	

Reference Books:

1. Varley's Practical Clinical Biochemistry, Gowenlock A. H., 6th Edition, 2006, CBS Publishers, New Delhi.
2. Practical clinical Biochemistry, Harold Varley (4th Edition), CBS publishers and Distributers. New Delhi -110002.
3. Methods in Molecular Biology, Vol-42, ELISA-Theory and Practice, by John R. Crowther, Humana Press, Totowa, New Jersey.
4. Indian Pharmacopeia Volume I, 7th Ed
5. Indian Pharmacopeia Volume II, 7th Ed

Section II: Analysis of Food [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Analysis of Lipids (Ref. 1 to 3):** a) Definition, Classification, General Considerations, Solvent Extraction Methods: Sample preparation, Solvent selection, Sample Preparation, Continuous Solvent Extraction Method: Goldfish Method, Semi-continuous Solvent Extraction Method: Soxhlet Method, Discontinuous Solvent Extraction Methods, Total Fat by GC for Nutrition Labelling. b) Characterization of Lipids (bulk such as oils): Estimation of free fatty acids, Saponification value of oils, iodine value, Determination of acid value of oil, determination of peroxide value of oil, p-anisidine Value and Totox Value, Thiobarbituric Acid Reactive Substances Test, Identification and quantification of fatty acids, Problem on quantitative methods.	**08**
II	**Analysis of Proteins (Ref. 1 to 3):** A) Protein Analysis: Introduction, Importance of Analysis, Content in Foods, Methods: Following methods with respect to principle, reactions, procedures and applications a) Kjeldahl's Method b) Dumas (Nitrogen Combustion) Method, c)	**06**

	Infrared Spectroscopy, d) Biuret Method e) Lowry Method f) Dye-Binding Methods g) Bicinchoninic Acid Method h) Ultraviolet 280nm, Comparison of Methods. B) Protein Characterization Procedures: Amino Acid Analysis, Protein Nutritional Quality: Introduction, Protein digestibility, Protein efficiency ratio, and net protein ratio, Assessment of Protein Functional Properties, Determination of net protein utilization, digestibility and biological value, Problem on quantitative methods.	
III	**Analysis of Carbohydrates (Ref. 1 to 3):** Introduction, Classification, Mono- and Oligosaccharides: Extraction, Analysis of carbohydrates from food sample by different method: Phenol-Sulfuric Acid Method, total reducing sugars by Nelson Somyogi method, volumetric determination by Fehling's solution, Colorimetric analysis of carbohydrates by Folin Wu method, total carbohydrates by Anthrone method, Estimation of starch by anthrone method, Determination of amylase, Estimation of pectic substances (gravimetric and colorimetric method), Estimation of crude fibbers. Degree of Gelatinization of Starch, Degree of Retrogradation of Starch.	**06**
IV	**Analysis of food preservatives (Ref. 4, 5) :** Definition, determination of $SO_2$by Tanners method, Nitrate and nitrites, boric acid, Benzoic acid, 4-hydroxybenzoate, ascorbic acid. Sweeteners: Saccharine identification and determination, Colours: Identification by general methods, Natural colours. Problem on quantitative methods.	**04**

Reference Books:

1. Food Analysis, Edited by S. Suzanne Nielsen, Fourth Edition, Springer.
2. Hand Book of Food Analytical Chemistry: Water, Proteins, Enzymes, Lipids, and Carbohydrates by Edited by Ronald E. Wrolstad, Terry E. Acree, Eric A. Decker, Michael H. Penner, David S. Reid, Steven J. Schwartz, Charles F. Shoemaker, Denise Smith, Peter Sporns, Wiley Interscience, a John Wiley & Sons, Inc., Publication.

3. Biochemical Methods, By S Sadashivan, A. Manickam, 3rd Edition, New Age International Publishers
4. Pearson's Chemical Analysis of Food.
5. https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/FOOD_ADDITVES.pdf

M. C. E. Society's
Abeda Inamdar Senior College
Of Arts, Science and Commerce, Camp, Pune-1
(Autonomous) Affiliated to Savitribai Phule Pune University
NAAC accredited 'A' Grade

Course/ Paper Title	**Physical methods of chemical analysis and Analytical Extraction Techniques**
Course Code	21SMAC233
Semester	III
No. of Credits	4 Credits, (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To inculcate analytical techniques knowledge. 2. To build the bridge between practical knowledge and theory of analytical techniques. 3. To equip students with advanced thermal techniques basics and applicability. 4. To familiarize students with basic extraction techniques. 5. To know about Solid-liquid extractions.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Understand voltammetric and thermal techniques. 2. Adjust with recent trends in practical aspects of techniques. 3. Get familiarize with classical approach for extraction. 4. Understand micro extraction, soxhlet extraction, microwave assisted extraction.

Section I: Physical methods of chemical analysis [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Coulometry (Ref. 1):** Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, constant current electrolysis, Electrolysis at constant working electrode potential, Coulometric methods of analysis, Faradays laws of electrolysis, Instrumentations-Constant current and constant voltage instruments.	**02**
II	**Voltammetry and Polarographic Methods of Analysis (Ref. 1 to 3): a) Polarography** (linear scan polarography): Polarographic principles, Instrumentation polarogram and polarographic currents, charging or capacitive current, role of supporting electrolyte, factors affecting on polarographic wave, Ilkovic Equation, Applications, specific examples of analysis – analysis of Cu, Cd, Zn, Pb etc. from tap water and alloys., problems. **b) Hydrodynamic Voltametry:** Hydrodynamic voltametry and applications of hydrodynamic voltametry, voltameric detectors in chromatography and flow injection analysis, Voltametric oxygen sensors, amperometric titration. **c) Cyclic Voltametry:** Principle of cyclic Voltammetry, cyclic voltamogram of $K_3[Fe(CN)_6$, determination of analytes using CV, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes. **d) Pulse Polarography:** different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, and Stripping method. Voltammetry with ultra-microelectrode, Applications of these techniques Cu and Zn from tap water by differential pulse polarography and by square wave polarography, Vitamin-C by differential pulse polarography, Determination of Pb in tap water by stripping method.	**14**
III	**Thermal methods of analysis (Ref. 4 to 8):** Principle, different methods of thermal analysis, A) Thermo gravimetric methods of analysis: Instrumentation, thermogram and information from thermogram, factors affecting thermogram, applications TGA for	**08**

	quantitative analysis (TG analysis of $CaC_2O_4.H_2O$, $CuSO_4.5H_2O$, dolomite ore, etc.) and problems based TGA B) Differential Thermal Analysis (DTA): Instrumentation, general principles, differential thermogram, DT and TG curve together, Applications (DT analysis of mixture of polymers, DT analysis of $CaC_2O_4.H_2O$, DT analysis of sulfur, DT analysis of $CuSO_4$ $5H_2O$). TG and DT curve for $Mn(PH_2O_2)_2.H_2O$, C) Differential Scanning Calorimetry (DSC): Principle, Instrumentation, and Applications (DCS curve of polyethylene terphthalate, DSC curve for isothermal crystallization of polyethylene, DSC of phenacetein), thermometric titrations, Evolved gas analysis.	

Reference Books:

1. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
2. Cyclic Voltammetery, Simultaneous Analysis and Reaction Mechanism, David K Gosser, VCH, 1994.
3. Analytical Chemistry, A Modern Approach to Analytical Science, Ed. by R. Kellner, J. M. Mermet, O. Otto, M. Valcarcel, H. M. Widmer, Second Ed. Wiley –VCH
4. Thermal Methods of analysis, principles, applications and problems, P. J. Haines, Springer-Science Business Media B.V. 1st Ed.
5. Vogel Text Book of quantitative analysis 6th Ed.
6. Principles of Thermal Analysis And Calorimetry, P. J. Haines, Royal Society of Chemistry
7. Principles and Applications of Thermal Analysis, Paul Gabbott, Blackwell Publishing Ltd. (2008).
8. Thermal Analysis in Practice, Fundamental Aspects, Matthias Wagner, Hanser Publications, 2018.
9. Introduction to Instrumental Analysis by R. D. Braun, Pharmamed Press.
10. Analytical Chemistry, A Modern Approach to Analytical Science, Ed. by R. Kellner, J. M. Mermet, O. Otto, M. Valcarcel, H. M. Widmer, Second Ed. Wiley –VCH

Section II: Analytical Extraction Techniques [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Classical Approach for Aqueous Extraction (Ref. 1, 2):** Introduction, Liquid-Liquid extraction (LLE), Theory of LLE: distribution ratio and coefficient, solute remaining unextracted, percent extraction, separation factor, factors favoring solvent extraction, synergic extraction, selection of solvents, solvent extraction, problems with LLE process, purge and trap for volatile organics in aqueous samples, Problems.	**06**
II	**Solid Phase extraction (SPE) (Ref. 1):**Introduction, Types of SPE media, SPE formats and apparatus, method for SPE operation, solvent selection, factors affecting SPE, selected methods of analysis for SPE: application of normal phase SPE, application of reversed phase SPE, application of ion exchange SPE, applications of molecularly impaired polymers, Automation and On-Line SPE and its applications.	**06**
III	**Solid phase micro-extraction (Ref. 1):** Introduction, theoretical considerations, experimental, Methods of analysis: SPME-GC: direct immersion SPME, headspace SPME, analysis of compounds from solid matrix, other SPME-GC application. Methods of analysis: SPME-HPLC-MS: analysis of abietic and dehydroabietic acid in food samples, analysis of fungicide in water. Automation of SPME and its application, new development in micro extraction (Introduction, stir absorptive extraction, liquid phase micro-extraction, membrane micro extraction, micro extraction in packed syringe).	**06**
IV	**Solid - Liquid Extraction, Microwave extraction (Ref. 1):** Classical Approach: Introduction, Soxhlet extraction, Automated Soxhlet extraction, other approaches, Pressurized Fluid Extraction: Introduction, theoretical consideration, Instrumentation for PFE, method development and applications. Microwave assisted extraction: Introduction, instrumentation, Applications.	**06**

Reference Books:

1. Extraction Techniques in Analytical Science, John R. Dean, Wiley
2. Vogel's Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
3. Solid Phase Micro extraction, A Practical Guide, Edited by Sue Ann Scheppers Wercinski, CRC press, Taylor and Francis.

Course/ Paper Title	**Metallurgy and Environmental Analytical Chemistry**
Course Code	21SMAC234A
Semester	III
No. of Credits	2 Credits, (28 L, 06T)

Aims & Objectives of the Course

Objectives
Students should – 1. Make students aware of basic geochemical materials and their method of analysis. 2. Provide comprehensive knowledge about chief industrial geochemical materials & selection of appropriate method of determination. 3. Develop basic idea pertaining to different water pollutants and essential analytical techniques.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Gain knowledge on concepts and principles of Geochemical analysis. 2. Carry out both qualitative and quantitative water analysis. 3. Develop basic scheme and choose appropriate route, regarding variety of water pollutants and their determination techniques.

Syllabus for 21SMAC234A: Metallurgy and Environmental Analytical Chemistry

Unit No.	Title with Contents	No. of Lectures
I	**Analysis of Geological materials (Ref. 1, 2):** Dolomite (For silicate, Mg and Ca content), Ilmenite (for silicate, Ti and Fe content), Monazite (for rare earth metals), Hematite and Magnetite (silicate and Fe content), Pyrolusite (for silicate and Mn content) and bauxite (for Al and Silicate content).	**07**
II	**Analysis of Industrial materials (Ref. 1, 2):** Stainless Steel (for Fe, Cr, Ni, Co, Cu, Mn, W, Si, V, Mo, Ti, Pb and Zr), Bronze and Gun metal (Cu, Sn), Brass (Cu, Zn, Sn, Pb), Solder (Pb and Sn), Nichrome (Fe, Ni, Cr), analysis of nickel Silver (Sn, Pb, Cu, Fe, Ni and Zn) and Aluminium based alloys (Al, Mg, etc.).	**07**
III	**Water pollution and analysis of polluted water (Ref. 3, 4):** Water pollutants, waste water treatment: domestic waste water treatment, aerobic treatment process, anaerobic treatment process, industrial waste water treatment, The purpose of chemical analysis, sampling of water, pH of water, specific conductance, determination of acidity and alkalinity, Chemical oxygen demand, biological oxygen demand, dissolved oxygen, turbidity, determination of aluminium, arsenic, boron, cadmium, calcium, carbon dioxide, chloride, residual chlorine, Chlorine demand, chromium, cyanide, total hardness, iron, lead, manganese, Zinc, methane, nitrate, nitrite, ammonia nitrogen, phenols, phosphates, silica, sulphate, sulfide, anionic detergents, tannin and lignin. Quantitative analysis of waste water for metal ions by AAS, FES and ICPAES.	**10**

ReferenceBooks: -

1. Standard methods of chemical analysis, volume 3, part A & B, by F.J. Welcher.
2. Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Vogel, 3rd Edition, ELBS, 1964.

3. Standard methods for the examination of water and waste water, 23rd Ed. Rodger Baird, Andrew Eatson, Eugene Rice, jointly published by: American Public Health Association, American Water Works Association, and Water Environment Federation.
4. Handbook of Environmental Analysis Chemical Pollutants in Air, Water, Soil, and Solid Wastes by Pradyot Patnaik, Third Edition, CRC press, Taylor and Francis, 2018.
5. Environmental Chemistry, Stanley E. Manahan, Ninth Edition, CRC press, Taylor and Francis, 2010.
6. Environmental Chemistry, A. K. De, 2nd ED. Wiley (1989).
7. Environmental pollution analysis, S. M. Khopkar, John Wiley (1993).

Course/ Paper Title	**Analysis of Controlled Substances**
Course Code	21SMAC234B
Semester	III
No. of Credits	2 Credits, (28 L, 06T)

Aims & Objectives of the Course

Objectives
Students should – 1. To develop the Post graduate level students with the specific knowledge of handling different types of evidences and their examinations. 2. To develop the laboratory skills in examining different types of evidences found at the crime scene. 3. This course provides an overview of the major disciplines of forensic chemistry and forensic toxicology, with examples to demonstrate their specific contributions to identification, collection, preservation, investigation, presentation, and biological and chemical analyses of physical evidence for the effective dispensation of justice. 4. Describe the scope of Forensic Science along with various principles governing it and Recall various sections of law. 5. Define the basic concepts of chemistry, forensic chemistry, toxicology, drugs of abuse and various related Acts.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Define forensic chemistry-related problems clearly, develop testable hypotheses regarding collected evidence, design and execute experiments to analyze this evidence, analyze data using appropriate instrumental and statistical methods, and draw appropriate conclusions.

2. Build up a conceptual understanding of criminal justice system, rules of evidence collection, legal system, critical thinking and analysis in a stepwise fashion that builds through the sequence of courses.
3. Demonstrate procedures in forensic chemistry and toxicology to be applied in crime detection and investigation.
4. Work collaboratively in the laboratory to acquire and analyze data and to solve problems scientifically and systematically. Develop professional and ethical responsibility.
5. Select, interpret and critically evaluate information from a range of sources that include books, scientific reports, journals, case studies and the internet.

Syllabus for 21SMAC234B: Analysis of Controlled Substances [24L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**The narcotic drug and Psychotropic Substances (NDPS) Act-1985 (Ref. 1,2):** Important Definition: Drug, Cannabis (Indian Hemp), Cannabis Products, Coca-derivatives, Coca Leaf, Coca Plant, Illicit Traffic, Controlled Substance, Manufactured Drug, Opium, Opium Poppy, Poppy Straw, Poppy Straw Concentrate, Psychotropic Substance, Prohibition Control and Regulation of NDPS.	01
II	**Chemical Screening and Microcrystal Tests (Ref. 3):** **a) Chemical tests:** Introduction, Chemistry of Color Formation, Limitations of Chemical Color Tests, Chemical Color-Test Methods, Documentation, Chemical Colour Tests: Chen's Test, Dille–Koppanyi's Test, Mecke's Test , Marquis' Test, Nitric Acid Test, Primary Amine Test, Secondary Amine Test, Tertiary Amine Test, Van-Urk's Test, Duquenois–Levine Test, Froehde's Test, Janovsky Test, Weber Test. **b) Microcrystal Techniques**: Introduction, Advantages of Microcrystal Techniques, Disadvantages of Microcrystal Techniques, Documentation, Microcrystal Test Techniques, Aqueous Test Technique, Volatility Test Technique, Acid and Anionic Test Technique, Aqueous Test Reagents.	03

III	**Analysis of Drugs/Narcotics (Ref. 4):** **A) Amphetamine and Related Compounds:** Introduction, Qualitative Identification of Amphetamines, Sampling and Physical Description of Amphetamines, Presumptive Testing of Amphetamines, Thin Layer Chromatography of Amphetamines, Definitive Identification of Amphetamines, Quantification of Amphetamines, Comparison and Profiling of Amphetamine Samples, The Leuckart Synthesis of Amphetamine, The Reductive Amination of Benzyl Methyl Ketone, The Nitrostyrene Synthesis, Impurity Extraction and Sample Comparison. **B) The Analysis of LSD**: Introduction, Qualitative Identification of LSD, Sampling and Physical Description of LSD Blotter Acid, Extraction of LSD Prior to Analysis, Presumptive Testing for LSD, Thin Layer Chromatography of Samples Containing LSD, Confirmatory Tests for the Presence of LSD. **C) *Cannabis sativa*** and **Products**: Introduction, Origins, Sources and Manufacture of Cannabis, Analytical Sequence, Bulk and Trace Sampling Procedures, Qualitative Identification of Cannabis, Identification of Herbal Material, Identification of Other Materials, Comparison of Cannabis Samples. **D) Diamorphine and Heroin:** Introduction, Origins, Sources and Manufacture of Diamorphine, Appearance of Heroin and Associated Paraphernalia, Bulk and Trace Sampling Procedures, Identification, Quantification and Comparison of Heroin Samples, Presumptive Tests for Heroin, Thin Layer Chromatography of Heroin Samples, Gas Chromatographic–Mass Spectroscopic Identification of Heroin, Quantification of Heroin Samples, Comparison of Heroin Samples. **E) Cocaine:** Introduction, Origins, Sources and Manufacture of Cocaine, Extraction and Preparation of Coca Paste, Synthesis of Pure Cocaine, Qualitative Identification of Cocaine, Presumptive Tests for Cocaine, Thin Layer Chromatography, Definitive Identification of Cocaine, Quantification of Cocaine, Quantification of Cocaine by GC–	**20**

	MS, Quantification of Cocaine by UV Spectroscopy, Comparison of Cocaine Samples. **F) Products from *Catha edulis* and *Lophophora williamsii*:** Introduction, Products of *Catha edulis*, Identification, Quantification and Comparison of Khat Samples, Comparison of Khat Samples, Products of *Lophophora williamsii*, Physical Description and Sampling of Materials, Presumptive Tests for Mescaline, TLC Analysis of Mescaline, HPLC Analysis of Mescaline, GC–MS Analysis of Mescaline, Comparison of Peyote Samples. **G) Analysis Barbiturates and Benzodiazepines:** Introduction, Analysis of Barbiturates and Benzodiazepines, Extraction of Barbiturates and Benzodiazepines from Dose Forms, Presumptive Tests for Barbiturates and Benzodiazepines, TLC of Barbiturates and Benzodiazepines, Confirmatory Analysis of Barbiturates and Benzodiazepines, Quantification of Barbiturates and Benzodiazepines.	

Reference Books:

1. Textbook of Forensic Pharmacy, C. K. Kokate, S. B. Ghokhale, Pharma Med Press (2008)
2. Textbook of Forensic Pharmacy, B. M. Miital, Nirali Publication
3. Basic Principles of Forensic Chemistry, Javed I. Khan, Thomas J. Kennedy, Donnell R. Christian, Jr. Humana Press
4. Analysis of Controlled Substances, Michael D. Cole, Wiley (2003)

Course/ Paper Title	**Practical: Basic Instrumental Analysis**
Course Code	21SMAC235
Semester	III
No. of Credits	2 Credits, (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To inculcate basic analytical techniques knowledge and practical applications. 2. To build the bridge between practical knowledge and theory of analytical techniques. 3. To equip students with basic analytical techniques usage and shortcomings. 4. Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc. safely in laboratory. 5. Define / understand various terms involved practical methods of quantitative analysis.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Students will understand basic analytical techniques. 2. Students will be enlightened with basic analytical techniques practical aspects. 3. Design / modify and validate new analytical method for chemical analysis of particularsample. 4. Apply / select particular method / instrumental parameters for analysis of given sample. 5. Give mathematical treatment to analytical data and able to interpret the results accurately. 6. Verify theoretical principle practically or apply theory to explain practical observations. 7. To conclude the results able to take the decision regarding quality of sample.

Syllabus 21SMAC235: Practical: Basic Instrumental Analysis [48L + 12T]

NOTE: Experiment No. I is COMPULSORY and perform any Eleven from II to VIII

Unit No.	Title with Contents
I	Calibration of UV-Visible spectrophotometer for control of absorbance as per IP or BP b) Theoretical basis for the choice of solvent for recording UV-Visible spectra of substances c) Theoretical basis for choice proper concentration for recording the UV-Visible spectrum d) Recording the UV-Visible spectrum of any one substance like caffeine, aspirin, paracetamol, KMnO4 or any other substance of interest having characteristic UV-Visible absorbance i) identification of characteristics peaks in spectrum, b) Choice of λmax for quantitative analysis c) Calculation of Molar absorptivity (ε) and d) Sp. absorbance (absorbance of sample solution for 1% solution). Theoretical interpretation of spectra. **(Compulsory)**
II	**Spectrophotometery** 1. Analysis of aspirin Colorimetry. 2. Assay of Vitamin-C by Colorimetry from lemon or orange juice or vitamin supplements. 3. Colorimetry / visible spectrophotometery phenolic compounds (Salicylic acid, salbutamol sulfate, phenol) by Folin-Ciocalteau reagent. 4. Colorimetry / visible spectrophotometery Analysis of paracetamol.
III	**Potentiometery** 5. Determination of Strength of commercial phosphoric acid by potentiometric titrations using standard solution of sodium hydroxide. 6. Comparison of end point redox titration between $K_2Cr_2O_7$ and standard Fe(II) i) by potentiometry and ii) external indicator. Calculate amount of Fe(II) by both methods and compare with standard value. Give critical comment on Fe(II) content by two methods with respect to standard value i.e. accuracy of results and advantages and disadvantages of each method.
IV	**Conductometery** 1. Determination of relative strength of acetic acid, chloroacetic acid and

	trichloroacetic acid through measuring their K_a value by conductivity measurement method. 2. Determination of boric acid by conductometry.
V	**Turbidometery** 1. Selective estimation of Chlorine from water or saline sample or food sample by calibration curve method using turbidimetry (give regression analysis) and its confirmation by potentiometric titration. 2. Selective estimation of SO_4^{2-} in presence of chloride from water sample or any other sample by calibration curve and its confirmation by turbidimetric titration method (give regression analysis for both curves).
VI	**Photoflourimetery** 1. Estimation of quinine sulphate from tablet by calibration curve and its confirmation by standard addition method. **2.** Estimation of riboflavin by photoflurimetry from multivitamin capsule by calibration curve and its confirmation by standard addition method.
VII	**pH-metery** **1.** Perform pH metric titration for estimation of CH_3COOH from vinegar using i) 0.1 M standardized NaOH simultaneously using phenolphthalein indicator and pH meter ii) 0.5M standardized NaOH using pH meter. Compare the results of three methods and give your comment. **2.** Determine aspirin in tablet by conventional titration and pH-metric titration and compare the results of two methods.
VIII	**Polarography** 1. Determination of optical rotation thereby calculate specific rotation of dextrose (glucose) and sugar (sucrose). Express purity of glucose and sugar samples on the basis of specific rotation. **2.** Determination of glucose from saline sample by polarimetrically. **3.** Estimation of Zn and Cd from the unknown solution by polarographic technique.

Reference Books:

1. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier
2. Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, Americal water works association, Water environment federation.
3. Vogel's textbook of Inorganic Quantitative Analysis
4. Chemical Analysis and Material Characterization by spectrophotometry, Bhim Prasad Kafle, Elsevier
5. Ultraviolet and Visible Spectrophotometry in Pharmaceutical Analysis, Sandor Gorog, Published by CRC press, Taylor and Fransis.
6. Any other relevant reference can be included.

Course/ Paper Title	**Practical: Analysis of Food and Bio analytical Samples**
Course Code	21SMAC236
Semester	III
No. of Credits	2 Credits, (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. Recognize the critical importance of body fluid analysis and identify chemical tests and reactions performed on various body fluids 2. To provide the students with knowledge on the key food safety issues, including the food safety hazards, their methods of detection and the key food quality properties. 3. Deal with the, sampling methods, and tools to conduct statistical analysis. 4. Acquire practical skills in analysis of biological samples, handling and interpretation data in various methods of analysis adapted to bioanalytical chemistry. 5. Undertake and compare various food analysis techniques, followed by analysis, interpretation and presentation of the results. 6. Analysis and interpretation of test results and will include pathophysiological correlations to the test results.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Apply valid sampling techniques to food materials having widely diverse properties and volumes and Select appropriate analytical techniques for specific food components 2. Compare advanced and conventional techniques and instruments to analyse chemical and physical properties of foods.

3. Apply a range of chemical analyses of food components and Analyse, interpret and report on results obtained in a scientific format.
4. Explain the principle of tests commonly included in a routine urinalysis and explain the principle of confirmatory chemical tests for bioanalytical samples.
5. Explain the clinical significance of body fluid analyses or results.
6. Differentiate normal from abnormal results and recognize and explain the clinical significance of abnormal results.

Syllabus for 21SMAC236: Practical: Analysis of Food and Bio analytical Samples

[48L+12T]

Unit No.	Title with Contents
I	**A) Analysis of Food material (ANY SIX)** 1. Estimation of glucose by titration in different samples by using Fehling's solution. 2. Estimation of tannin from tea or coffee sample by Folin-Denis method 3. Separation of amino acids by two dimensional paper chromatography. 4. Estimation of total carbohydrates from food samples by Anthrone method. 5. Determination of saponification value and acid value of an oil sample. 6. Determination of iodine value of oil sample. 7. Isolation of Cinnamaldehyde from Cinnamon by microscale steam distillation. Characterization and interpretation of isolated Cinnamaldehyde by MP and TLC. 8. Determination of HMF content from Honey sample. 9. Estimation of reducing sugars by DNSA method 10. Determination of total ash, acid insoluble ash and sulphated ash of Turmeric. 11. To determine phosphoric acid in cold drink by molybdenum blue method. 12. To determine the amount of acetic acid of commercial vinegar by Volumetric/potentiometric titration.
II	**B) Analysis of Body Fluids (ANY SIX)** 1. Estimation of glucose from blood sample by Kit method.

	2. Estimation of cholesterol from blood sample by Kit method. 3. Estimation of urea from blood sample by Kit method. 4. Estimation of creatinine from urine sample by Kit method. 5. Determination of phosphorus content in serum and urine sample by spectrophotometry. 6. Determination of Na from serum sample by flame photometry using calibration curve method. 7. Estimation of haemoglobin from blood sample. 8. Estimation of reducing sugars by DNSA method. 9. Estimation of total protein from serum sample by Lowry's method. 10. Estimation of total protein from serum sample by Biuret method. 11. Analysis of urine for normal constituents.

Reference Books:

1. Post-graduate Chemistry Practicals- S. S. Kelker, H. N. Patel, S. P. Turakhia, A. G. Gadre, Himalaya Publishing House.
2. Biochemical Methods, Third Edition, By S Sadashivan, A. Manickam; New Age International publishers.
3. Lab. Manual: Manual of Methods of Analysis of Foods, Vegetables: Fruit and vegetable products: https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals /FRUITS_AND_VEGETABLE.pdf
4. Manual Of Methods Of Analysis Of Foods Food Safety And Standards Authority Of India Ministry Of Health And Family Welfare Government Of India New Delhi 2015 Milk And Milk Products: https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/MILK_AND_MILK_PRODUCTS.pdf
5. Any other relevant reference can be included.

Course/ Paper Title	**Practical: Geochemical and water analysis**
Course Code	21SMAC237
Semester	III
No. of Credits	2 Credits, (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To equip the students with skill in qualitative and quantitative chemical analysis of inorganic materials. 2. To analyze ions using colorimeter, potentiometer or any other analytical technique. 3. Describe the principles behind common analytical techniques; gather and interpret their own geochemical data using the appropriate instrumentation and data processing techniques. 4. Introduce the procedure for carrying out laboratory analysis and data evaluation methods in exploration geochemistry. 5. Describe the chemical compositions of natural waters, and explain how and why these compositions vary

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Learn the principles of important methods used to analyse the chemical and mineralogical composition of rocks and minerals. 2. Understand about volumetric and gravimetric analysis of ions in complex materials. 3. Perform experiments using colorimeter, potentiometer, and flame photometer. 4. Understand analytical Instruments, Data Acquisition and Interpretation.

5. Understand chemistry involved in environment.
6. Perform experimental analysis of some properties of water ad wastewater.

Syllabus for 21SMAC237: Practical: Geochemical and water analysis [48L + 12T]

Unit No.	Title with Contents
I	**Volumetric and Gravimetric methods for quantitative analysis of complex materials (ANY FIVE)** 1. Analysis of Dolomite ore for Ca, Mg and Silicate material 2. Analysis of Bronze with respect to Copper and Tin 3. Analysis of Zn-Chrome pigment for Cr and Zn 4. Determination of Calcium and Magnesium in limestone or dolomite samples using EDTA. 5. Analysis of mixed fertilizer sample for total nitrogen, K and phosphate content 6. Analysis of Cement with respect to SiO_2 , Calcium, Iron, Magnesium and Aluminium 7. To analyse given sample of Magnalium alloy and determine percentage of aluminium gravimetrically and magnesium complexometrically 8. Analysis of copper ferrite (CuFe2O4) and determine amount of copper and iron volumetrically 9. Analysis of brass alloy for Cu and Sn 10. Analysis of nichrome alloy with respect to nickel and chromium
II	**Instrumental Methods of selective analysis from complex materials (ANY FOUR)** 1. Analysis of fertilizer Micronutrient Supplement for Fe, Mn, Cu, and B. Colorimetry: Fe with thiocyanate, Mn as KMnO4, B using curcumin reagent, and Cu using diethyldithiocarbamate ligand. (Any One) 2. Analysis of Chloride, Bromide and Iodide from mixture by potentiometry. 3. Identification of form of iodine (qualitative test) in table salt and its

	quantitative estimation by volumetric method. 4. Determination of Ca in milk powder by flame photometry by standard addition or calibration curve method. 5. Determination Critical Micelle Concentration of detergent powder or pure detergent by conductometry /viscometry. 6. Determine amount of magnesium from given talcum powder. 7. Determination of calcium from given sample of plaster of Paris. 8. Estimation of Cu and Fe(III) by spectrophotometric titration. (Standardization of EDTA is expected). 9. Determination of phosphate in fertilizer and cola drinks by Molybdenum blue method. 10. Determination of commercial vinegar by potentiometric titration and its confirmation by volumetric amethod.
III	**Analysis of Waste water (ANY THREE)** 1. Qualitative test for phosphate in hard water / soil sample /food / detergent and its estimation by colorimetry. 2. Determination of COD of waste water sample. 3. Analysis of Waste water Sample w. r. t. Turbidity, Colour and Total hardness. 4. Determination of Alkalinity and Buffering capacity of waste water. 5. To determine concentration in mg/lit of sulphate in given water sample by Nephelometrically. 6. Qualitative test for phosphate in hard water and its estimation by colorimetry. 7. Determination of Cr(VI) in waste water by diphenylcarbazide method.

Reference Books:

1. Vogel's Textbook of Inorganic Quantitative Analysis, A. I. Vogel, 3rd Ed.
2. Lab Manual in biochemistry, immunology and biotechnology, Arti Nigam, Archana.
3. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill Publishing Company Ltd.

4. Standard methods for the examination of water and waste water, 23rd Ed. Rodger Baird, Andrew Eatson, Eugene Rice, jointly published by: American Public Health Association, American Water Works Association, Water Environment Federation.
5. Environmental Chemistry, Stanley E. Manahan, Ninth Edition, CRC press, Taylor and Francis, 2010.
6. Handbook of Environmental Analysis Chemical Pollutants in Air, Water, Soil, and Solid Wastes by Pradyot Patnaik, Third Edition, CRC press, Taylor and Francis, 2018.
7. Any other relevant reference can be included

SEMESTER – IV

Course/ Paper Title	**Advanced Methods of Chemical Analysis**
Course Code	21SMAC241
Semester	IV
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. Introduce, in an integrated way, the fundamentals, methods, applications and limitations of mass spectrometry. 2. Interpret and correlate the information provided by the various types of mass spectra and gas chromatogram. 3. Introduce the student to principles and theory of Gas chromatography and capillary electrophoresis. 4. Acquaint the student to principles and theory of HPLC. 5. Provide advance knowledge of HPLC operation and maintenance. 6. Explain the fundamental concepts & theories of separation techniques in SFC & SFE.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Identify, describe and explain the function of the several components of a mass spectrometer. 2. Interpret and evaluate the information contained in the several types of spectra (MS) obtained with different types of mass spectrometers.

3. Categorize the types, basic components and properties of gas chromatography.
4. Evaluate the method development and analysis by capillary electrophoresis of abnormal results.
5. Explain theory and instrumentation of HPLC.
6. Learn applications of HPLC for organic, inorganic and natural products.
7. Explain the usage of electron spectroscopy as a source of information about the surface and atomic or molecular composition of matter.

Section I: Mass spectrometry, Gas Chromatography and Electrophoresis [24L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Mass Spectrometry (Ref-1, 2):** Fundamentals of Electron ionization and Chemical ionization. Features of atomic mass spectroscopy, Atomic weight in mass spectroscopy, mass to charge ratio, Types of atomic mass spectroscopy, mass spectrometers, transducer for mass spectroscopy, quadruple mass analyzer, time of flight mass analyzer. Interpretation of mass spectra, Types of ions isotopic abundances and characteristic ion clusters, Nitrogen rule and rings-plus-double-bonds, steps in interpretation. Inductively coupled mass spectroscopy (ICPMS), Instrumentation for ICPMS, Atomic mass spectra and interferences, Applications of ICPMS. Numerical problems.	**06**
II	**Gas Chromatography (Ref. 3, 4):** Fundamentals of Chromatographic Separation (overview, the development of chromatogram), Characteristics value in chromatogram, Chromatographic theories (plate theory, kinetic theory), Rs as measure of peak separation, qualitative and quantitative analysis. Problems. Retention data and partition coefficient, separation in the gas phase, Principle and Components of gas chromatography: Carrier gas, sample injection, split injection, spitless injection, cold on column injection, programmable temperature	**08**

	vaporization, head space injection, solvent effects, column, detectors- TCD, FID, ECD, Stationary phases for GC: stationary phases for packed column, capillary column, deactivation of surface, different stationary phases, Applications of GC, Quantitative analysis by GLC-different methods, Elemental Analysis using Gas Chromatography, analysis of Al, analysis of a mixture using the interna1 normalisation method, determination of sucrose as its trimethylsilyl derivative using gas-liquid chromatography, Problem on quantitative analysis.	
III	**Capillary Electrophoresis (Ref. 5, 6):** Types of electrophoretic systems: Moving boundary electrophoresis, Zone electrophoresis, Steady state electrophoresis; Support media in Zone electrophoresis: filter paper, cellulose acetate, gel media. Basic Principles: Basic Electrophoretic Separation Modes, Zone Electrophoresis, lsotachophoresis, lsoelectric Focusing, Set-up for Capillary Electrophoresis, Theory of Electrophoretic Migration, Determination of Effective Mobility, Electro-osmosis, Performance Criteria, Efficiency, Resolution. Instrumentation: Injection, Hydrodynamic Injection, Electro-kinetic Injection, General Aspects of Injection, Detection, General Aspects, Evaluation of Detector Performance, UV-VIS Absorbance Detection, Light Sources for UV-VIS Detection, Optical Layout of a UV-VIS Detector for CE, Design of the Detection Cell, Fluorescence Detection: Excitation Sources for Fluorescence Detection, Optical Layout of a Fluorescence Detector, Derivatization with Fluorescent Tags, Pre- and Post-Column Derivatization, Electrochemical Detection, Conductometric Detection, Amperometric Detection, Capillary Column, Sample Collection, Commercial Instruments. Factors Affecting Electrophoretic Mobility: Characteristic of charged molecules, Characteristic of the electrophoretic system; Detection in	**10**

	electrophoresis: optical methods, radiochemical methods, biological assay methods. General Aspects of Qualitative and Quantitative Analysis, Application: Drugs and Natural Products, Amino Acids, Peptides and Proteins.	

Reference Books:

1. Basic Gas Chromatography Mass Spectrometry, Principles and Techniques, F.W. Karasekand R.E. Clement, Elsevier, (Elsevier Science B.V.) 1988
2. Fundamentals of Analytical Chemistry, 6th edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing.
3. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH.
4. Introduction to Instrumental Analysis by R. D. Broun, Mc Graw Hill (1987).
5. Electrophoresis, Analytical chemistry through open learning Series, Wiley
6. Capillary Electrophoresis: Principles and Practice, R. Kuhn S. Hoffstetter-Kuhn, Springer Laboratory, Springer-Verlag

Section II: Liquid Chromatography and Electron spectroscopy [24 L + 6 T]

Unit No.	Title with Contents	No. of Lectures
I	**Instrumentation of HPLC (Ref. 1):** Introduction: HPLC-A powerful separation method, The HPLC instrument, Pumps: General requirements, The short-stroke piston pump, Sample injectors, Detectors: General, UV detectors, Refractive index detectors, Fluorescence detectors, Electrochemical (amperometric) detectors, Columns and Stationary Phases: Columns for HPLC, Precolumn, General properties of stationary phases, Silica, chemically modified silica, Styrene-divinylbenzene.	**04**

II	**HPLC Methods (Ref. 2):** a) Adsorption Chromatography: Normal-Phase Chromatography: What is adsorption? The eluotropic series, Selectivity properties of the mobile phase, Applications, b) Reversed-Phase Chromatography: Principle, Mobile phases in reversed-phase chromatography, Solvent selectivity and strength, Stationary phases, Applications. c) Ion-Exchange Chromatography: Introduction, Principle, Properties of ion exchangers, Applications. d) Ion-Pair Chromatography: Introduction, e) Ion-pair chromatography in practice, Applications, f) Size exclusion Chromatography.	**06**
III	**Analytical HPLC (Ref. 2):** Qualitative analysis, Trace analysis, Quantitative analysis, Recovery, Peak-height and peak-area determination for quantitative analysis.	**02**
IV	**Super Critical Fluid Chromatography and Extraction (Ref. 3):** Properties of supercritical fluid, Supercritical fluid chromatography: Principle, Instrumentation and operating variables, effect of pressure, stationary phases, mobile phases, detectors, comparison with other types of chromatography, Applications in pharmaceuticals, supercritical fluid extraction: Advantages of SFE, instrumentation, of line and online extraction, applications.	**02**
V	**Electron spectroscopy (Ref. 4):** Introduction, principle of ESCA, electron spectroscopy for chemical analysis, ESCA satellite peaks, spectral splitting, ESCA chemical shifts, Apparatus used for ESCA, X-ray source, samples, Analyzers, Detectors, Chemical analysis using ESCA, Applications, Auger electron microscopy, Ultraviolet photoelectron spectroscopy.	**08**
VI	**Flash chromatography (Ref. 5):** Principle of Flash chromatography, Steps of Flash chromatography, Uses of Flash chromatography.	**02**

Reference Books:

1. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH
2. Practical High-Performance Liquid Chromatography, Veronika R. Meyer, Fifth Ed. John Wiley and Sons, Ltd.
3. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
4. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
5. P Ayare, V Khanvilkar, N Chalak; Flash Chromatography: Area & Applications; Pharma Tutor; 2014; 2(5); 89-103

Course/ Paper Title	**Pharmaceutical chemistry and Pharmaceutical Analysis**
Course Code	21SMAC242
Semester	IV
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To be employed in researching within the chemical and pharmaceutical field, to pick a career as pharmacists, as well as in scientific reporting and as laboratory chemists. 2. To provide adequate scientific knowledge and training in order to operate in the field of industrial pharmacy. 3. To provide specific knowledge in the field of biochemistry, pharmacology, toxicology, as well as in pharmaceutical chemistry and technology, including the formulation of pharmaceutical products. 4. To develop and demonstrate depth and breadth of knowledge in biomedical, pharmaceutical, social/administrative/behavioral, and clinical sciences. 5. To integrate knowledge from foundational sciences to explain how specific drugs or drug classes work and evaluate their potential value in individuals and populations. 6. To apply knowledge in foundational sciences to solve therapeutic problems.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Define / understand various terms in pharmaceutical raw material and finished product analysis. 2. Explain various pharmaceutical dosage forms and types of raw materials used.

3. To describe basic principles of methods of pharmaceutical analysis according to IP.
4. Explain importance particular test in pharmaceutical raw material and finished product analysis.
5. Perform and explain importance of limit tests, identification tests and micobiological limit test of raw materials and finished products.
6. Solve numerical problems on analysis pharmaceutical raw material and finished product analysis.
7. Interpret IR spectra, HPLC chromatogram, UV-Visible spectra of pharmaceutical materials.
8. To perform total analysis of pharmaceutical raw material and finished product analysis according to IP / BP / USP.

Section I: Pharmaceutical chemistry [24 L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Pharmaceutical Chemistry (Ref. 1 to 5):** Definition of a drug, Requirements of an ideal drug, Classification of drugs (based on therapeutic action), Nomenclature of drugs: Generic name, Brand name, Systematic name, Definition of the following medicinal terms: Pharmacon, Pharmacophore, Prodrug, Half-life efficiency, LD50, ED50, Therapeutic Index., Brief idea of the following terms: Receptors, Drug-receptor interaction, Drug Potency, Bioavailability, Drug toxicity, Drug addiction, Spurious Drugs, Misbranded Drugs, Adulterated Drugs, Pharmacopoeia. Routes of drug administration with advantages and disadvantages, Formulations, Different dosage forms. Synthesis and therapeutic use of Diclofenac sodium (DFS), Aceclofenac, Paracetamol, Phenytoin, Aspirin, Atenolol, Laevodopa, Ciprofloxacin, Metronidazole, Dapsone, Ethambutol.	**10**
II	**Biopharmaceuticals (Ref. 6 to 9):** Introduction to Biopharmaceuticals, Sources of Biopharmaceuticals (*E. Coli*,	**04**

	Animal cells, Additional systems), Upstream & Downstream processing, Product Analysis, Therapeutic Hormones, Recombinant Blood Products & Therapeutic Enzymes, Production of antibodies, Vaccines & adjuvants.	
III	**Phytochemicals (Ref. 10 to 11):** Primary and secondary metabolites from plants, Classification of Plant Secondary metabolites, Functions of Plant Secondary Metabolites, Chemistry of Phenolics, Terpenoids, Alkaloids, Phytochemicals as Drugs, Key factors affecting synthesis of secondary metabolites, Commercial applications. Extraction of phytoconstituents, Choice of solvent for extraction, classical and modern methods of extraction, Percolation & Maceration, Soxhlet extraction, Steam Distillation & Rotary vacuum evaporator, Liquid-Liquid & Solid Phase Extraction, Ultrasonication, Microwave Assisted Extraction, Supercritical Fluid extraction. Classical methods of analysis (Gravimetric & Titrimetric), Chromatographic & Spectroscopic analysis of phytoconstituents, Phytochemical variations in plants Analysis of herbal formulation, Effect of drying on phytoconstituents.	**06**
IV	**Nutraceuticals (Ref. 13 to 16):** Definitions of Functional foods, Nutraceuticals and Dietary supplements. Classification of Nutraceuticals, Health problems and diseases that can be prevented or cured by Nutraceuticals i.e. weight control, diabetes, cancer etc. Phytochemicals as nutraceuticals: Occurrence and characteristic features (chemical nature medicinal benefits) of a) Carotenoids: α and β-Carotene, Lycopene, Xanthophylls, lutein b) Sulfides: Diallylsulfides, Allyltrisulfide. c) Polyphenolics: Reservetrol d) Flavonoids- Rutin, Naringin, Quercitin, Anthocyanidins, catechins, Flavones e) Prebiotates / Probiotics.: Fructo oligosaccharides, Lacto bacillum f) Phytoestrogens, Isoflavones, daidzein, Geebustin, lignans g. Tocopherols. Source,	**04**

	Name of marker compounds and their chemical nature, Medicinal uses and health benefits of following used as nutraceuticals/functional foods: Spirulina, Soya bean, Ginseng, Garlic, Broccoli, Gingko, Flaxseeds.	

Reference Books:

1. Quantitative Analysis of Drugs in Pharmaceutical Formulations by P.D. Sethi
2. Indian Pharmacopoeia all editions
3. A Text Book of Pharmaceutical Analysis by Kennenth A. Conners
4. Pharmaceutical Analysis: David Lee
5. Biosimilars; Regulatory, Clinical and Biopharmaceutical development: Springer
6. Brahmankar, D.M., "Biopharmaceutical and Pharmacokinetics: A Treatise", VallabhPrakashan, 1995.
7. Notari, R.E., "Biopharmaceutics And Clinical Pharmacokinetics: An Introduction",4thedition, Marcell Deckker, 2005
8. Pharmaceutical Chemistry: H.J. Roth, A. Kleemann
9. Pharmacognosy: Tyler, Brody, Robbers
10. Text book of Pharmacognosy: G.E. Trease, W.C. Evans
11. Herbal Drug Technology: Agrawal, Paridhavi.
12. Dietetics by Sri Lakshmi
13. Role of dietary fibres and nutraceuticals in preventing diseases by K. T Agusti and P. Faizal, BS Publication.
14. Advanced Nutritional Therapies by Cooper. K.A., (1996).
15. The Food Pharmacy by Jean Carper, Simon & Schuster, UK Ltd., (1988).

Section II: Pharmaceutical Analysis [24L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Introduction to Pharmaceutical analysis (Ref. 1 to 3):** Definitions of Drug & Cosmetics, Substandard Drugs, Role of FDA, Introduction to New Drug, Introduction to drug dosage	**04**

	Forms, Excipients and routes of drug administration, Tablets and types of tablets, capsules and types of capsules, monographs, introduction to different pharmacopoeias.	
II	**Monographs and Chemical Analysis of Organic Pharmaceuticals (Ref.1 to 3):** Monographs and Chemical Analysis as per IP of adrenaline, Niacinamide, Cephalexin, isoniazide, paracetamol, aspirin, Sodium benzoate, salicylic acid, sulphacteamide, salbutamol sulphate, Diphenhydramine, omeprazole, amitriptyline hydrochloride, Benzocaine, dopamine hydrochloride, ibuprofen, Chloramine-T, Dapsone, Pyrazinamide, Chloroquine, Metronidazole, Diethycarbamazine, Clotrimazole, Acylclovir, 5-fluorouracil, tolbutamide, warfarin and Problems based on assay of these materials.	**10**
III	**Monographs and Chemical Analysis of Inorganic Pharmaceuticals (Ref.1 to 3):** An outline of uses, sources of impurities, tests for purity and identity, including limit tests for iron, arsenic, lead, heavy metals, chloride, sulphate and special tests if any, Monographs and Chemical Analysis of the following classes of inorganic pharmaceuticals included in Indian Pharmacopoeia and Problems based on assay of these materials. **Haematinics:** Ferrous sulphate, Ferrous gluconate, **Antacids:** Aluminium hydroxide gel, Magnesium hydroxide, **Antimicrobial agents:** Hydrogen peroxide, Boric acid, Bleaching powder, **Dental products:** Calcium carbonate, Sodium fluoride	**06**
IV	**Analysis of special classes of drugs (Ref.1 to 3):** Definition, classification and principles and procedures involved in the quantitative determination of any two drugs from each category of both API and dosage forms (IP) of the following and Problems based on assay of these materials Analgesics & Antipyretics, Antihypertensives, Antihistamines, Alkaloids, Antibiotics, Anticancer, Anti-tubercular, Antiviral,	**04**

	Antifungal, Diuretics.	

Reference Books:

1. Indian Pharmacopeia Volume I, 7th Ed
2. Indian Pharmacopeia Volume II, 7th Ed
3. Indian Pharmacopeia Vol-III, 7th Ed.
4. Liberman H. A, Lachman C, Pharmaceutical Dosage forms. Disperse systems, volume 1, 2, 3, Marcel Dekkar Inc.
5. Laboratory Manual of Physical Pharmaceutics, C.V.S. Subramanyam, J. Thimma settee
6. Introduction to Pharmaceutical Analytical Chemistry, Stig Pedersen-Bjergaard, Bente Gammelgaard, Trine Grønhaug Halvorsen, Second Edition, Wiley (2012)
7. A.H. Becket and J.B. Stenlake, Practical Pharmaceutical Chemistry, part- II, 4th ed., CBS Publishers & Distributors, New Delhi, 1997.
8. Validation of Analytical Procedures, Text & Methodology, International conference on Hormonization, Geneva.

Course/ Paper Title	**Analytical Method validation and Drug Development**
Course Code	21SMAC243
Semester	IV
No. of Credits	4 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To give the knowledge regarding the data handling and basic concepts in analytical Chemistry. 2. To familiarize students with assay and validation methods. 3. To give the students brief knowledge regarding dissolution studies. 4. To be employed in researching within the chemical and pharmaceutical field, to pick a career as pharmacists, as well as in scientific reporting and as laboratory chemists. 5. To provide adequate scientific knowledge and training in order to operate in the field of industrial pharmacy.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Analyze data statistically and understood the basic terms in analytical chemistry. 2. Became familiar with assay and validation methods. 3. Receive basic knowledge regarding dissolution studies. 4. Define / understand various terms in pharmaceutical raw material and finished product analysis. 5. Explain various pharmaceutical dosage forms and types of raw materials used. 6. Explain importance particular test in pharmaceutical raw material and finished product

analysis.

7. Perform and explain importance of limit tests, identification tests and micobiological limit test of raw materials and finished products.

Section I: Analytical Method Validation [24 L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Assay Validation and Inter Laboratory Transfer (Ref-1):** Introduction, fundamental definitions, Essential principles of method transfer, method validation report, the inter-laboratory qualification (ILQ) process.	**04**
II	**Statistical Analysis and analytical Figure of Merit (Ref-1, 2):** Introduction, Errors (gross errors, systematic errors, random errors), accuracy, validation parameters: Accuracy, precision, mean and standard deviation, calibration, (linear response functions: linear regression-errors in slope and the intercept, error in the estimate of concentration, standard additions, non-linear response functions, internal standards), selectivity and specificity, limits of detections, limit of quantification, sensitivity, ruggedness and robustness, how to reduce systematic errors, mean and standard deviation, reliability of results, confidence interval, comparison of results, comparison of two means of two samples.	**14**
III	**Assay method development and validation (Ref. 2):** Ibuprofen tablets by HPLC, paracetamol tablets by UV spectrophotometric method, Salbutamol Sulphate by RP-HPLC, Rabeprazole in Bulk and Tablet dosage form by RP-HPLC Method.	**02**
IV	**Specific methods and Applications: Dissolution Studies (Ref. 1):** Introduction, Dissolution test, Apparatus – USP type –I and II, Sampling and analytical instrumentation, Single point test Vs. Dissolution profile, Calibration, Regulatory guidelines, analytical validation, linearity, accuracy, precision, specificity.	**04**

Reference Books:

1. Development and validation of Analytical Methods, Progress Pharmaceutical and Biomedical Analysis, Vol-3, Edited by Chitofer M. Riley and Tomas W. Rosanske (Elvier)
2. Method Validation in Pharmaceutical Analysis: A Guide to Best Practice, 2nd Edition, Joachim Ermer, Phil W. Nethercote, Wiley international.
3. Vogel's Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
4. Handbook of modern pharmaceutical analysis, edited by Satinder Ahuja and Stephen Scypinski, Academic Press, Separation science Series, Vol-3
5. HPLC method Development for pharmaceuticals, Edited by Satinder Ahuja and Henrik Rasmussen, Academic Press, Separation science Series, Vol-8
6. Practical HPLC method Development, Snyder, Kirkiand, Glajch, Wiley India Pvt. Ltd.

Section II: Drug Development [24 L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Classification of drugs (Ref 1 to 3):** Alphabetical, Taxonomical, Morphological, Pharmacological, Chemical, Chemo-taxonomical**.**	**02**
II	**Drug Development Process (Ref 1 to 3):** Clinical trials, definition, types of clinical trial, choice of patients, exclusion criteria, inclusion criteria, ethical and legal aspects of clinical trials, methods of randomization, size, documentation monitoring management of clinical trial, clinical trial registry of India, phase I,phase II, phase III and phase IV studies, design, safety evaluation, guidelines as per ICMR, WHO and Drugs control authorities, preparation of IND/NDAs, post marketing surveillance of drugs, statistical designs in clinical trials, data analysis techniques and presentation skills.	**05**
III	**Sources of Impurities in Pharmaceutical products (Ref 1 to 3):**	**05**

	Impurities in Pharmaceuticals: Source and effect of impurities in pharmacopoeial substances - Atmospheric contaminations, Cross contamination, Microbial contamination, Container contamination, Packaging errors, Chemical instability, Temperature effect and Physical changes, shelf life of pharmaceutical product and determination of shelf life, importance of limit test, Principle and procedures of Limit tests for limit tests for arsenic, heavy metals, iron, lead, sulphate and chloride.	
IV	**Physicochemical properties of pharmaceutical products (Ref. 4 to 9)** **a)** Determinations and applications of Refractive index, optical rotation, dielectric constant, dipole moment, dissociation constant, Disintegration Test for Tablets and Capsules, Dissolution Test for Tablets and Capsules, moisture / water content by Karl-Fischer titration, Ash values. **b)** Principles and procedures involved in the determination of the official compounds in IP with the following analytical techniques: Non-aqueous, Complexometric, Oxidation-reduction, Diazotization methods, Neutralization, Acid – Base. **c)** Principles and procedures involved in using the following reagents in the determination of pharmaceutical dosage forms official in IP: MBTH (3-methyl-2-benzothiazolone hydrazone), F.C. Reagent (Folin-Ciocalteu), PDAB (para-Dimethyl Amino Benzaldehyde), 2,3,5-triphenyltetrazoliumsalt, Chlorimide,2,6-dichloroquinone, N-(1-naphthyl)ethylenediaminedihydrochloride (B.M. Reagent), Carr–Price Reagent, 2,4–DNP. **d)** A detailed study of the principles and procedures involved in the quantitative determination of the organic functional groups in pharmaceutical formulations: Amines, Carbonyl compounds, Esters, Hydroxy, carboxyl and Amino Acids **e)** Identification and quantitative determination of preservatives,	**12**

	Antioxidants, colouring materials, emulsifiers and stabilizers in Pharmaceutical formulation. Analysis of drugs from biological samples including, selection of biological sample, extraction of drugs by various methods as LLE, SPE and Membrane filtration. Factors affecting extraction of drugs.	

Reference Books:

1. Text book of Pharmacognosy by C. K. Kokate, S. B. Gokhale, A.P. Purohith, NiraliPrakashan
2. Text book of Pharmacognosy by C.S. Shah and J. S. Quadry, CBS Publishers & Distributors Pvt. Ltd.
3. Text Book of Pharmacognosy by T. E. Wallis. CBS Publishers & Distributors Pvt. Ltd.
4. Remington's Pharmaceutical Sciences by Alfonso and Gennaro.
5. Quantitative Analysis of Drugs in Pharmaceutical Formulations by P.D. Sethi
6. Indian Pharmacopoeia all editions
7. A Text Book of Pharmaceutical Analysis by Kennenth A. Conners
8. H. Beckett and J. B. Stenlake Practical Pharmaceutical Chemistry, Part I and Part II, 4th Edition.
9. G. H. Jeffery, J. Basset, J. Mendham, R. C. Denny (Rev. by) Vogels Text Book of Quantitative Chemical Analysis, 5th Edition 1989, ELBS.
10. Validation of Analytical Procedures, Text & Methodology, International conference on Hormonization, Geneva.

Course/ Paper Title	**Analytical Chemistry of agriculture, Soil and Detergents**
Course Code	21SMAC244A
Semester	IV
No. of Credits	2 Credits (24 L, 06T)

Aims & Objectives of the Course

Objectives
Students should – 1. Make students aware of basic soil analysis techniques and relevant procedural errors. 2. Provide comprehensive knowledge about essential fertilizers elemental analysis. 3. Describe basic principles techniques / methods soil analysis, pesticide residue analysis and detergent analysis.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Make students aware of basic soil analysis techniques and relevant procedural errors. 2. Provide comprehensive knowledge about essential fertilizers elemental analysis. 3. Describe basic principles techniques / methods soil analysis, pesticide residue analysis and detergent analysis.

Syllabus for 21SMAC244A: Analytical Chemistry of agriculture, Soil and Detergents

Unit No.	Title with Contents	No. of Lectures
I	**Analysis of soil (Ref. 1, 2):** **a)** Sampling of soil, sample preparation, Pre-treatment of Samples and Contamination, Trace Element Analysis, Sub-sampling, Drying	10

	Techniques, Milling, Grinding and homogenization. **b) Weighing and Dispensing:** Weighing Errors, Dispensing Errors. **c) Acid-digestion, Ashing and Extraction Procedure:** Acid-digestion and Washing: Acid-digestion of soils, Total soil nitrogen; Microwave acid-digestion, Dry ashing; Extraction Procedures for soils: pH extractants, Phosphate extractants, Potassium extractants, Trace element extractants. **d) Analysis of Soil:** Soil Analytical Procedures - Determination of extractable boron, Cation exchange capacity, exchangeable bases and base Saturation, Measurement of calcium and magnesium by AAS, Measurement of potassium and sodium by flame photometry, Determination of fulvic and humic acids, Discussion - Determination of available nitrogen, Method-a: Determination of nitrate by selective ion electrode, Method-b: Determination of extractable ammonium-N, Method-b: Determination of extractable nitrate-N, Discussion, Determination of organic plus ammonium nitrogen, Method-a: Determination of soil nitrogen by autoanalysis, Method-a: Reduction of nitrate before digestion and colorimetric auto analysis, Method-b: Determination of organic plus ammonium-N by digestion and distillation, Discussion, Determination of soil organic matter, Method-a: Determination of soil organic matter by loss on ignition, Determination of pH and lime requirement, Method-a: Measurement of pH, Method-b: Determination of lime requirement, Method-c: Determination of pH in soils with soluble salts, Discussion - Determination of extractable phosphorus, Method-a: Determination of extractable phosphorus (manual method), Determination of extractable magnesium, Determination of extractable trace elements, Discussion-Determination of extractable sulphur, Method-a. Determination of extractable sulphur (manual method).	
II	**Analysis of Pesticide Residues and Fertilizers (Ref. 1, 3):**	**08**

	a) Pesticide Residues: Preparation of Samples, Collection and Preparation of Soil Samples, Collection and Preparation of Water Samples, Individual Pesticide Residue Analytical Methods: Aldicarb (GC), Captafol (HPLC); Multiple Pesticide Residue Analytical Methods: Substituted Phenyl Urea Herbicides (GC), Organochlorine and Organophosphorus Pesticides (GC), Dithiocarbamate and Thiuram Disulphide Fungicides (photometric). **b) Fertilizers:** Sampling and sample preparation, total nitrogen: Kjeldahl method, total nitrogen by reduced iron method, urea nitrogen, total Kjeldahll nitrogen methods. 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.	
III	**Analysis of soaps and detergents (Ref. 4):** General scheme of analysis, sampling, alcohol soluble materials, moisture and volatile matter, active ingredient and equivalent combined SO_3^{3-}, Tests for soaps: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, Tests for synthetic detergents: Unsulfonated or unsulfated matter, ester SO_3, Combined alcohols, total combined SO_3, Alkalinity, chlorides, silicate, phosphate, borates, UV spectroscopic analysis of detergents: Biodegradability of detergents, Determination of sodium alkyl benzene sulfonate, determination of sodium toluene sulfonate, determination of sodium xylene sulfonate, determination of germicides in soaps and detergents.	**06**

Reference Books:

1. Methods in Agricultural Chemical Analysis: A Practical Handbook, N.T. Faithfull, CABI Publishing, Typeset by Wyvern 21 Ltd, Bristol (2002).

2. Soil Sampling and Methods of Analysis, Edited by M.R. Carter E.G. Gregorich, Canadian Society of Soil Science, Second Edition (2008)
3. Manual of Pesticide Residue Analysis Volume I, Edited by Hans-Peter Thier and Hans Zeumer, Pesticides Commission, VCH, New York.
4. Standard methods of chemical analysis, volume 3, part-B, F.J. Welcher.

Course/ Paper Title	**Polymer Analysis**
Course Code	21SMAC244B
Semester	IV
No. of Credits	2 Credits (24 L, 06T)

Aims & Objectives of the Course

Objectives
Students should – 1. Provide the students with fundamental principles of polymers, classification, preparation, structure and properties. 2. Provides students with an opportunity to identify different types of polymers in our surrounding. 3. Introduces students to the practical application of polymers. 4. To introduce the specialized subject of the chemistry of polymers. 5. To understand in detail the mechanisms of the reactions that lead to the formation of polymers.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Student received basic knowledge of polymer chemistry. 2. Define the basic concepts and terms in polymer chemistry and the different types of polymerization. 3. Explain the relation between the polymer structure and its molecular weight. 4. Recall the different methods of polymer preparation, importance of different types of polymers. 5. Use calculations of molecular weight of polymer in solving problems.

Syllabus for 21SMAC244B: Polymer Analysis [24L + 6T]

Unit No.	Title with Contents	No. of Lectures
I	**Introduction and Identification to polymers (Ref. 1, 2, 3):** Basic concepts & definitions: monomer & functionality, oligomer, polymer, repeating unites, degree of polymerization, molecular weight & molecular weight distribution, Preliminary Identification Methods: Solubility, Density, Behavior on Heating; Infrared Spectroscopy, Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Ultraviolet-Visible Spectroscopy, Differential Scanning Calorimetry, Mass Spectrometry, Chromatography, Emission Spectroscopy.	**06**
II	**Measurement of molecular weight and size (Ref. 2, 3):** Introduction, Molecular Weight Calculations, Chromatography, Ultracentrifugation, Osmometry, Light Scattering, End-Group Analysis, Turbidimetric titrations, colligative properties measurements, solution viscosity and molecular size.	**03**
III	**Individual polymers (Ref. 4, 5):** Preparation and applications of following polymers- Polyethylene, Polystyrene, Polyester, polyformaldehyde, Polycarbonate, Polyurethane, Polyamides, Polyethylene glycol, Polyvinyl acetate, Polyvinyl alcohol, polyvinyl chloride (PVC) Teflon, Polyisoprene, Polybutadine, Phenol-formaldehyde resin, Urea- formaldehyde resin, Epoxy polymers, Silicone polymers, Rayon, Cellophane, Cellulose nitrate, Cellulose acetate.	**04**
IV	**Polymer reactions (Ref. 4, 5):** Hydrolysis, Acetolysis, aminolysis, hydrogenation, addition and substitution reactions, reactions of specific groups such as –OH, -COOH, >C= and other groups, Cyclisation reaction, cross linking reactions, reaction leading to graft and block co-polymers.	**02**
V	**Analysis and testing of polymers (Ref. 1 to 5):** a) Chemical analysis	**09**

	of polymers: X-ray diffraction analysis, thermal analysis, TGA, DTA. b) Physical testing of polymers: Mechanical properties, Fatigue testing, impact testing, tear resistance, hardness, abrasion resistance. c) Thermal properties: Softening temperature, flammability. d) Optical properties: transmittance, color, gloss, haze and transparency. e) Electrical properties: dielectric constant and loss factor, resistively, dielectric strength, electronic properties. f) Chemical properties: resistance to solvents, vapor permeability, weathering.	

Reference Books:

1. Principles of Polymer Science, Bahadur and Sastry, Narosa Publishing House 2002.
2. Polymer Science, Gowarikar, Johan wiley and Sons 1986.
3. Polymer analysis, Barbara H. Stuart, Analytical Techniques in the Sciences (AnTS), John Wiley and Sons Ltd.
4. Polymer Science by V. R. Gowarikar, N.B. Vishvanathane, New Age International Ltd. Publisher (1998)
5. Polymer Science by Vasant Gowarikar, Wiley Easteren New York (1998).

Course/ Paper Title	**Practical: Advanced Instrumental Analysis**
Course Code	21SMAC245
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To introduce the students to advanced analytical techniques practical knowledge. 2. To build the bridge between practical knowledge and theory of analytical techniques. 3. Define / understand various terms involved practical methods of quantitative analysis. 4. Explain instrumentations of colorimeter, spectrophotometer, photoflurometer, TGA, HPLC, GC, Flame-photometer, CV, AAS, etc. 5. Explain / describe basic principles of chromatography different instrumental methods of analysis.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Students will understand advanced analytical techniques used in industries and research. 2. Students will be enlightened with recent trends in practical aspects of techniques. 3. Design / modify and validate new analytical method for chemical analysis of particular sample. 4. Apply / select particular method / instrumental parameters for analysis of given sample. 5. Give mathematical treatment to analytical data and able to interpret the results accurately. 6. Verify theoretical principle practically or apply theory to explain practical observations. 7. Conclude the results able to take the decision regarding quality of sample.

8. Able to handle particular instrument according to SOP.

Syllabus for 21SMAC245: Practical: Advanced Instrumental Analysis [48L+12T]

(Total 12 practical to be conducted)

Unit No.	Title with Contents
I	**Flame Photometery** 1. Flame photometric estimation of Na and K from their given sample by working curve method. 2. Estimation of Na and K / Ca and K from the binary mixture by internal standard method using lithium as internal standard on flame photometry.
II	**Thermo Gravimetric Analysis** 1. Study of GC chromatogram: Record the TGA of pure $NaHCO_3$ (room temp to 300 °C). Explain different characteristics of thermogram and quantitative analysis by TGA. Explain how thermal decomposition reaction can be predicted from wt. loss. 2. TGA analysis $CuSO_4.5H_2O$
III	**Gas Chromatography** 1. Study of GC chromatogram: Record the chromatogram of pure ethanol, methanol, acetone and their mixture. Identify peaks of respective substances in mixture and calculate relative percentage of these three substances by percent area method. 2. Quantitative analysis of alcohol in beverages by Gas Chromatography.
IV	**High Pressure Liquid Chromatography (HPLC)** 1. To estimate the amount of paracetomol and dichlofenac sodium in pharmaceutical tablets (USP) by HPLC technique. 2. Analysis of Caffeine and benzoic acid from cold drink by HPLC.
V	**Cyclic Voltammetry** 1. Cyclic voltammetric study of Fe(II)/Fe(III) system. Basic principle and calculation of basic parameters from CV.

	2. Quantitative estimation of quinone system or any other biological system by Cyclic voltammetry.
VI	**Double beam spectrophotometer** 1. The Determination of Aspirin and caffeine in a Proprietary Analgesic or given mixture by Ultraviolet (UV) Spectrometry. 2. UV absorbance based assay of plane paracetamol table using specific absorbance (British Pharmacopeia)
VII	**Electrophoresis** 1. Separation and molecular weight determination of protein by gel electrophoresis 2. Separation of several dyes of different molecular sizes by gel electrophoresis.
VIII	**Polarimetry** 1. Determine the relative strength of given two acids by polarimetric measurement. 2. Investigate the effect of substitution of chloride ions on rate constant of inversion of cane sugar by using mono and dichloro acetic acid as catalyst.
IX	**Atomic Absorption Spectroscopy** 1. Estimation of As, Pb, Se, Cr, Zn, and some important transition elements from the commercial samples by Atomic absorption spectrometry with working curve and standard addition method. 2. Estimation of Cu, Al, Ni, Fe and some important transition elements from the commercial samples by Atomic absorption spectrometry with working curve and standard addition method.

Reference Books:

1. Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, Americal water works association, Water environment federation.
2. Vogels textbook of Inorganic Quantitative Analysis
3. Ultraviolet and Visible Spectrophotometry in Pharmaceutical Analysis, SandorGorog, Published by CRC press, Taylor and Fransis.
4. Any other relevant reference can be included.

Course/ Paper Title	**Practical: Analysis of Pharmaceutical Products**
Course Code	21SMAC246
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. Define / understand various terms in pharmaceutical raw material and finished product analysis. 2. Explain various pharmaceutical dosage forms and types of raw materials used. 3. To describe basic principles of methods of pharmaceutical analysis according to IP. 4. Explain importance particular test in pharmaceutical raw material and finished product analysis. 5. Perform and explain importance of limit tests, identification tests and limit test of raw materials and finished products.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Interpret IR spectra, HPLC chromatogram, UV-Visible spectra of pharmaceutical materials. 2. To perform total analysis of pharmaceutical raw material and finished product analysis according to IP / BP / USP. 3. Standardize analytical instruments according IP /BP/ USP. 4. Take a decision on the basis of analytical results regarding quality of raw materials sothat material can be accepted for production or rejected.

Syllabus for 21SMAC246: Practical: Analysis of Pharmaceutical Products [48 L + 12T]

Total 12 practical to be conducted

Unit No.	Title with Contents
1)	Table Work: Characterization of organic compounds by UV-Visible, IR and NMR spectroscopy (any two compounds, Example- paracetamol and aspirin - actual spectra must be given for analysis)
2)	Assay of Assay of Local anesthetics (benzocaine) by non aqueous titration method.
3)	Determination of iron from tablet and Syrup by titration with ceric ammonium sulphate.
4)	Estimation of Vit. C from tablet using Dichlorophenol-Indophenols dye by volumetric method.
5)	Determination of moisture content from pharmaceutical sample by Karl fisher titration method.
6)	Assay of sulpha drugs by diazotization titration.
7)	Estimation of aspirin, paracetamol and caffine from APC tablet by HPLC.
8)	Estimation of Fe(II) using 1,10-phenanthroline from tablet/Syrup by Spectrophotometry.
9)	Determination of Paracetamol from pharmaceutical sample by Spectrophotometry.
10)	The Determination of Aspirin and caffeine in a Proprietary Analgesic or given mixture by Ultraviolet (UV) Spectrometry.
11)	Moisture content by Loss on drying of caffeine (oven drying method) and water content of dextrose (anhydrous or monohydrate) by Karl Fischer Method.
12)	Analysis of Ca-Gluconate or any Ca-supplementary tablet with respect to identification test, average wt. of 20 tablet, and Ca(II) content per tablet as per Indian Pharmacopeia. Express result as Ca-gluconate content ± Standard deviation. (Perform standardization of Na_2EDTA).
13)	Synthesis of aspirin (or any other medicinal compound) and recrystallization. Test as per IP: Identification, TLC, MP and assay.
14)	To estimate the amount of paracetomol and diclofenac sodium in pharmaceutical

	tablets (USP) by HPLC technique.
15)	Limit Tests: i) Iron from CaCO3 ii) Sulphate and Chloride from Paracetamol, Dextrose or any pharmaceutical Preparation.
16)	Analysis of aspirin w.r.t. determination of total ash, sulphated ash and loss on drying.
17)	Estimation of % purity of a given sample of sodium chloride as per IP.
18)	Determination of Fe(II) present in an Iron tablet using KMnO4.
19)	The Determination of Caffeine by High Performance Liquid Chromatography (HPLC).
20)	Estimation of sodium benzoate by Non-aqueous titration.
21)	Estimation of ibuprofen from pharmaceutical sample.

Reference Books:

1. Indian Pharmacopeia Volume I, 7th Ed
2. Indian Pharmacopeia Volume II, 7th Ed
3. Indian Pharmacopeia Vol-III, 7th Ed.
4. Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed.
5. Post-graduate Chemistry Practicals - S. S. Kelker, H. N. Patel, S.P. Turakhia, A. G. Gadre, Himalaya Publishing House.
6. Any other relevant reference can be used.

Course/ Paper Title	**Practical: Analysis of polymers and complex materials**
Course Code	21SMAC247A
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. To equip the students with skill in polymer related laboratory work 2. To familiarize students with chromatographic separation techniques. 3. To train the students in preparation/isolation standard/reference materials. 4. Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory. 5. Define / understand various terms involved practical methods of quantitative analysis. 6. To analyze organic and inorganic materials using appropriate chemical / instrumental methods

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Students became familiar with analyzing the polymers as well as principles and techniques of chromatography 2. They can synthesize and isolate standard/reference materials. 3. Explain / describe basic principles of chemical / instrumental methods used for analysis. 4. Able to handle particular instrument according to SOP. 5. Perform analysis of sample with described procedure. Able to handle analytical instruments.

6. To conclude the results able to take the decision regarding quality of sample. And perform calculations and interpret the results.

Syllabus for 21SMAC247A: Practical: Analysis of polymers and complex materials [48 L + 12T]

Unit No.	Title with Contents
I	**Compulsory Experiment - Table Work (ANY ONE):** 1. Theoretical basis of method development and validation – Accuracy, precision, noise level, detection limit, quantitation limit, Calibration curve and standard addition method and theoretical basis of choice between two, **2.** Expression of results: Calculation of mean, standard deviation, error and absolute error, **3.** Regression analysis of calibration curve and its importance.
II	**Analysis of Polymers (ANY FOUR)** 1. Determination of Molecular weight of polymer by viscosity measurements. 2. Preparation of Urea formaldehyde and Phenol formaldehyde resins. 3. Determination of water absorption by polymer, carbon black content and swelling network in polymers. 4. Determination of chlorine content in PVC. 5. To determine the molecular weight of given polymer by turbidimetry. 6. Determination of hydroxyl No. of polymer using colorimetric method. 7. Preparation of polyaniline. 8. Determine the refractive indices of polymer samples by using abbe's refractometer.
III	**Chromatographic Methods (ANY FOUR)** 1. Identification of amino acids / sugars / or any other mixture by two-dimensional chromatographic method (TLC) 2. Separation of leaf pigments by adsorption Chromatography 3. Separation of amino acids by ion exchange chromatography 4. Determination of cation exchange capacity of cation exchange resin or anion

	exchange capacity of anion exchange resin 5. Separation and molecular weight determination of protein by gel electrophoresis. 6. Separation and identification of the given mixture of colourless compounds (Diphenylamine, Benzophenone and Naphthalene) 7. Isolation, identification and estimation of synthetic food colours.
IV	**Preparation / Isolations of Analytical Standards or reference material (ANY THREE)** 1. Isolation and purification caffeine. Impurity present if any by TLC and MP, loss on drying. 2. Selective estimation of Ni(II) from steel alloy or (Ni(II)-Fe(III) synthetic solution) by solvent extraction 3. Estimation of Fe(III) from detergent by solvent extraction 4. To determine the Equilibrium constant of a particular reaction by solvent extraction. 5. Extraction of Piperine from *Piper nigrum* (Black pepper). 6. Extraction of Trimyristin from *Myristica fragrance* (Nutmeg).

Reference Books:

1. Vogel's Textbook of Inorganic Quantitative Analysis, A. I. Vogel, 3rd Ed.
2. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier
3. Lab Manual in biochemistry, immunology and biotechnology, Arti Nigam, Archana
4. Ayyagari, Tat-McGraw-Hill Publication.
5. Indian Pharmacopeia, 7th Ed.
6. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill
7. Publishing Company Ltd.
8. Polymer Synthesis and Characterization, A Laboratory Manual, Stanely R Sandler, Wolf Karo, Jo-Anne Bonesteel, Eli M Pearce, Published by Academic press (Elsevier).
9. General Chemistry Experiments by Anil J. Elias

Course/ Paper Title	**Project/Industrial Training**
Course Code	21SMAC247B
Semester	IV
No. of Credits	2 Credits (48 L, 12T)

Aims & Objectives of the Course

Objectives
Students should – 1. Maintain proper record of analytical data in note book for research purpose. 2. Perform review of literature related to the topic of project work and design the problem for project work. 3. Decide and describe methodology for problem to solve proposed problem in the form of project. Decide and perform application of research work. 4. To design experiment for research work. Collect the resources, design small equipment, etc. for completion of research work.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Collect experimental data (raw data) and analyze the data in the perspective of problem. 2. Present data in graphical forms for the conclusive results. 3. Use computer as a tool for result analysis, presentation and writing the project. 4. To obtain concrete conclusion from the results on the basis of reported theory / research work and analytical results. 5. To perform report writing, scientifically. 6. To write research project / paper in scientific manner, calculations and interpret the results.

Syllabus for 21SMAC247B: PROJECT/INDUSTRIAL TRAINING

Title with Contents
a) The projects will be initiated in the beginning of Semester III and the examination will be conducted at the end of Semester IV. **b) At least 1/3 students of total strength at M. Sc.-II must be allotted projects** **c)** Each student will perform project separately. Working hours are same as practical of CHA-247(A) project length should be sufficient and should be equivalent to 12 practical. Project report must be written systematically and presented in bound form: The project will consist of Title page, certificate, content, summary of project (2-3 page) followed by introduction (4 to 7 pages), literature survey (4-7) pages (recently published about 30papers must be included), experimental techniques, results, discussion, conclusions, Appendix consisting of 1) references, 2) standard spectra / data if any and 3) safety precautions. If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. Systematic record of attendance of project students must be maintained by a mentor. Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical work and discuss results and conclusions in details (20 min.) which will be followed by question-answer session (10 min). It is open type of examination.

Dr. Khursheed Ahmed
Chairman, BoS Chemistry
and Head, Department of Chemistry.