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)

NEP – 2020 Syllabus with effective from
Academic Year 2024-25

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 M. Sc. Part – II (Analytical Chemistry) as per NEP

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	23SMAC31MM	Advanced Methods of Chemical Analysis	2
2	23SMAC32MM	Physical Methods of Chemical Analysis	2
3	23SMAC33MM	Industrial Analytical Chemistry	2
4	23SMAC34MM	Analytical methods of Food	2
5	23SMAC35MM	Pharmaceutical Chemistry	2
6	23SMAC36MM	Practical: Pharmaceutical and Food Analysis	2
7	23SMAC37MM	Practical: Analysis of Industrial Products	2
		(Major Elective: Any One From 23SMAC38M)	
8	23SMAC38MEA	Practical: Basic Instrumental Methods of Chemical Analysis	2
9	23SMAC38MEB	Practical: Optional Analytical Chemistry Practicals	2
		(Major Elective: Any One From 23SMAC39M)	
10	23SMAC39MEA	Quality Control and Quality Assurance in Pharma Industry	2
11	23SMAC39MEB	Analytical Methods of Controlled Substances	2
12	23SMAC39MEC	Drug Discovery and Biological Assays	2
13	23SMAC39MED	Analytical Chemistry of Agriculture, Soil and Detergents	2
14	23SMAC31RP	Research Project	4
SEMESTER-IV			
1	23SMAC41MM	Analytical Spectroscopic Techniques	2
2	23SMAC42MM	Modern Methods of Chemical Analysis	2
3	23SMAC43MM	Analytical Method Validation and Extraction Techniques	2
4	23SMAC44MM	Chemical methods of Pharmaceutical Analysis	2
5	23SMAC45MM	Practical: Analysis of Pharmaceutical and Bioanalytical Samples	2
6	23SMAC46MM	Practical: Analysis of Complex materials	2
		(Major Elective: Any One From 23SMAC47M)	
7	23SMAC47MEA	Practical: Advanced Instrumental Methods of Chemical Analysis	2
8	23SMAC47MEB	Practical: Applied Analytical Chemistry Practicals	2
		(Major Elective: Any One From 23SMAC48M)	
9	23SMAC48MEA	Techniques in Bioanalytical Chemistry	2
10	23SMAC48MEB	Laboratory Automation and Sensor Based Techniques	2
11	23SMAC48MEC	Techniques in Molecular Biology	2
12	23SMAC48MED	Material Characterization Techniques	2
13	23SMAC41RP	Research Project	6

*N.B.: 1. TWO Credit Theory Paper = 30 Hours lectures per semester and 2 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 Exam of 15 Marks.
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.

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SEMESTER-III

Course/ Paper Title	**Advanced Methods of Chemical Analysis**
Course Code	**23SMAC31MM**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To understand the principles and mechanisms of mass spectrometry, gas chromatography, and molecular luminescence spectrometry. 2. To apply analytical techniques to interpret mass spectra, chromatograms, and luminescence spectra for qualitative and quantitative analysis. 3. To explore the diverse applications of Molecular luminescence spectrometry in fields such as pharmaceuticals, environmental analysis, forensics, and biochemistry. 4. To apply electrophoresis techniques effectively in scientific research and industrial processes.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Explain the fundamental principles and mechanisms behind Mass Spectrometry, Gas Chromatography, and Molecular Luminescence Spectrometry. 2. Design and optimize analytical methods using mass spectrometry for different sample types and research purposes. 3. Apply knowledge of MS, GC, and MLS in practical scenarios across various scientific fields, demonstrating an understanding of their applications. 4. Apply electrophoresis techniques in laboratory experiments and research projects.

23SMAC31MM: Advanced Methods of Chemical Analysis (30 Hours)

Sr. No.	Name of the Topic	Lectures
1	**Mass Spectrometry:** 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. **Ref. 2: Pages 41-76**	08
2	**Gas Chromatography:** Recapitulation of Fundamentals of Chromatographic Separation involving an 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 etc. Principle and Components of gas chromatography: Carrier gas, sample injection, split injection, spitless injection, cold on column injection, programmable temperature 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. Numerical problems based on this technique. **Ref. 1: 536-558** **Ref. 2: Relevant Pages**	08
3	**Molecular Luminescence spectrometry:** 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,	08

	analytical applications, problems. **Ref. 3: Pages 399-426**	
4	**Capillary Electrophoresis:** General introduction, electrophoretic mobility of the molecule, Types of electrophoretic systems: Moving boundary electrophoresis: Principle and working, Steady state electrophoresis: principle and working, isoelectric focusing, Zone electrophoresis: principle and working, support media, filter paper, cellulose acetate, Applications of electrophoresis: separation of protein, separation of polynucleotides, Numerical problems. **Ref. 4: Pages 851-867** **Ref. 5: Relevant Pages**	06

References:

1. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH.
2. Basic Gas Chromatography Mass Spectrometry, Principles and Techniques, F.W. Karasek and R.E. Clement, Elsevier, (Elsevier Science B.V.) 1988
3. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication..
4. Electrophoresis, Analytical chemistry through open learning Series, Wiley.
5. Capillary Electrophoresis: Principles and Practice, R. Kuhn S. Hoffstetter-Kuhn, Springer Laboratory, Springer-Verlag.
6. Chromatography Mass Spectroscopy in Polymer Analysis by T. R. Crompton, iSmithers – A Smithers Group Company, UK.

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Course/ Paper Title	**Physical Methods of Chemical Analysis**
Course Code	**23SMAC32MM**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To build the bridge between practical knowledge and theory of analytical techniques. 2. To equip students with advanced electrochemical techniques and applicability. 3. To familiarize students with electroanalytical techniques. 4. Define various terms and basic principle in thermogravimetry and Explain instrumentation in thermal methods of analysis. 5. Explain applications of thermogravimetry in industry and analytical laboratory.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Adjust with recent trends in practical aspects of electoanalytical techniques. 2. Explain /Describe applications of electrochemistry in industry and in analytical laboratory. 3. Apply / select particular method of analysis for sample to be analysed. 4. Solve numerical problems on electrochemistry and interpret polarogram, cyclic voltammogram, pulse polarogram, thermogram, differential thermogram and DSC thermogram etc. 5. Differentiate among the various methods of electrochemistry and thermogravimetry.

23SMAC32MM: Physical Methods of Chemical Analysis

Sr. No.	Name of the Topic	Lectures
1	**Electrogravimetry:** Introduction, Classification of electroanalytical techniques, Electrical components, Theory and principle of electrogravimetry, Types of electrogravimetry, Electrolysis in a simple cell, Electrolysis in a Non-galvanic cell, Electrolysis in a galvanic cell, Electrolysis at constant current and potential, Elelctrolysis at controlled potential, Spontaneous or Internal electrolysis, Problems involved in electogravimetry. **Ref. 1: Pages 287-315**	04

2	**Coulometry:** Introduction, Coulometric calculations, Determination of Charge, Coulometers, Constant current coulometry, Faradays laws of electrolysis, Comparison of constant current coulometry with conventional volumetric titration, Coumlometric titrations, Applications of coulometric titrations, Controlled potential coulometry, Applications of Controlled potential coulometry, Problems involved in Coulometry. **Ref. 1: Pages 316-338**	04
3	**Polarography:** Introduction, Principle of polarography, Difficulties encountered in polarography, Experimental set-up, Advantages and disadvantages of DME, Applications of polarography, Problems involved in polarography. **Pulse Polarography:** Different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, and Stripping method, Determination of 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. **Ref. 1: Pages 339-362** **Ref. 2: Pages 742-753**	06
4	**Voltammetry: a) Hydrodynamic Voltametry:** Hydrodynamic voltametry and applications of hydrodynamic voltametry, voltameric detectors in chromatography and flow injection analysis, Voltametric oxygen sensors, amperometric titration. **b) 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. Voltammetry with ultra-microelectrode. **Ref. 2: Pages 723-742**	04
5	**Introduction to Thermal Methods:** Introduction, Historical development, Definitions: Thermal analysis, General apparatus, Factors affecting thermal analysis results, The sample, The crucible, The rate of heating, The atmosphere, The mass of the sample, Simultaneous and complementary techniques. **Ref. 3: Pages 1-21**	02
6	**Thermal Methods of Analysis:** Principle, different methods of thermal analysis, A) Thermo gravimetric methods of analysis: Instrumentation, thermogram and information from thermogram, factors affecting thermogram, applications TGA for 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	10

	phenacetein), thermometric titrations, Evolved gas analysis. **Ref. 3: Pages 22 to 113**	

References:

1. Analytical Chemistry by Dhruba Charan Dash, PHI Learning Private Limited, New Delhi.
2. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed. Cengage Publication.
3. Thermal Methods of analysis, principles, applications and problems, P. J. Haines, Springer-Science Business Media B.V.
4. Principles and Applications of Thermal Analysis, Paul Gabbott, Blackwell Publishing Ltd. (2008).
5. Introduction to polarography and allied techniques by Kamala Zutshi, New Age International (P) Ltd., Publishers, New Delhi.
6. Vogel's Text Book of quantitative analysis 6^{th} Ed.
7. Introduction to Instrumental Analysis by R. D. Braun, Pharmamed Press.
8. Thermal Analysis in Practice, Fundamental Aspects, Matthias Wagner, Hanser Publications, 2018.
9. Principles of Thermal Analysis and Calorimetry, P. J. Haines, Royal Society of Chemistry.

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Course/ Paper Title	**Industrial Analytical Chemistry**
Course Code	**23SMAC33MM**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To provide comprehensive knowledge about chief industrial materials & selection of appropriate method of its determination. 2. To develop basic idea pertaining to different water pollutants and essential analytical techniques. 3. To provide the students with fundamental principles of polymers and dyes, classification, preparation, structure and properties. 4. To provide students with an opportunity to identify different types of polymers, dyes and colours in our surrounding. 5. Introduces students to the practical application of polymers and dyes and to understand in detail the mechanisms of the reactions that lead to the formation of industrial products.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Explain basic terms and processes of industrial analytical chemistry. 2. Define the basic concepts and terms in industrial chemistry and the different types of processes. 3. Carry out both qualitative and quantitative water analysis. 4. Develop basic scheme and choose appropriate route, regarding variety of water pollutants and their determination techniques. 5. Recall the different methods of polymer preparation, importance ofdifferent types of polymers.

23SMAC33MM: Industrial Analytical Chemistry (30 Hours)

Sr. No.	Name of the Topic	Lectures
1	**Water Pollution and Measurement of Water Quality a) Water Pollutants:** Brief explanation of following with respect to their sources and toxic effects - Inorganic pollutants (Heavy Metals (Cd, Hg, Pb), Metalloids, Organotin Compounds, Inorganic Species (CN-, NH_3 and other species), Asbestos, Organic Pollutants (Soaps, Detergents, and Detergent Builders, Pesticides in Water, Polychlorinated Biphenyls), Emerging Water Pollutants, Pharmaceuticals, and Household Wastes, Radionuclides in the Aquatic Environment. **b) Analysis of Physical Properties:** Colour (Visible Inspection, Spectrophotometric-Multi-Wavelength Method, Turbidity, Odour, Taste, Acidity, Alkalinity, Calcium Carbonate Saturation, Hardness, Chemical Oxidantation Demand/Requirement, Chlorine Demand/Requirement, Conductivity, Salinity. **c) Organic constituents:** Biochemical oxygen demand, Chemical oxygen demand, total organic carbon, phenols (direct photometric method), surfactants. **Ref. 1: Relevant pages from 30-169** **Ref. 2: Pages 159-183**	10
2	**Polymer Analysis:** Introduction and Identification to polymers – 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. Molecular Weight Calculations, Viscosity average molecular weights. Individual polymers – Preparation and applications of following polymers - Polyethylene, Polystyrene, Polyester, polyformaldehyde, Polyurethane, Polyamides, Polyethylene glycol, Polyvinyl acetate, Polyvinyl alcohol, polyvinyl chloride (PVC) Teflon, Polybutadine, Phenol-formaldehyde resin, Urea-formaldehyde resin, Polymer reactions – Hydrolysis, Acetolysis, aminolysis, hydrogenation, addition and substitution reactions, reactions of specific groups such as –OH, -COOH, >C=O and other groups. **Ref. 3: Pages 1-12, 86-92, 215-251 (Relevant Pages), 291-303.** **Ref. 4: Pages 1-68**	10
3	**Synthetic Dyes :** Introduction to Dyes, General Information About Fibres and Dyeing Methods, Classification of Dyes on the Basis of Mode of Application, Chemical Classification of Dyes, Nitro Dyes, Azo Dyes, Heterocyclic Dyes, Thioindigos and Indigos, Anthraquinone Dyes, Reactive Dyes, Acridine Dyes, Pigments, Non-Textile Uses of Dyestuffs, Synthesis of Some Specific Dyes: Eriochrome Black T, Eriochrome Black A, Eriochrome Red B, Celliton Scarlet B, Diamond Black-F, Direct Deep Black, Safranine-T, Safranine-T, Dispersol	10

	Blue, Copper Phthalocyanine (Monastral fast blue), Sulphur Black T, Rhodamine B. **Ref. 5: Pages 1.1-1.9, 3.1-3.6, 4.1-4.10, 7.1-7.4, 9.1-9.41, 15.1-15.14, 16.1-16.9, 20.1-20.5, 21.1-21.12, 23.1-23.13, 36.1-36.10.** **Ref. 6: Relevant Pages**	

References:

1. Handbook of Methods in Environmental Studies Vol. 1: Water and Wastewater Analysis by S. K. Maiti, ABD Publishers Jaipur (India).
2. Environmental Chemistry by Stanley E. Manahan, Ninth Edition, CRC press, Taylor and Francis, 2010.
3. Polymer Science by V. R. Gowarikar, N.B. Vishvanathane, New Age International Ltd. Publisher (1998)
4. Polymer analysis, Barbara H. Stuart, Analytical Techniques in the Sciences (AnTS), John Wiley and Sons Ltd.
5. Synthetic Dyes by Synthetic Dyes, Himalaya Publishing House, Mumbai.
6. The Chemistry of Synthetic Dyes by K. Venkataraman, Academic Press New York and London.
7. Handbook of Environmental Analysis Chemical Pollutants in Air, Water, Soil, and Solid Wastes by Pradyot Patnaik, Third Edition, CRC press, Taylor and Francis, 2018.
8. Standard methods of Chemical Analysis, Vol. 2, (Part A & B) by F. J. Welcher, 5th edn., Von Nostrand & Robert E. Krieger Publishing Co. New York, (1975 and 2000)
9. Quantitative Inorganic Analysis by A. I. Vogel, English Language Book Society, London, (1975).

Course/ Paper Title	**Analytical methods of Food**
Course Code	**23SMAC34MM**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. 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. 2. Be familiar with the current state of knowledge on food composition. Identify reasons for determining composition and characteristics of food. 3. Describe principles and relevant theory used to determine moisture, carbohydrate, lipid, proteins, and ash content of a food. 4. This course will allow students to learn basic food chemistry, enhance understanding of the composition of foods, learn analysis of food composition and how to prepare and design food nutrition labels.

Expected Course Specific Learning Outcomes

Learning Outcome
Students will be able to:– 1. Understand the strengths, limitations and creative use of techniques for problem-solving and design experiments and understand the instrumentation. 2. To understand and identify food hazards and traceability and perform laboratory analyses for routine chemical testing, in the framework of an accredited laboratory. 3. Identify and critically evaluate food analysis method 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. 4. Understand the quality attributes, their measurement principle and instrumentation of various instruments used in food quality analysis. 5. Thoroughly understand various types of additives to be added and their role in respective food items.

23SMAC34MM: Analytical methods of Food (30 Lecture)

Sr. No.	Name of the topic	Lectures
1	**Introduction to Food Analysis:** Introduction, Selection of Sampling Procedures, Sampling Procedures, Preparation of Samples, Grinding, Enzymatic Inactivation, Importance of Moisture Assay, Moisture Content of Foods, Forms of Water in Foods, Sample Collection and Handling, Oven Drying Methods: General Information, Removal of Moisture, Decomposition of Other Food, Constituents, Temperature Control, Types of Pans for Oven Drying Methods, Handling and Preparation of Pans, Control of Surface Crust Formation (Sand Pan Technique), Calculations; Distillation Procedures, Chemical Method: Karl Fischer Titration. **Ref. 1: Pages 1-13, 71-80 and 87-96.**	04
2	**Analysis of Carbohydrates:** Introduction, colour tests, Reactions of carbohydrates, Analysis of carbohydrates from food sample by different method: Phenol-Sulfuric Acid Method, total reducing sugars by Nelson Somyogi method and Dinitrosalicylic Acid 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 Fructose and Inulin, 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. **Ref. 1: Pages 149-169.** **Ref. 2 and 3: Relevant pages.**	06
3	**Analysis of Lipids:** a) Definition, Classification, General Considerations, Solvent Extraction Methods: Sample preparation, Solvent selection, Sample Preparation, Continuous Solvent Extraction Method: Goldfish Method, Semicontiguous 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. **Ref-1: 241, 246-258**	08
5	**Analysis of Proteins:** 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) Infrared Spectroscopy, d) Biuret Method e) Lowry Method f) Dye-Binding Methods g) Bicinchoninic Acid	08

	Method h) Ultraviolet 280nm, Comparison of Methods. 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. **Ref-1: 271 – 277** **Ref. 2: Relevant pages.**	
6	**Determination of food preservatives:** 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. **Ref. 4 and 5: Relevant pages.**	04

References:

1. Food Analysis, Edited by S. Suzanne Nielsen, Fourth Edition, Springer.
2. Biochemical Methods, By S Sadashivan, A. Manickam, 3rd Edition, New Age International Publishers.
3. 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.
4. Pearson's Chemical Analysis of Food.
5. https://fssai.gov.in/upload/uploadfiles/files/Manual_Food_Additives_25_05_2016(1).pdf
6. https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/FOOD_ADDITVES.pdf

Course/ Paper Title	**Pharmaceutical Chemistry**
Course Code	**23SMAC35MM**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To make student understand the different dosage forms and routes of administration. 2. To understand and learn the importance of phytochemicals as medicine and the methods used for extraction and identification of secondary metabolites. 3. To apply knowledge in foundational sciences to solve therapeutic problems. 4. To isolate, elucidate and characterize medicinal compounds from natural origin. 5. To understand the basic concepts in biopharmaceuticals and Nutraceuticals.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Define various terms in pharmaceutical raw material and finished product analysis. 2. Explain various pharmaceutical dosage forms and types of raw materials used. 3. Know the crude drugs, their uses and chemical nature and the evaluation techniques for the nutraceutical's drugs. 4. Demonstrates general methods of extraction of Volatile oils, Terpenoids & Resins etc. 5. Describe the various methods of extraction isolation & purification of phyto-pharmaceuticals.

23SMAC35MM: Pharmaceutical Chemistry (30 Hours)

Sr. No.	**Name of the Topic**	Lectures
1	**Pharmaceutical Chemistry:** 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	10

	of the following terms: Receptors, Drug-receptor interaction, Drug Potency, Bioavailability, Drug toxicity, Drug addiction, Spurious Drugs, Misbranded Drugs, Adulterated Drugs, generic drugs, and substandard drugs. Routes of drug administration with advantages and disadvantages, Introduction to drug dosage Forms and Excipients, Tablets and types of tablets, capsules and types of capsules and Role of FDA. **Synthesis and therapeutic use of** Diclofenac sodium, Aceclofenac, Paracetamol, Phenytoin, Aspirin, Atenolol, Laevodopa, Metronidazole, Dapsone, Ethambutol. **Ref. 1: Pages 03-17**	
2	**Nutraceuticals:** General aspects, Market, growth, scope and types of products available in the market. Health benefits and role of Nutraceuticals in ailments like Diabetes, CVS diseases, Cancer, Irritable bowel syndrome and various Gastro intestinal diseases. Study of following herbs as health food: Alfa-alfa, Chicory, Ginger, Fenugreek, Garlic, Honey, Amla, Ginseng, Ashwagandha, Spirulina **Ref. 2: Pages 76-112.** **Ref. 3: 735-777**	04
3	**Biopharmaceuticals:** Introduction to Biopharmaceuticals, Sources of Biopharmaceuticals (*E. Coli*, Animal cells, Additional systems), Upstream & Downstream processing, Product Analysis, Therapeutic Hormones, Recombinant Blood Products & Therapeutic Enzymes, Production of antibodies, Vaccines & adjuvants. **Ref. 4 and 5: Relevant Pages**	04
4	**Phytochemicals:** 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. **Ref. 6: 41-104 and 256-285** **Ref. 7: Relevant Pages**	06
5	**Sources of Impurities in Pharmaceutical products:** Impurities in Pharmaceuticals: Source and effect of impurities in pharmacopoeial substances - Atmospheric contaminations, Cross contamination, Microbial	06

	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. **Ref. 8: Pages 1.1 to 2.11**	

References:

1. Introduction to Synthetic Drugs and Dyes by R.S. Rao, Dr. Gomathi Shridhar, Dr. Bholanath Mukherjee and Dr. Tanuja Parulekar, Himalaya Publishing House Pvt. Ltd, Mumbai.
2. Herbal Drug Technology by Dr. G. Arunachalam, Dr. V. E. Ida Christi, Dr. Prashant Kumar, Thakur Publication Pvt. Ltd., Lucknow.
3. Pharmacognosy and Pharmacobiotechnology by Ashutosh Kar, New Age International (P) Ltd., Publishers, New Delhi.
4. Biosimilars, Regulatory, Clinical, and Biopharmaceutical Development by Hiten J. Gutka, Harry Yang and Shefali Kakar, AAPS Advances in the Pharmaceutical Sciences Series, Springer Nature Switzerland.
5. Biopharmaceutical and Pharmacokinetics: A Treatise by Brahmankar, D. M., Vallabh Prakashan, 1995.
6. Pharmacognosy and Phytochemistry-II by Dr. K. Prabhu and Dr. G. Arunachalam, Thakur Publication Pvt. Ltd., Lucknow.
7. Textbook of Pharmacognosy and Phytochemistry by Biren N. Shah and A.K. Seth, Reed Elsevier India Private Limited.
8. Pharmaceutical Analysis, Vol. 1 by A. V. Kasture, K. R. Mahadik, S. G. Wadodkar and H. N. More, Nirali Prakashan, Pune.
9. Herbal Drug Technology by S. S. Agarwal and M Paridhavi, Universities Press (India) Private Limited. Hydrabad.

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	**Practical: Pharmaceutical and Food Analysis**
Course Code	**23SMAC36MM**
Semester	III
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. 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. 2. Deal with the, sampling methods, and tools to conduct statistical analysis. 3. Acquire practical skills in analysis of all types of food samples, handling and interpretation data in various methods of analysis adapted to analytical chemistry. 4. Undertake and compare various analysis techniques, followed by analysis, interpretation and presentation of the results for food and pharmaceutical samples..

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. Able to synthesize, purify, identify and analyze medicinal agents. 5. Able to extract, purify, identify and understand the therapeutic value of herbal/crude/natural products.

23SMAC36MM: Practical: Pharmaceutical and Food Analysis

S. No.	Name of the Experiment
I	**Analysis of Food Products (Any EIGHT)**
1	Estimation of glucose by titration in different samples by using Fehling's solution.
2	Estimation of total carbohydrates from food samples by Anthrone method.
3	Determination of saponification value of oil sample.
4	Assay of boric acid.
5	To determine the amount of acetic acid of commercial vinegar sample.
6	Determination of total ash, acid insoluble ash and sulphated ash of Turmeric or any other vegetable drug.
7	Determination of HMF content from Honey sample.
8	Estimation of Vitamin C in juices and squashes.
9	Estimation of tannin from tea/coffee sample by Folin-Denis method.
10	Determination of iodine value of oil sample.
11	Determination of acid value of oil sample.
12	Estimation of reducing sugars by DNSA method.
II	**Synthesis of Medicinally Important Compounds (Any FOUR)** (TLC Analysis is recommended)
13	Synthesis of Aspirin.
14	Synthesis of Benzotriazole.
15	Synthesis of Benzocaine.
16	Synthesis of para-Bromoacetanilide.
17	Synthesis of Chlorbutanol.
18	Synthesis of 2,3-Diphenyl Quinoxaline.
19	Synthesis of 3,4-dihydropyrimidin-2(1H)-ones.
20	Synthesis of Paracetamol.
III	**Isolation of Medicinally Important Compounds (Any THREE)** (Any other suitable experiment can be included)
21	Caffeine from tea leaves (Soxhlet extraction).
22	Piperine from pepper (Soxhlet extraction).
23	Trimyristin from nutmeg.
24	Cinnamaldehyde from cinnamom.
25	Eugenol from clove.
26	Citric acid from Lemon

References:

1. Analytical Chemistry of Foods by C. S. James, Springer-Science+Business Media, B.V.,

2. Post-graduate Chemistry Practicals - S. S. Kelker, H. N. Patel, S. P. Turakhia, A. G. Gadre, Himalaya Publishing House.
3. Experiments in Pharmaceutical Chemistry by Charles Dickson, CRC Press, Taylor & Francis Group, London.
4. Vitamin C as a Model for a Novel and Approachable Experimental Framework for Investigating Spectrophotometry, Journal of Chemical Education, DOI:10.1021/acs.jchemed.9b00197
5. Lab. Manual: Manual of Methods of Analysis of Foods, Vegatables: Fruit and vegetable products: https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals /FRUITS_AND_VEGETABLE.pdf
6. 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
7. Advanced Practical Medicinal Chemistry by Ashutosh Kar, New Age International (P) Ltd., Publishers.
8. Any other relevant reference can be added.

Course/ Paper Title	**Practical: Analysis of Industrial Products**
Course Code	**23SMAC37MM**
Semester	III
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. Provide comprehensive knowledge about chief industrial materials & selection of appropriate method of its determination. 2. Develop basic idea pertaining to different water pollutants and essential analytical techniques. 3. Provides students with an opportunity to identify different types of polymers, dyes and colours in our surrounding. 4. To understand in detail the mechanisms of the reactions that lead to the formation of industrial products.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Student received basic knowledge of industrial analytical chemistry and the different types of processes. 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. 4. Recall the different methods of polymer preparation, importance of different types of polymers.

23SMAC37MM: Practical: Analysis of Industrial Products

Unit No.	Title with Contents
I	**Analysis of Polymers (ANY FIVE)**
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.
9	Determination of glass transition temperature, T_g by dilatometry technique.
II	**Chromatographic Methods of Analysis (ANY FIVE)**
1	Separation of leaf pigments by adsorption Chromatography.
2	Determination of cation exchange capacity of cation exchange resin or anion exchange capacity of anion exchange resin.
3	Separation and identification of the given mixture of colourless compounds (Diphenylamine, Benzophenone and Naphthalene)
4	Separation and molecular weight determination of protein by gel electrophoresis.
5	Isolation, identification and estimation of synthetic food colours.
6	Identify and separate the components of given mixture of colours by paper chromatography.
7	Demonstration experiment on HPLC.
8	Demonstration experiment on Gas Chromatography.
III	**Analysis of Waste water (ANY FIVE)**
1	To determine concentration of sulphate in given water sample Nephelometrically.
2	To determine total alkalinity of water/Waste water.
3	Estimation of calcium and magnesium in given water sample.
4	Analysis of Waste water Sample w. r. t. Turbidity, Colour and Total hardness.
5	Determination of COD of waste water sample.
6	Determine chloride content in given water sample.
7	Determination of Cr(VI) in waste water by diphenylcarbazide method.
8	Analysis of waste water /natural water sample for pH, dissolved oxygen, total dissolved salts (conductometry).
9	Estimation of phosphate in hard water / soil sample /food / detergent by colorimetry.

References:

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.

Course/ Paper Title	**Practical: Basic Instrumental Analysis**
Course Code	**23SMAC38MEA**
Semester	III
No. of Credits	2 Credits, (60 L)

Aims & Objectives of the Course

Objectives
1. To familiarize students with various basic analytical instruments used in chemical analysis. 2. To provide practical exposure to operating instruments such as colorimeter, pH-meter, potentiometer and conductometer. 3. To develop a fundamental understanding of the principles behind operation of each instrument. 4. To teach students how to collect, analyze, and interpret data obtained from instrumental analysis. 5. To introduce the concept of quality control in instrumental analysis and its significance in obtaining reliable results.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. To effectively operate basic analytical instruments to perform different types of analyses. 2. To comprehend the underlying principles behind colorimetry, pH-metery, potentiometry and conductometry. 3. To demonstrate the ability to operate basic analytical instruments effectively. 4. To identify common problems associated with instrumental analysis and apply troubleshooting techniques to resolve them. 5. To interpret data obtained from instrumental analysis and to draw conclusions from experimental results.

23SMAC38MEA: Practical: Basic Instrumental Methods of Chemical Analysis

N.B.: Experiment No. 1 to 3 are Compulsory. Perform any **TWELVE** experiments from 2 to 18

S. No.	Name of the Experiment
1	Recording the UV-Visible spectrum of any one substance like caffeine, aspirin, paracetamol, $KMnO_4$ or any other substance of interest having characteristic UV-Visible absorbance a) identification of characteristics peaks in spectrum, b) Choice of λ_{max} for quantitative analysis c) Calculation of Molar absorptivity (ε) and d) Sp. Absorbance (absorbance of sample solution for 1% solution). Theoretical interpretation of spectra.
2	Table Work: a) Theorical 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, b) Expression of results: Calculation of mean, standard deviation, error and absolute error, elimination of data, c) Regression analysis of calibration curve and its importance.
3	Table Work: Characterization of organic compounds by VU-Visible, IR and NMR spectroscopy (any two compounds, Example- paracetamol and aspirin - actual spectra must be given for analysis)
	Colorimetry
4	Analysis of aspirin from pharmaceutical tablet by Colorimetry.
5	Assay of Vitamin-C by Colorimetry from vitamin supplements.
6	Colorimetric assay of phenolic compounds (salicylic acid or salbutamol sulphate) by Folin-Ciocalteau reagent.
7	Colorimetric assay of paracetamol from pharmaceutical tablet.
8	Colorimetric determination of NH_4^+ or NH_3 from water sample by phenate method.
9	Colorimetric determination of phosphate in sugarcane juice or fertilizer or detergent or water sample by Molybdenum blue method.
	pH-metry
10	Estimation of CH_3COOH from vinegar simultaneously using volumetric titration and pH-metric titration.
11	Determine the aspirin in pharmaceutical tablet by pH-metric titration.
12	Determine the Ibuprofen in pharmaceutical tablet by pH-metric titration.
	Potentiometry
13	Determination of Strength of commercial phosphoric acid by potentiometric titrations using standard solution of sodium hydroxide.
14	Determination of Fe(II) ion simultaneously by conventional titration using diphenyl amine as an external indicator and potentiometric titration.
	Conductometry
15	Determination of relative strength of acetic acid and chloroacetic acid through measuring their dissociation constant values by conductivity.
16	Determination of Sulfate ion by Conductometric Titration.

	Electrophoresis
17	Separation and molecular weight determination of protein by gel Electrophoresis.
18	Separation of several dyes of different molecular sizes by gel electrophoresis.
	Thermo Gravimetric Analysis
19	Study of GC chromatogram: Record the TGA of pure $NaHCO_3$ (room temp to300 °C). Explain different characteristics of thermogram and quantitativeanalysis by TGA. Explain how thermal decomposition reaction can be predicted from wt. loss.
20	TGA analysis $CuSO_4.5H_2O$

Reference:

1. Advanced Physical Chemistry experiment by Dr. J.N. Gurtu and Amit Gurtu, Pragati Prakashan.
2. Separation, Preconcentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier.
3. Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, American water works association, Water environment federation.
4. Vogel's textbook of Inorganic Quantitative Analysis 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: Optional Analytical Chemistry Practicals**
Course Code	**23SMAC38MEB**
Semester	III
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory. 2. Explain instrumentations of colorimeter, spectrophotometer, photo-fluorometer, TGA, HPLC, GC, Flame-photometer, CV, AAS, etc. 3. Explain / describe basic principles of chromatography different instrumental methods of analysis 4. Design / modify and validate new analytical method for chemical analysis of particular sample.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Define / understand various terms involved practical methods of quantitative analysis. 2. Apply / select particular method / instrumental parameters for analysis of given sample. 3. Verify theoretical principle practically or apply theory to explain practical observations. 4. To conclude the results able to take the decision regarding quality of sample. 5. Differentiate among the various analytical methods / techniques of chemical analysis.

23SMAC38MEB: Practical: Optional Analytical Chemistry Practicals

N.B.: Perform any **FIFTEEN** experiments from the following –

S. No.	Name of the Experiment
	pH-metry
1	Estimation of carbonate and bicarbonate present together in a mixture by pH-metry.
2	Determination of strength of acid in a mixture by pH-metry.
3	Determination of strength of ammonia solution by pH-metric.
	Spectrophotometry
4	Spectrophotometric estimation of chlorophylls in leaf pigments.
5	Colorimetric determination of NH_4^+ or NH_3 from water sample by phenate method.
6	Colorimetric determination of phosphate in sugarcane juice or fertilizer or detergent or water sample by Molybdenum blue method.
	Potentiometry
7	Determination of the strength of acetic acid by potentiometry.
	Conductometry
8	Estimation of aspirin from pharmaceutical tablet by conductometry.
9	Determination of relative strength of acid by conductometry.
	Photofluorimetry
10	Photofluorimetric assay of thiamine from vitamin supplements by calibration curve method.
	Viscosity
11	Viscosity of ethyl cellulose by Oswald viscometer using viscometer which comply specification of IP.
	Polarography
12	Polarographic determination of Cu and Zn.
13	Estimation of Pb(II) by amperometric titration.
	Volumetric titration
14	Assay of Isonicotinic acid hydrazide.
15	Volumetric assay of Dapsone from pharmaceutical tablets.
16	To analyse the percentage of magnesium from the sample of talcum powder.
	Atomic Absorption Spectroscopy
17	Estimation of As, Pb, Se, Cr, Zn, and some important transition elements from the commercial samples by Atomic absorption spectrometry with working curve method.
18	Estimation of Cu, Al, Ni, Fe and some important transition elements from the commercial samples by Atomic absorption spectrometry with working curve method.
	HPLC
19	Assay of Omeprazole in Gastro-Resistant Omeprazole Tablets
20	Analysis of Aspirin, Paracetamol and Caffeine from APC tablet by HPLC.

Reference books:

1) Advanced Physical Chemistry experiment by Dr. J.N. Gurtu and Amit Gurtu, Pragati Prakashan.
2) Separation, Pre concentration and Spectrophotometry in Inorganic Analysis, by Z. Marczenko and M. Balcerzak, Analytical Spectroscopy Library – 10, Elsevier.
3) Standard methods for the examination of water and wastewater, 23rd Ed. Roger B. Baird, Andrew D Eaton, Eugene W. Rice, American Public Health Association, American water works association, Water environment federation.
4) Vogel's textbook of Inorganic Quantitative Analysis 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	**Quality Control and Quality Assurance in Pharma Industry**
Course Code	**23SMAC39MEA**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To understand the scope of quality certifications applicable to pharmaceutical industries. 2. To understand the responsibilities of QA & QC departments. 3. To know about packaging and labeling in industry. 4. To know about SOPs followed as per regulations.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. To understand the responsibilities of QA and QC departments. 2. Understand the cGMP aspects in a pharmaceutical industry. 3. To understand the scope of quality certifications applicable to Pharmaceutical Industries. 4. Understand the CPSCEA guidelines for Prevention of cruelty to animals act

23SMAC39MEA: Quality Control and Quality Assurance in Pharma Industry

Sr. No.	Name of the Topic	Lectures
1	**Quality Assurance and Quality Management Concepts:** History of Drug Regulations, the Regulatory Drug Approval Process, Quality Assurance, Objectives of Quality Assurance, Current Good Manufacturing Practices (cGMP), Quality Control, Objectives of Quality Control.	02
2	**Total Quality Management (TQM):** Total Quality Management: Evolution of Quality Management, Definition of TQM, Key Elements of TQM, Philosophies of TQM, TQM in Drug Industry and Quality by Design.	02
3	**International Conference on Harmonization (ICH):** ICH and its Purpose,	04

	History of ICH, Process of Harmonization, ICH Guidelines: Quality, Safety, Efficacy, Multidisciplinary (QSEM) with special emphasis on Q-series guidelines , Quality Guidelines, ICH Guidelines for Stability, Types of Stability Testing, Stability Testing Protocol, Overview of ICH Stability Guidelines Contents.	
4	**Pharmaceutical Quality by Design:** Definition, Overview, Elements of QbD, Quality by Design Tools, Risk Assessment, Design of Experiments, Process Analytical Technology (PAT).	02
5	**Introduction to ISO 9000, ISO 14000 and NABL Accreditation:** History of ISO, Overview of ISO, Aim of ISO International Standards, ISO 9000 Family, Criteria to get ISO 9001 Certification, Benefits of ISO 9001 Certification, ISO 14000 - Aim of ISO 14000 Standards, Benefits of ISO 14000, NABL Accreditation.	02
6	**Quality Control:** Definition, Scope of Quality Control, Organization of QC, Responsibilities of QC, Sampling, Testing and Analysis, Product Assessment, Reference Samples/Retained Samples. Out Of Specifications (OOS) Results, Drug Packaging, Functions of Packaging, Classification of Pharmaceutical Packaging, Quality Control of Packaging Materials, Parameters Tested, Tests on Containers as Per Indian Pharmacopoeia, Tests on Glass Containers, Metal Containers for Eye Ointments, Plastic Containers and Closures, Rubber Closures for Parenteral Product Containers, Tests for Paper and Boards, Dimensions, Thickness, Grammage, pH of Surface, pH of Extract, Alkalinity, Moisture Content, Ash Content. Good Laboratory Practices - Scope of GLP, Definitions, Quality assurance unit, protocol for conduct of non-clinical testing, control on animal house, report preparation and documentation, Committee for the Purpose of Control And Supervision of Experiments on Animals (CPCSEA) guidelines.	08
7	**Major Keywords of Quality Assurance**: Calibration – Objectives and significance of Calibration, Frequency of Calibration, Calibration Methods, Qualification – Phases of Qualification, Considerations While Doing Qualification, Requalification, Factory Acceptance Test and Site Acceptance Test, Validation – History of Validation, Scope and Advantages of Validation, Types of Validation, Revalidation, Validation Master Plan, Analytical Method Validation. Role of QA in Pharma Industries. Method validation as per ICH guidance – specificity, accuracy, precision, Detection Limit, Quantitation Limit, linearity, Range and Robustness.	06
8	**Documentation in Pharmaceutical Industry:** Importance of Documentation in Pharmaceutical Industry, Good Documentation Practices, Types of Documents, Master Formula Record (MFR), Batch Manufacturing Record (BMR), Standard Operating Procedure (SOP), Quality Review, Quality Audits, Quality Documentation, Distribution Records.	04

References:

1. Pharmaceutical Quality Assurance as per PCI Regulations by Anusuya R. Kashi, Bindu Sukumaran and Venna P., Nirali Prakashan, Pune.
2. International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human use, Q2(RT), Geneva, Switzerland, November 2005.
3. Quality Assurance Guide by organization of Pharmaceutical Procedures of India, Volume I & II, Mumbai.
4. Good Laboratory Practice Regulations, Sandy Weinberg Vol. 69, Marcel Dekker Series.
5. Quality Assurance of Pharmaceuticals- A compedium of Guide lines and Related materials Vol I & II, WHO Publications.
6. The International Pharmacopoeia – vol I, II, III, IV & V - General Methods of Analysis and Quality specification for Pharmaceutical Substances, Excepients and Dosage forms, WHO, Geneva.

Course/ Paper Title	**Analytical Methods of Controlled Substances**
Course Code	**23SMAC39MEB**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
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.

23SMAC39MEB: Analytical Methods of Controlled Substances

Sr. No.	Name of the Topic	Lectures
1	**NDPS Act-1985:** Introduction to the narcotic drug and Psychotropic Substances (NDPS) Act-1985, 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, Regulation and offences of NDPS. **Ref. 1: Pages 122-134**	02
2	**Chemical Screening and Microcrystal Tests: 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. **Ref. 2: Pages 79-95**	06
3	**Analysis of Drugs/Narcotics: 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	22

	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–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. **Ref. 3: 13-34, 37-43, 49-65, 73-92, 97-109, 113-124, 139-149**	

Reference

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

Course/ Paper Title	**Drug Discovery and Biological Assays**
Course Code	**23SMAC39MEC**
Semester	III
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. Provide students with a comprehensive overview of the drug discovery process, including its historical perspective, stages, and the crucial role of biological assays. 2. Familiarize students with various types of biological assays, including biochemical assays, cell-based assays, and in vivo assays, highlighting their advantages and limitations. 3. Introduce students to techniques like High-Throughput Screening (HTS), Combinatorial Chemistry, and Imaging Techniques in biological assays, emphasizing principles, applications, and data analysis. 4. Provide practical insights into drug discovery through microbiological and animal cell culture studies, covering topics such as anticancer drug discovery, antifungal and antiparasitic drug studies, and antibiotic discovery. 5. Equip students with the skills to determine Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) values in antibiotic discovery, along with an understanding of regulatory and ethical considerations.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Demonstrate a comprehensive understanding of the drug discovery process, recognizing its historical context and the importance of biological assays. 2. Design and implement assays for different biomolecular targets, with a focus on enzymes, receptors, and nucleic acids. 3. Apply knowledge of imaging techniques, combinatorial chemistry, and practical microbiological and animal cell culture studies to drug discovery scenarios. 4. Understand and adhere to regulatory and ethical considerations in microbiological and animal cell culture studies, demonstrating awareness of emerging trends in the field. 5. Communicate effectively about drug discovery concepts, assay results, and ethical considerations, both in oral and written forms.

23SMAC39MEC: Drug Discovery and Biological Assays

Sr. No.	Name of the Topic	Lectures
1	**Introduction to Drug Discovery and Biological Assays:** Overview of Drug Discovery, Historical perspective, Drug development process, Importance of biological assays in drug discovery. Types of Biological Assays: Biochemical assays, Cell-based assays, In vivo assays, Advantages and limitations. **Ref. 1 and Ref. 2: Relevant pages**	04
2	**Bimolecular Targets in Drug Discovery:** Enzyme Targets: Role of enzymes in drug discovery, Assay design for enzyme targets. Receptor Targets: G protein-coupled receptors (GPCRs), Ligand-gated ion channels. Nucleic Acid Targets: DNA and RNA as drug targets, Assays for nucleic acid targets. **Ref. 2 and Ref. 3: Relevant pages**	06
3	**Techniques in Biological Assays:** High-Throughput Screening (HTS) – Principles and applications, Automation in HTS, Data analysis and interpretation. Combinatorial Chemistry in Drug Discovery – Solid-phase synthesis, Library design, Screening techniques. Imaging Techniques in Biological Assays: Fluorescence microscopy, Live-cell imaging, Applications in drug discovery. **Ref. 3 and Ref. 4: Relevant pages**	08
4	**Practical Applications in Microbiology and Animal Cell Culture:** Anticancer Drug Discovery: Introduction to anticancer assays, Cell culture techniques for anticancer studies, Cytotoxicity Assays, Determination of IC50 Values. Antifungal and Antiparasitic Drug Discovery: Microbiological assays for antifungal agents, Animal cell culture in antiparasitic drug studies. Antibiotic Discovery and Resistance Assays. Determination of MIC and MBC Values. Regulatory and Ethical Considerations, Emerging Trends: Guidelines and ethical considerations in microbiological and animal cell culture studies **Ref. 4 to 7: Relevant pages**	12

References:

1. High Throughput Screening: The Discovery of Bioactive Substances" by H. G. Günther, M. J. H. van den Berg
2. GPCR Molecular Pharmacology and Drug Targeting: Shifting Paradigms and New Directions" by Annette Gilchrist
3. Cancer Drug Discovery and Development: Anticancer Drug Development Guide" by Beverly A. Teicher
4. Antimicrobial Susceptibility Testing Protocols" by Stephen A. B. Borron and Philip C. Carlyn
5. Live Cell Imaging: A Laboratory Manual" by Robert D. Goldman, David L. Spector.
6. Antibiotics: Challenges, Mechanisms, Opportunities" by Christopher Walsh.

Course/ Paper Title	**Analytical Chemistry of Agriculture, Soil and Detergents**
Course Code	**23SMAC39MED**
Semester	III
No. of Credits	2 Credits, (30 Hours)

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. Carry out basic experiments of Soil analysis. 2. Evaluate the method development and analysis of fertilizers and soil contents. 3. Choose suitable method / techniques to characterize quality of soil, fertilizer and detergent.

23SMAC39MED: Analytical Chemistry of Agriculture, Soil and Detergents

Sr. No.	Name of the Topic	Lectures
1	**Analysis of Pesticide Residues and Fertilizers: 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 Kjeldahl nitrogen methods. **Phosphorus**: total phosphorus, available and non-available, alkali metric ammonium molybdophosphate method, water	10

	soluble phosphorous, citrate insoluble phosphate, Potassium: potassium by sodium tetra phenyl borate method, flame photometric methods. **Ref. 1: Pages 17-23, 87-116, 135-148, 167-172, 241-250, 297-307, 353-359, 401-406** **Ref. 2: Pages 106-123**	
2	**Analysis of soil:** Sampling of soil, sample preparation, Pre-treatment of Samples and Contamination, Trace Element Analysis, Sub-sampling, Drying Techniques, Milling, Grinding and homogenization, Electrometric Measurement of Soil pH, Determination of Buffering Capacity of Soil, Soil Acidity, Electrical Conductivity, Organic Carbon, Soil Microbial Biomass Carbon, Total Nitrogen, Mineralisable Nitrogen, Determination of Soil Microbial Biomass Nitrogen, Total Phosphorus, Extractable Phosphorus Determination, Total Potassium, Ammonium Acetate Extractable Potassium, Cation Exchange Capacity, Anion Exchange Capacity, Exchangeable Bases, Exchangeable Calcium and Magnesium in Calcareous Soils, Micronutrients determination, Arsenic Determination, Fluoride Estimation in Soil and Water, Determination of Lime and gypsum Requirements of soil, Determination of Lime Potential, Available Sulphur Determination, Determination of Carbonate and Bicarbonate in Soil and Determination of Chloride in Soil Extract. **Ref. 3: Pages 78-138**	10
3	**Analysis of soaps and detergents (Ref. 4): a) Surfactant types; classification, identification, separation:** Why analyse surfactants, Features peculiar to surfactant analysis, Basic Definitions (surfactant, anionic surfactant, cationic surfactant, non-ionic surfactant, amphoteric surfactant, weakly acidic and basic surfactants), Common types of surfactants of all four classes, **b) Elemental analysis:** Metals, Determination of nitrogen, Determination of sulphur, Determination of phosphorus. **c) Basic techniques:** Extraction of surfactants (Liquid-solid extraction: Liquid-liquid extraction using separating funnels, Liquid-liquid extraction using extraction columns), Acid-base titration**:** (general principles, end point detection, Determination of weak acids and bases and their salts, Potentiometric titration: Principle, Applications, Methods for esters, amines, alcohols and unsaturated fatty materials, Two-phase titration of ionic surfactants with surfactants of opposite charge, Introduction, ISO 2271: Principle and procedure, Potentiometric titration with surfactants of opposite charge using a surfactant-sensitive electrode, Advantages of potentiometric titration, Construction and performance of surfactant-sensitive electrodes, Titration procedure, Open-column chromatography. **d) Analysis of Representative surfactants: i) Analysis of Anionics:** Introduction, general methods- Para-toluidine precipitation/titration	10

	method, Analysis of Alkane sulphonates: Determination of total alkane sulphonate, Determination of mean molecular weight of alkane monosulphonates, Separation and determination of alkane mono- and disulphonates, Carboxylates: Titration with benzethonium chloride, Solvent extraction, Acid-base titration, Determination of soaps in fatty products, **ii)Analysis of nonionics:** Analysis of Ethoxylated alcohols, alkylphenols and fatty acids: Composition, Determination by potentiometric titration, Determination by the cobaltothiocyanate colorimetric method, Determination of total nonionics and polyethylene glycols, Volumetric determination of polyethylene glycols, Determination of oxyethylene groups, Fatty acid ethoxylates: determination of polyethylene glycols, freefatty acid and mono- and diester; **iii) Analysis of cationics and amphoterics:** Introduction, Analysis of Quaternary ammonium salts:, Two-phase titration with sodium dodecyl sulphate, Two-phase titration with sodium tetraphenylborate, Determination of free amine and amine hydrochloride, Amines: Determination of molecular weight and total, primary, secondary and tertiary amines. **Ref. 4: Pages 1, 8, 17-24, 31-36, 42-75, 105-109, 119-124, 142-143, 149-160, 171-177, 222-226, 264-280, 310-317** **Ref. 5: Relevant Pages**	

References:

1. Methods in Agricultural Chemical Analysis: A Practical Handbook by N.T. Faithfull, CABI Publishing, Typeset by Wyvern 21 Ltd, Bristol (2002).
2. Manual of Pesticide Residue Analysis Volume I, Edited by Hans-Peter Thier and Hans Zeumer, Pesticides Commission, VCH, New York.
3. Physical and Chemical Methods in Soil Analysis by Dipak Sarkar and Abhijit Haldar, New Age International Publishers, New Delhi.
4. Introduction to Surfactant Analysis, Edited by D. C. Cullum, Springer-Science and Business Media, B.V, 1994.
5. Handbook of Detergents, Editor-In-Chief Uri Zoller, Part-C, Heinrich Waldhoff, Rüdiger Spilker, Marcel Dekker, New York, 2005.
6. Soil Sampling and Methods of Analysis, Edited by M.R. Carter E.G. Gregorich, Canadian Society of Soil Science, Second Edition (2008).

Course/ Paper Title	**Research Project**
Course Code	**23SMAC31RP**
Semester	III
No. of Credits	4 Credits

Aims & Objectives of the Course

Sr. No.	Objectives
	Student should understand and learn;
1.	Each student should carry out a research project.
2.	This should make them familiar with i. Literature survey, research methodologies ii. Data Analysis iii. Purification techniques. iv. Characterization of the products by analytical and spectral methods.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Understand the various synthetic pathways and implement it in the production of pharmacological compounds.
2.	Students will be able to interpret spectral data and other observations.

Details for 23SMAC31RP: Research Project

The candidates shall undertake the project work in the Third and Fourth Semester either in the Department or in Industries, Research Institute, or any other Organizations (National / International). The progress report of the project to be submitted in the third semester and the project report has to be submitted at the end of the fourth semester.

In case the candidate undertakes the project work outside the Department, **any one teacher from the Department** shall be the co-guide and the teacher/scientist under whom the work is carried out will be the guide. The candidate shall bring the attendance certificate from the place where the project work is carried out.

Following points must be included during the project work:

1. Students should undertake projects related to Chemistry.
2. Interdisciplinary projects shall be encouraged; however, there **must be some Chemistry**

component.

3. Students should spend enough time for the project works
4. If student is performing project in another institute, for such student, internal mentor must be allotted and he will be responsible for internal assessment of the student. In this case student has to obtain certificate from both external and internal mentor.
5. Systematic record of attendance of project students must be maintained by the mentor.
6. Students must present his monthly progressions to his mentor/guide/co-guide and prepare his report with geotag photo as monthly progress report and submit at time of examination.
7. Daily Project work book / dairy will be maintained by students and weekly checked from mentor / guide.
8. If sufficient work is not carried out in third semester, literature survey and research papers related project work will be presented as review paper in front of examiner along with the work.
9. Project progression of third semester will be evaluated jointly by all examiners. Typically, student must present his practical work and discuss results / difficulties / records in details (15-20 min.) which will be followed by question-answer session (10 min). It shall be open type of examination.

SEMESTER IV

Course/ Paper Title	**Analytical Spectroscopic Techniques**
Course Code	**23SMAC41MM**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
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
Student should 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.

23SMAC41MM: Analytical Spectroscopic Techniques (30 Hours)

Sr. No.	Name of the Topic	Lectures
1	**Spectroscopic Methods of Analysis:** 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. **Ref. 1: Pages 477-521** **Ref. 2: Pages 359-380**	02

2	**Atomic Absorption and emission Spectroscopy:** 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. **Ref. 1: Pages 548-578** **Ref. 2: Pages 412-421, 434-439** **Ref. 4: Pages 31-54**	10
3	**Nuclear magnetic resonance spectroscopy**: ^{1}HNMR: Introduction, theory, Nuclear Relaxation process in ^{1}HNMR, Instrumentation, Spin-spin relaxation, spin-lattice relaxation, Reference compounds, Chemical shifts, spin-spin Splitting, protons on heteroatom's, coupling protons with other nuclei, solvents, qualitative and quantitative analysis, problems. ^{13}C NMR: Introduction, interpretation of ^{13}C NMR spectra, Chemical shifts, Spin Coupling, quantitative analysis, problems. **Ref. 8 to 10: Relevant Pages**	08
4	**Electron Paramagnetic Resonance Spectroscopy:** Basic Theory, relaxation process in ESR, Instrumentation, 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, 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, alternant hydrocarbons, hyperfine splitting constants, second order splitting, Applications. **Ref. 6 and 7: Relevant pages**	10

References:

1. Analytical Chemistry, 7th Ed. by Christian, G. D., Wiley India, New Delhi, 2003.
2. Practical Inductively Coupled Plasma spectroscopy, John R. Dean, Wiley India Pvt. Ltd.
3. Modern analytical chemistry by Harvey David, The McGraw-Hill Companies, Inc., 2000
4. Spectrochemical Analysis by Atomic Absorption and Emission by Lauri H,J, Lajunen, The Royal Society of Chemistry, Thomas Graham House, The Science Park, Cambridge
5. Basic Gas Chromatography Mass Spectrometry, Principles and Techniques, F.W. Karasek and R.E. Clement, Elsevier, (Elsevier Science B.V.) 1988
6. Electron Paramagnetic Resonance Spectroscopy (fundamentals) by Patrick Bertrand, UGA edition, Springer.
7. Materials Characterization - Introduction to Microscopic and Spectroscopic Methods (2nd Edition) by Yang Leng, Ed. Wiley-VCH.
8. Analytical Atomic Spectrometry with Flames and Plasmas by Jose A. C. Broekaert, Wiley-VCH Verlag GmbH & Co. KGaA.
9. Introduction to Magnetic Resonance of Spectroscopy ESR, NMR, NQR, D.N. Sathyanarayana, I. K. International Publishing House Pvt. Ltd.
10. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
11. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed., Cengage Publication.

Course/ Paper Title	**Modern Methods of Chemical Analysis**
Course Code	**23SMAC42MM**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. Introduce the student to principles and theory of liquid chromatography and electron Spectroscopy for Surface Analysis and elemental analysis. 2. Acquaint the student to principles and theory of HPLC. 3. Provide advance knowledge of HPLC operation and maintenance. 4. 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 HPLC. 2. Interpret and evaluate the information contained in the several types of spectra obtained with different instruments. 3. Explain theory and instrumentation of HPLC. 4. Learn applications of HPLC for organic, inorganic and natural products. 5. Explain the usage of electron spectroscopy as a source of information about the surface and atomic or molecular composition of matter. 6. Explain the fundamental concepts & theories of separation techniques in SFC & SFE. 7. Calculate the elemental composition in the samples.

23SMAC42MM: Modern Methods of Chemical Analysis

Sr. No.	Title with Contents	Lectures
1	**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:	04

	Columns for HPLC, Precolumn, General properties of stationary phases, Silica, chemically modified silica, Styrene-divinylbenzene. **Ref. – 1: Pages 4-126**	
2	**HPLC Methods**: 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, Ion-pair chromatography in practice, Applications. e) **Ion Chromatography**: Principle, Suppression techniques, Applications, f) **Size exclusion Chromatography**: Principle, The calibration chromatogram, Molecular mass determination by means of size-exclusion chromatography, Coupled size-exclusion columns, Applications. g) **Affinity Chromatography**: Principle, Affinity chromatography as a special case of HPLC, Applications. h) **Flash chromatography** (Ref. 5): Principle of Flash chromatography, Steps of Flash chromatography, Uses of Flash chromatography. **Ref. – 1: Pages 146-225**	10
3	**Electron Spectroscopy for Surface Analysis:** Basic principles, x-ray photoelectron spectroscopy, Auger Electron spectroscopy, Instrumentation: ultra-high vacuum, source gun, electron gun, Ion gun, electron energy analysers, Characteristics of Electron spectra: photoelectron spectra, Auger electron spectra, Qualitative and quantitative analysis: qualitative analysis, peak identification, chemical shift, problems with insulating materials, Quantitative analysis: peak and sensitivity factor, composition depth profiling. **Ref. 2: Pages 221-250**	08
4	**Super Critical Fluid Chromatography and Extraction**: 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. **Ref. – 3: Pages 856-864**	04
5	**Elemental Analysis:** Particular analyses, Elemental organic microanalysis, Total nitrogen analysers (TN), Total sulphuranalysers, Total carbon analysers, problems on empirical and molecular formula on C, H, O, N and S analysis. Numerical problems based on this technique. **Ref. 4: Pages 441-451**	04

References:

1. Practical High - Performance Liquid Chromatography (4th Edition) by Veronika R. Meyer, John Wiley and Sons, New York.
2. Materials Characterization, introduction to microscopic and spectroscopic techniques (2nd Edition) by Yang Leng, Wiley-VCH.
3. Principles of Instrumental Analysis (6th Edition) by Douglas A. Skoog, F James Holler and Stanley R. Crouch, Thomson Brooks/Cole, Thomson Corporation. Thomson, Belmont, CA, USA.
4. Chemical Analysis, Modern Instrumentation Methods and Techniques (2nd Edition) by Francis Rouessac and Annick Rouessac, John Wiley & Sons Ltd, England.
5. Analytical Chemistry, 7th Ed. by Christian, G. D., Wiley India, New Delhi, 2003.
6. Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.
7. Principles of Instrumental Analysis, Skoog, West, Holler, 6th Ed., Cengage Publication.

Course/ Paper Title	**Analytical Method Validation and Extraction Techniques**
Course Code	**23SMAC43MM**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To give the knowledge regarding the data handling and basic concepts in analytical Chemistry. 2. To familiarize students with assay, validation methods, dissolution studies and extraction techniques. 3. To provide adequate scientific knowledge and training in order to operate in the field of industrial pharmacy. 4. To familiarize students with basic extraction techniques and introduce different types of.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Define various terms in analytical extraction and method development and validation. 2. Explain instrumentations and methodology in analytical extraction. 3. Explain basic principles of analytical extraction method development and validation. 4. Describe applications analytical extraction and method development and validation in industry and in analytical laboratory. 5. Apply / select particular method of analysis for sample to be analysed. 6. Solve numerical problems on analytical extraction and method development and validation. 7. Develop analytical method for analysis of given sample. Apply statistical treatment to the analytical data. Select appropriate parameters for the development of analytical method 8. Differentiate among the methods of analytical extraction.

23SMAC43MM: Analytical Method Validation and Extraction Techniques

Sr. No.	Name of the Topic	Lectures
1	**Introduction to Analytical Method Validation:** Drug Development Process, FDA Hierarchy and Organization, International Conference on Harmonization, AMV Guidance, and Validation Process. **Ref. 1: Pages 1-20**	02
2	**HPLC Method Development and Optimization with Validation:** HPLC Method Development Approaches, Method Goals, HPLC Method Development Instrumentation, Method Optimization. **Ref. 1: Pages 37-58**	02
3	**Method Validation Basics:** Method Validation Guidelines, Terms and Definitions- Accuracy, Precision, Specificity, Detection Limit, Quantitation Limit, Linearity and Range, Robustness, Validation according to Method Type, Documentation. **Ref. 1: Pages 61-78**	02
4	**Analytical Method Transfer:** Introduction, Terms, Definitions, and Responsibilities, Analytical Method Transfer Options, Elements of AMT, Documentation of Results: AMT Report, Potential AMT Pitfalls. **Ref. 1: Pages 165-172**	02
5	**Specific methods and Applications – Dissolution Studies:** 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. **Ref. 2: Pages 169 to 182**	04
6	**Classical Approaches for Aqueous Extraction:** Introduction, Liquid–Liquid Extraction, Theory of Liquid–Liquid Extraction, Selection of Solvents, Solvent Extraction, Problems with the LLE Process, Purge and Trap for Volatile Organics in Aqueous Samples. Examples of Solvent Extraction- estimation individual metal ions Be, B, Cu, Fe and Pb by solvent extraction. Problems. **Ref. 4: Pages 39 – 45** **Ref. 3: Relevant pages**	06
7	**Solid Phase Extraction (SPE):** 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-	04

	Line SPE and its applications. **Ref. 4: 49 – 78**	
8	**Solid -Liquid Extraction, Microwave Extraction:** a) Classical Approach: Introduction, Soxhlet extraction, Automated Soxhlet extraction, other approaches. b) Pressurized Fluid Extraction: Introduction, theoretical consideration, Instrumentation for PFE, method development and applications. c) Microwave assisted extraction: Introduction, instrumentation, Applications. **Ref. 4: 127 – 182**	04
9	**Method Development with Solid Phase Micro-extraction:** Introduction, Evaluating SPME versus other sample preparation, Techniques, SPME Versus SFE, Procedure for sample preparation with SPME, Quantitation of liquid and solid samples. **Ref. 5: Pages 27-55**	04

References:

1. Handbook of Analytical Validation by Michael E. Swartz and Ira S. Krull, CRC Press, Taylor & Francis Group, London.
2. Development and validiation of Analytical Methods, Progress Pharmaceutical and Biomedical Analysis, Vol-3, Edited by Chitofer M. Riley and Tomas W. Rosanske (Elsvier).
3. Vogel's Textbook of quantitative Chemical Analysis, Sixth Ed. by Mendham, Denney, Barnes, Thomas, Pearson Education.
4. Extraction Techniques in Analytical Science by John R. Dean, Wiley.
5. Solid Phase Microextraction, A Practical Guide, Edited by Sue Ann Scheppers Wercinski, CRC press, Taylor and Francis.
6. International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human use, Q2(RT), Geneva, Switzerland, November 2005.

Course/ Paper Title	**Chemical methods of Pharmaceutical Analysis**
Course Code	**23SMAC44MM**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To describe basic principles of methods of pharmaceutical analysis according to IP. 2. Explain importance particular test in pharmaceutical raw material and finished product analysis. 3. Perform and explain importance of limit tests, identification tests and micobiological limit test of raw materials and finished products. 4. Solve numerical problems on analysis pharmaceutical raw material and finished product analysis. 5. Interpret IR spectra, HPLC chromatogram, UV-Visible spectra of pharmaceutical materials. 6. To perform total analysis of pharmaceutical raw material and finished product analysis according to IP / BP / USP. 7. The principles and procedures for the determination of various pharmaceutical bulk drugs and their formulations belonging to different categories are discussed in detail. 8. The applications of the important reagents like MBTH, FC, PDAB etc. in the determination of the pharmaceuticals are also discussed.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Take a decision on the basis of analytical results regarding quality of raw materials so that material can be accepted for production or rejected. 2. Explain the principles of volumetric and electrochemical analysis. 3. Carry out various volumetric and electrochemical titrations.

4. Describe basic principles of methods of pharmaceutical analysis according to IP.
5. Explain importance particular test in pharmaceutical raw material and finished product analysis.
6. Perform and explain importance of limit tests, identification tests and micobiological limit test of raw materials and finished products.
7. The quantitative determination of various organic compounds is clearly understood. The spectral analysis, dissolution parameters and microbial assays are also learned.

23SMAC44MM: Chemical methods of Pharmaceutical Analysis

Sr. No.	Name of the Topic	Lectures
1	**Introduction to Pharmaceutical Analysis:** Introduction, Introduction to Titrimetry, Electroanalytical Methods, Spectroscopy and Chromatography. **Ref. 1: Pages 3-23**	02
2	Principles and procedures involved in the determination of the official compounds in IP with the following analytical techniques - a. Acid – Base b. Complexometric c. Oxidation-reduction d. Precipitation Titrations e. Diazotization f. Non-aqueous **Ref. 1: Pages 71-125** **Ref. 7: Relevant Pages**	06
3	A detailed study of the principles and procedures involved in the quantitative determination of the following organic functional groups – a. Amines b. Carbonyl compounds c. Esters d. Hydroxy and carboxyl compounds e. Amino Acids **Ref. 1: Pages 463-480**	02
4	Principles and procedures involved in using the following reagents in the determination of pharmaceutical dosage forms official in IP – a. MBTH (3-methyl-2-benzothiazolone hydrazone) b. Tri Keto Hydrindine Hydrate (Ninhydrin Reagent) c. PDAB (para-Dimethyl Amino Benzaldehyde) d. 2,4,6-Tripyridyl-S-Triazine (TPTZ) e. 1,2-Naphtha Quinone-4-Sulphonate Sodium (NQS) f. Bratton–Marshall Reagent (BM Reagent) g. Folin–Ciocalteu Reagent (FC Reagent) h. 2,6-Dichloro Quinone Chloroimide (Gibb's Reagent) **Ref. 1: Pages 435-462**	04
5	**Physical Test, Determinations, Limit tests and Sterilization:** a. Disintegration Test for Tablets and Capsules. b. Dissolution Test for Tablets and Capsules. c. Moisture / water content by Karl-Fischer titration. d. Limit tests for arsenic, heavy metals, iron, lead, sulphate and chloride. e. Ash value, Types of Ashes, sulphated ash.	08

	f. Methods for Sterilization Steam Sterilization, Dry heat sterilization, Sterilization by Filtration, Gas Sterilization, Sterilization by Ionizing radiation, Sterilization by heating with Bactericides. **Ref. 2: Pages 93-149** **Ref. 3: Pages 198-210** **Ref. 4 and 5: Relevant Pages** **Ref. 7: Pages 223-227**	
6	**Monographs and Chemical Analysis of Pharmaceutical Preparations:** Introduction to monographs, introduction to different pharmacopoeias. Monographs and Chemical Analysis as per Indian Pharmacopeia of Adrenaline, Isoniazide, Paracetamol, Aspirin, Sulfacetamide, Omeprazole, Benzocaine, Ibuprofen, Chloroquine, Metronidazole, Diethycarbamazine, Acylclovir, 5-Fluorouracil, Tolbutamide, Warfarin and Problems based on assay of these materials. **Ref. 4 to 6: Relevant pages.**	08

References:

1. Pharmaceutical Analysis by P. D. Chaithanya Sudha, Pearson, New Delhi.
2. Pharmaceutical Chemical Analysis: Methods for Identification and Limit Tests by Ole Pedersen, CRC press. Taylor & Francis Group, 2006.
3. Pharmaceutical Microbiology by Ashutosh Kar, New Age International Pvt. Ltd., New Delhi.
4. Indian Pharmacopeia Volume I, 7th Ed.
5. Indian Pharmacopeia Volume II, 7th Ed.
6. Indian Pharmacopeia Volume III, 7th Ed.
7. Pharmaceutical Drug Analysis by Ashutosh Kar, New Age International Pvt. Ltd., New Delhi.

Course/ Paper Title	**Practical: Analysis of Pharmaceutical and Bioanalytical Samples**
Course Code	**23SMAC45MM**
Semester	IV
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. Define 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. Acquire practical skills in analysis of biological samples, handling and interpretation data in various methods of analysis adapted to bioanalytical chemistry. 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. To perform total analysis of pharmaceutical raw material and finished product analysis according to IP / BP / USP. 2. Standardize analytical instruments according IP /BP/ USP. 3. Take a decision on the basis of analytical results regarding quality of raw materials sothat material can be accepted for production or rejected. 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, differentiate normal from abnormal results and recognize and explain the clinical significance of abnormal results.

23SMAC45MM: Practical: Analysis of Pharmaceutical and Bioanalytical Samples

S. No.	Name of the Experiment
I	**Analysis of Pharmaceutical Formulations (Any EIGHT)**
1	Assay of Assay of Local anesthetics (benzocaine)/sodium benzoate by non-aqueous titration method.
2	Determination of iron from tablet and Syrup by titration with ceric ammonium sulphate.
3	Estimation of Vit. C from tablet using Dichlorophenol-Indophenols dye by volumetric method.
4	Assay of sulpha drugs by diazotization titration.
5	Estimation of Acid neutralizing capacity of a drug.
6	Estimation of Fe(II) using 1,10-phenanthroline from tablet/Syrup by Spectrophotometry.
7	Analysis of Ca-Gluconate or any Ca-supplementary tablet.
8	Estimation of % purity of a given sample of sodium chloride as per IP.
9	Estimation of ibuprofen from pharmaceutical sample.
10	Analysis of aspirin w.r.t. determination of total ash, sulphated ash and loss on drying.
II	**Analysis of Bioanalytical Samples (Any SEVEN)**
13	Estimation of glucose from blood sample.
14	Estimation of cholesterol from blood sample.
15	Estimation of urea from blood sample.
16	Estimation of creatinine from urine sample.
17	Determination of phosphorus content in serum or urine sample.
18	Estimation of total protein from serum sample.
19	Estimation of ketone bodies from the blood sample.
20	Determination of Na from serum sample by flame photometry using calibration curve method and standard addition method.
21	Urine analysis for abnormal constituents like albumin, sugars and ketone bodies.

References:

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

Course/ Paper Title	**Practical: Analysis of Complex Materials**
Course Code	**23SMAC46MM**
Semester	IV
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. To train the students in preparation/isolation standard/reference materials. 2. Maintain proper record of analytical data in notebook. Observer personal safety in laboratory and able handle all chemicals, instruments, etc safely in laboratory. 3. Define / understand various terms involved practical methods of quantitative analysis. 4. To analyse 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 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.

23SMAC46MM: Practical: Analysis of Complex Materials

Unit No.	**Title with Contents**
I	**Volumetric and Gravimetric methods for quantitative analysis of complex materials (ANY FIVE)**
1	Analysis of Bronze with respect to Cu and Sn.
2	Determination of Ca and Mg in limestone or dolomite samples using EDTA.
3	Analysis of mixed fertilizer sample for total nitrogen, K and phosphate content.

4	To analyse given sample of Magnalium alloy and determine percentage of Al and Mg.
5	Analysis of copper ferrite ($CuFe_2O_4$) and determine amount of Cu and Fe.
6	Analysis of brass alloy for Cu and Sn.
7	Analysis of nichrome alloy with respect to Ni and Cr.
II	**Instrumental Methods of selective analysis from complex materials (ANY SEVEN)**
1	Analysis of fertilizer Micronutrient Supplement for Fe, Mn, Cu, and B. Colorimetry: Fe with thiocyanate, Mn as $KMnO_4$, 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 in table salt and its quantitative estimation by volumetric method.
4	Determination of Ca in milk powder by flame photometry.
5	Determination Critical Micelle Concentration of detergent powder or pure detergent by conductometry /viscometry.
6	Determine amount of magnesium from given talcum powder by volumetric method.
7	Determination of calcium from given sample of plaster of Paris.
8	Determination of phosphate in fertilizer and cola drinks by Molybdenum blue method.
9	Determination of commercial vinegar by potentiometric titration and its confirmation
III	**Preparation / Isolations of Analytical Standards or reference material (ANY THREE)**
1	Isolation and purification of 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	Estimation of protein by Lowry method.
5	Estimation of Ca and Mg from form the mixture their oxalate by recording their TGA curve.

References:

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. Indian Pharmacopeia, 7th Ed.
5. Polymer Synthesis and Characterization, A Laboratory Manual, Stanely R Sandler, Wolf Karo, Jo-Anne Bonesteel, Eli M Pearce, Published by Academic press (Elsevier).

Course/ Paper Title	**Practical: Advanced Instrumental Analysis**
Course Code	**23SMAC47MEA**
Semester	IV
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. To familiarize students with advanced instrumental analysis techniques such as flame photometry, photofluorimetry, high performance liquid chromatography, cyclic Voltammetry and spectrophotometry. 2. To train students in the proper operation, calibration, and maintenance of sophisticated analytical instruments used in advanced analysis. 3. To develop skills in data processing, analysis, and interpretation using specialized software tools for advanced instrumental data. 4. To educate students on quality assurance procedures, method validation techniques, and compliance with regulatory standards in instrumental analysis.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. To demonstrate proficiency in operating advanced instruments, including setting parameters, acquiring data, and troubleshooting instrument issues. 2. To analyse and interpret complex datasets obtained from advanced instruments, draw conclusions, and present findings effectively. 3. To diagnose and address technical issues that may arise during experiments, enhancing problem-solving abilities. 4. To develop and optimize analytical methods for specific applications using advanced instrumental techniques.

23SMAC47MEA: Practical: Advanced Instrumental Analysis

Note: Any **FIFTEEN** Experiments to be performed

S. No.	Name of the Experiment
	Flame photometry
1	Flame photometric analysis of water/soil sample for Na^+ and K^+ by calibration curve

	method.
2	Estimation of K^+ from soil/water sample by internal standard method.
3	Flame photometric estimation of Ca^{2+} from water or any sample.
	Photofluorimetry
4	Estimation of quinine sulphate from tablet by calibration curve and its confirmation by standard addition method.
5	To investigate the effect quenching on the fluorescence intensity of Quinine sulphate by fluorimetry.
6	Estimation of riboflavin by photoflurimetry from multivitamin capsule by calibration curve and its confirmation by standard addition method.
	Turbidimetry / Nephelometry
7	Estimation of Chloride from water or any other sample by calibration turbidimetric titration method and its confirmation by potentiometric titration.
8	Selective estimation of SO_4^{2-} in presence of chloride from water or any other sample by calibration curve method.
	Double beam spectrophotometer
9	UV absorbance based assay of plane paracetamol table using specific absorbance (British Pharmacopeia).
10	Assay of chloramphenicol capsules by spectrophotometric method.
	Polarimetry
11	Determine the relative strength of given two acids by polarimetric measurement.
12	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.
	Cyclic Voltammetry
13	Cyclic voltammetric study of Fe(II)/Fe(III) system. Basic principle and calculation of basic parameters from CV.
14	Quantitative estimation of quinone system or any other biological system by Cyclic voltammetry.
	High Performance Liquid Chromatography (HPLC)
15	To estimate the amount of paracetomol and dichlofenac sodium in pharmaceutical tablets (USP) by HPLC technique.
16	Analysis of Caffeine and benzoic acid from cold drink by HPLC.
	Gas Chromatography
17	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.
18	Quantitative analysis of alcohol in beverages by Gas Chromatography.

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, American water works association, Water environment federation.
2. Vogels textbook of Inorganic Quantitative Analysis.
3. Ultraviolet and Visible Spectrophotometry in Pharmaceutical Analysis, Sandor Gorog, Published by CRC press, Taylor and Fransis.
4. Any other relevant reference can be included.

Course/ Paper Title	**Practical: Applied Analytical Chemistry Practicals**
Course Code	**23SMAC47MEB**
Semester	IV
No. of Credits	2 Credits, (60 Hours)

Aims & Objectives of the Course

Objectives
1. To understand the fundamental principles underlying pH metry, potentiometry, conductometry, and colorimetry. 2. To gain proficiency in handling and operating various instruments used in these practical techniques. 3. To learn the application of pH metry, potentiometry, conductometry, and colorimetry in analytical chemistry. 4. To acquire skills to interpret, analyze, and draw conclusions from experimental data obtained through these techniques. 5. To develop the ability to design experiments, select appropriate methods, and troubleshoot experimental setups.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Explain the theoretical foundations of pH metry, potentiometry, conductometry, and colorimetry, detailing their operating principles and applications. 2. Demonstrate proficiency in handling and calibrating instruments used in these techniques, ensuring accurate measurements and data acquisition. 3. Perform experiments employing pH metry, potentiometry, conductometry, and colorimetry to determine unknown concentrations or analyze various samples. 4. Analyze and interpret data obtained from experimental results using appropriate statistical and analytical methods. 5. Devise experimental procedures for specific analytical problems, selecting suitable techniques and optimizing conditions for accurate measurements.

23SMAC47MEB: Practical: Applied Analytical Chemistry Practicals

Note: Any **FIFTEEN** Experiments to be performed

S. No.	Name of the Experiment
1	Determination of Zinc in Pharmaceutical Preparations by Ion Exchange Separation and Complexometric Titration.
2	The Determination of Aspirin and caffeine in a Proprietary Analgesic by Ultraviolet (UV) Spectrometry.
3	The Determination of Calcium in Dolomite by Flame Emission Spectrometry.
4	To find out partition coefficient of I_2 between CCI_4 and H_2O.
5	To find out the refractive index of the given liquid and also find its molecular refractivity.
6	To find the specific rotation and molecular rotation of cane sugar polarimetrically and also find the concentration of the unknown solution.
7	To determine the dissociation constants of a polybasic acid (phosphoric acid) by titrating it against sodium hydroxide solution pH metrically.
8	To study the complex formation between Fe(III) and salicylic acid and to find the formula and stability constant of the complex.
9	Synthesis of any other medicinal compound by green chemistry route.
10	Identification of amino acids / sugars / or any other mixture by two-dimensional chromatographic method.
11	Determination of molecular weight by gel permission column chromatography.
12	Analysis of Cement for Calcium, Magnesium and Aluminium.
13	Selective estimation of Ni(II) from steel alloy by solvent extraction.
14	To perform Limit Tests for Fe, Ba and nitrate on dibasic calcium phosphate.
15	Analysis of Caffeine and benzoic acid from cold drink by HPLC.
16	Thin Layer Chromatography (TLC) analysis of analgesics.
17	To perform Adulteration Test for milk and milk products.
18	Determination of partition coefficient of benzoic acid between benzene and water.
19	Determination of Ambroksol HCl, Methyl Paraben and Propyl Paraben in commercial syrup qualitatively by using High Performance Liquid Chromatography (HPLC).
20	Determination of total cation in water by cation exchange method.

References:

1. Experiments in Modern Analytical Chemistry by D. Kealey, Springer Science+Businccss Media, LLC.
2. Advanced Physical Chemistry Experiments by J.N. Gurtu and Amit Gurtu, Pragati Prakashan.
3. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill Publishing Company Ltd.

4. Lab Manual in biochemistry, immunology and biotechnology, Arti Nigam, Archana Ayyagari, Tat-McGraw-Hill Publication.
5. An introduction to Practical Bichemistry, David T. Plummer, Tata McGraw-Hill Publishing Company Ltd.
6. Vogel's Textbook of Inorganic Quantitative Analysis, A. I. Vogel, 3rd Ed.
7. Indian Pharmacopeia Vol-III, 7th Ed.
8. Analytical Chemistry for Technicians, John Kenkel**,** Third Edition, CRC Press LLC, 2003.
9. Environmental Chemistry, Microscale Laboratory Experiments, Jorge G. Ibanez, Margarita Hernandez-Esparza, Carmen Doria-Serrano, Arturo Fregoso-Infante, Mono Mohan Singh, published by Springer.
10. Common milk adulteration and their detection techniques, Azad and Ahmed International Journal of Food Contamination (2016) 3:22.

Course/ Paper Title	**Techniques in Bioanalytical Chemistry**
Course Code	**23SMAC48MEA**
Semester	IV
No. of Credits	2 Credits (30 Hours)

Aims & Objectives of the Course

Objectives
1. The primary objectives of this course are to 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.

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. Take-up career in research organizations and to pursue higher studies in bioanalytical and with high regard for ethical values, environmental and social issues. 4. Understand the quality attributes, their measurement principle and instrumentation of various instruments used in bioanalysis.

23SMAC48MEA: Techniques in Bioanalytical Chemistry

Sr. No.	Name of the Topic	Lectures
1	**Biological samples:** Their composition and properties and their collection and storage. **Ref. 1: Pages 1-18** **Ref. 4: Pages 23-27**	02

2	**Organ function tests:** 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 tests. Kidneys - urine formation, normal and abnormal constituents of urine. Renal function tests - creatinine and urea clearance tests, phenol red test. Numerical problems based on these methods. **Ref. 3: Pages 41-50** **Ref. 5: Pages 43-59 and 183-197**	06
2	**Analysis of Blood and urine:** Determination of blood and 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. Numerical problems based on these methods. **Ref. 1 and 2: Relevant Pages**	10
3	**Determination of vitamins in body fluid:** Classification of vitamins with example, Each vitamin must be explained with respect of functions, deficiency diseases 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.. **Ref. 1 and 2: Relevant Pages**	06
4	**Biological and Microbiological Assays:** a. Introduction to biological assay, Biological assay of Heparin sodium, Biological Assay of Insulin, Oxytocin, Histamine and Vasopressin. b. Microbiological test for Antibiotics, Standard preparation and units of activity, Test organisms and Inoculums, Cylinder-plate assay, Turbidimetric assay and Kirby-Bauer disk diffusion and well diffusion assay. **Ref. 6: Pages 25.1 - 25.12** **Ref. 7: Pages 168-186**	06

References:

1. Practical clinical Biochemistry, Harold Varley (4th Edition), CBS publishers and Distributers. New Delhi -110002.
2. Basic Concepts in Clinical Biochemistry: A Practical Guide by Vijay Kumar and Kiran Dip Gill, Springer Nature Singapore Pte Ltd. 2018.
3. Methods in Molecular Biology, Vol-42, ELISA-Theory and Practice, by John R. Crowther, Humana Press, Totowa, New Jersey.
4. Bioanalysis of Pharmaceuticals by Steen Honoré Hansen and Stig Pedersen-Bjergaard, John Wiley & Sons, Ltd, UK.
5. Clinical Biochemistry, Tenth Edition by Peter Rae, Mike Crane and Rebecca Pattenden, John Wiley & Sons, Ltd, UK.
6. A Text Book of Pharmacology – II by Manjunatha P. Mudagal and Uday Raj Sharma, Nirali Prakashan, Oune.
7. Collins and Lyne's Microbiological Methods, Eighth Edition by C. H. Collins, Patricia M. Lyne, J. M. Grange and J. O. Falkinham, Oxford University Press Inc., New York.

Course/ Paper Title	**Laboratory Automation and Sensor Based Techniques**
Course Code	**23SMAC48MEB**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To familiarize students with the knowledge regarding the Laboratory automation and sensors in analytical Chemistry. 2. Apply advanced techniques and tools of sensing and automation to solve multi-disciplinary challenges in industry and society. 3. To provide in depth knowledge in physical principles applied in sensing, measurement and a comprehensive understanding on how measurement systems are designed, calibrated, characterised, and analysed. 4. To introduce the students to sources and detectors of various Optical sensing mechanisms and provide in-depth understanding of the principle of measurement, and theory of instruments and sensors. 5. Develop a good sense of understanding towards computerized automation based instrumentation industry. 6. Impart the working principle of sensors and transducer.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Define / understand various terms in Laboratory automation and sensors. 2. Explain instrumentation of automated laboratory analysis and sensors. 3. To describe basic principles of automated laboratory analysis and sensors. 4. Explain importance of automated laboratory analysis and sensors. 5. Explain the principle and applications of chemical and biological sensors.

23SMAC48MEB: Laboratory Automation and Sensor Based Techniques

Sr. No.	Name of the Topic	Lectures
1	**Automation in the Analytical Laboratory:** Fundamentals and Objectives of Analytical Automation, Discrete or Batch Methods, Flow Methods, Robots in the Analytical Process, A Brief History of FIA Definitions. **Ref. 1: Pages 164-212, Ref. 3: Pages 784-792**	02
2	**Design of Chemical Processes For Automated Synthesis:** Integrated Chemical Process – Concept, Double Elimination (Stepwise Process, One-Pot Process for Vitamin A, One-Pot Aromatization of Cyclic Enones, One-Pot Synthesis of Acetylenes), One-Pot Alkylation–Desulfonylation, Parallel Recognition Process, Automated Synthesis, Future Prospects. **Ref. 2: Pages 241-267.**	04
3	**Parallel Automation For Chemical Analysis:** The Need For Automated Chemical Analysis, Automation Approaches In Chemical Analysis – Serial Automation Processes, Parallel Automation Processes, Hybrid Automation Systems, Features And Advantages of Parallel Automation Systems, Post-Combinatorial-Synthesis Compound Characterization, Postsynthesis *In Vitro* Drug Testing, Postsynthesis *In Vivo* Drug Testing, Automation And Parallel Separations, Future Prospects In Parallel Automation. **Ref. 2: Pages 340-362.**	04
4	**Fundamentals of Flow Injection Analysis:** FIA Transient Signals, Theoretical Background: Dispersion of a Solute in a Flowing Stream, Empirical Assessment of the Sample Dispersion, Optimization of an FIA System, Use of FIA Signals. Essential Elements of an FIA Assembly, Introduction, The Propulsion System, The Sample Introduction System, The Detection System. FIA Modes, Multi-determinations (and Speciation) in FIA, Reversed FIA, Miniature Systems, Monitoring Industrial Processes, Dialysis: Membrane Separation, Treatment of Samples for their Analytical Measurement, Gases in FIA Reactions and Assemblies. **Ref 1: Pages 25-100.**	06
5	**Chemical Sensors:** Introduction to Sensors, Definitions, Recognition Elements, Transducers - the Detector Device, Methods of Immobilization, Performance Factors, Areas of Application. Electrochemical Transducer, Potentiometry and Ion-Selective Electrodes, Voltammetry and Amperometry, Conductivity, Field-Effect Transistors, Modified Electrodes, Thin-Film Electrodes and Screen-Printed Electrodes, Photometric Sensors, Sensing Elements, Ionic Recognition, Molecular Recognition (Chemical, Spectroscopic and Biological Recognition), Immobilization of Biological Components, Performance Factors – Selectivity, Sensitivity, Time Factors, Precision, Accuracy and Repeatability, Different Transducers and Factors Affecting the Performance of Sensors. Specific applications of senosors:	08

	Determination of Glucose in Blood, Determination of Nanogram Levels of Copper(I) in Water, Determination of Several Ions Simultaneously, Determination of Attomole Levels of a Trinitrotoluene- Antibody Complex and Determination of Flavanols in Beers. **Ref. 4: Pages 1-124 and 214-229**	
6	**Biosensors in analysis:** Introduction, Developments in Biosensors, Electrochemical Biosensors, Amperometric Sensors, Cyclic Voltammetry, Potentiometric Sensor, Conductometric Sensors, Electrochemical Impedance Spectroscopy. Optical-based Biosensor, Surface Plasmon Resonance, Chemiluminescence, Fibre Optic Biosensor, Piezoelectric Sensors, Calorimetric-based Biosensor. Immobilisation Methods, Principles of Biorecognition. **Ref. 5: Pages 1-45**	06

References:

1. Flow Injection Analysis of Pharmaceuticals - Automation in the laboratory by José Martínez Calatayud, Taylor & Francis Ltd, London.
2. Laboratory Automation in the Chemical Industries by David G. Cork and Tohru Sugawara, Marcel Dekker, Inc. New York.
3. Analytical Chemistry, 7th Ed. by Christian, G. D., Wiley India, New Delhi.
4. Chemical Sensors and Biosensors by Brian R. Eggins, John Wiley & Sons Ltd, England.
5. Biosensors: Fundamentals and Applications by Bansi Dhar Malhotra and Chandra Mouli Pandey, A Smithers Group Company, UK.
6. Chemical Sensors by T. E. Edmonds, Springer Science+Business Media, LLC.
7. Chemical Sensors and Biosensors by Florinel-Gabriel Banica, John Wiley & Sons, Ltd., UK.
8. Principles of Chemical Sensors by Jiri Janata, Springer Science+Business Media, LLC.

Course/ Paper Title	**Techniques in Molecular Biology**
Course Code	**23SMAC48MEC**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To encourage students to adopt a multidisciplinary approach by integrating principles and techniques from Biology into the field of Chemistry. 2. To provide students with a thorough understanding of the principles and techniques employed in Molecular Biology, Recombinant DNA Technology, Immunotechniques, Microscopic Techniques, and Radiolabelling. 3. To familiarize students with practical applications of Molecular Biology and other techniques in the analysis of biological molecules, cells, and tissues. 4. To develop critical thinking skills for interpreting and analyzing data generated through various biological methods. 5. To introduce students to advanced techniques such as one and two-dimensional gel electrophoresis, ELISA, western blot, FISH, GISH, and radiolabelling.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Students should demonstrate a deep understanding of the fundamental concepts and principles of molecular biology, recombinant DNA technology, immunotechniques, microscopic techniques, and radiolabelling. 2. Apply knowledge gained to effectively analyze and interpret data generated through various biological methods. 3. Evaluate the significance of techniques in addressing biological questions and their applications in diverse fields, including medical research. 4. Critically analyze scientific literature related to the methods covered in the course, understanding their implications and limitations. 5. Communicate effectively about biological methods, research findings, and ethical considerations, both in oral and written forms.

23SMAC48MEC: Techniques in Molecular Biology

Sr. No.	Name of the Topic	Lectures
1	**Recombinant DNA Technology:** Isolation, purification of RNA, DNA and Proteins. Analysis of RNA, DNA and Proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels. Isolation, separation and analysis of carbohydrates and lipid molecules. RFLP, RAPD and AFLP techniques. **Ref. 1 and Ref 2: Relevant Pages**	08
2	**Immunoanalytical Techniques:** Radioimmunoassay, its principle and applications, instrumentation for radio bioassay, clinical application of the radioimmunoassay of insulin, Estrogen and progesterone. Enzyme- linked immunosorbent assay (ELISA), Types of ELISA, principles, practical aspects, applications. Detection of Molecules using: ELISA, RIA, western blot, Immunoprecipitation, flow cytometry and immunofluorescence. Detection of Molecules in living cells, Insitu localization by techniques such as FISH and GISH. **Ref. 6: Pages 201-210, Ref. 7: Pages 199-221** **Ref. 3: Relevant Pages**	08
3	**Microscopic Techniques:** Visualization of cells and sub-cellular components by light microscope. Resolving power of different microscopes, Microscopy of living cells, SEM and TEM. , Different fixation and staining techniques. **Ref. 4: Relevant Pages**	06
4	**Radioanalytical Methods of Analysis:** Introdcution, **a) Activation analysis:** Neutron activation analysis, principle, technique, steps involved in neutron activation analysis. Radiochemical and instrumental methods of analysis, important applications of NAA. **b) Isotope dilution analysis:** Principle, types of isotope dilution analysis, typical applications of isotope dilution analysis. Detection and measurement of different types of Radio isotopes used in biology. Incorporation of radioisotopes in biological cells and tissues. Molecular imaging of radioactive material, Safety guidelines. **Ref. 5: Pages 337-350**	08

References:

1. Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter.
2. Molecular Biology Techniques: An Intensive Laboratory Course" by Heather B. Miller, D. Scott Witherow.
3. Current Protocols in Immunology" by John E. Coligan, Ada M. Krieg, David M. Shevach, et al.
4. Fundamentals of Light Microscopy and Electronic Imaging" by Douglas B. Murphy.

5. Nuclear and Radiochemistry : Fundamentals and Applications by Karl Heinrich Lieser, VCH Publishers, Inc., New York, NY (USA)
6. Immunology An Introductory Textbook by Anil K. Sharma, Pan Stanford Publishing Pvt. Ltd., Singapore.
7. Understanding Bioanalytical Chemistry - Principles and applications by Victor A. Gault and Neville H. McClenaghan, A John Wiley & Sons, Ltd.
8. Principles and Practice of Immunoassay by Christopher P. Price and David J. Newman, Macmillan Publishers Ltd, 1991

Course/ Paper Title	**Material Characterization Techniques**
Course Code	**23SMAC48MED**
Semester	IV
No. of Credits	2 Credits, (30 Hours)

Aims & Objectives of the Course

Objectives
1. To provide a broad overview about different techniques available for structural characterization of various materials systems. 2. To provide an introduction to materials characterization and its importance. 3. To discuss different types of characterization techniques and their uses. 4. To review the topic of crystal structure and how structures can be determined using diffraction methods. 5. To describe the properties and behaviour of x-rays and their use in materials characterization. 6. To describe the operation and use of a TEM and a SEM.

Expected Course Specific Learning Outcomes

Learning Outcome
Student should be able to – 1. Students are able to understand different characterization techniques of solids 2. Discuss Principle of XRD, instrumentation of powder XRD, Brags law, applications of XRD for crystal structure determination, numerical problems 3. Apply their knowledge to the interpretation of SEM and TEM images. 4. Differentiate between Scanning and Transmission of electron. 5. Explain the basics of X-rays, the Principle of XRF, types of XRF, instrumentation, qualitative and quantitative analysis, and numerical analysis.

23SMAC48MED: Material Characterization Techniques

Sr. No.	Name of the Topic	Lectures
1	**Transmission Electron Microscopy:** Instrumentation, Electron Sources, Thermionic Emission Gun, Field Emission Gun, Electromagnetic Lenses, Specimen Stage, Specimen Preparation, Prethinning, Final Thinning, Electrolytic Thinning, Ultramicrotomy, Image Modes (Mass–Density Contrast, Diffraction Contrast, Phase Contrast), Selected-Area Diffraction (SAD), Selected-Area Diffraction Characteristics. **Ref. 1: Pages 83-126**	10
2	**Scanning Electron Microscopy:** Instrumentation, Optical Arrangement, Signal Detection, Detector, Probe Size and Current Contrast Formation, Electron–Specimen Interactions, Topographic Contrast, Compositional Contrast, Operational Variables, Working Distance and Aperture Size, Acceleration Voltage and Probe Current, Astigmatism, Specimen Preparation, Preparation for Topographic examination. **Ref. 1: Pages 127-160**	10
3	**X-Ray Diffraction Methods:** Miller and Weiss indices, X-Ray Radiation, Generation of X-Rays, X-Ray Absorption, Theoretical Background of Diffraction, Diffraction Geometry, Bragg's Law, Reciprocal Lattice, Diffraction Intensity, Structure Extinction, X-Ray Diffractometry, Instrumentation, System Aberrations, Samples and Data Acquisition, Sample Preparation, Acquisition and Treatment of Diffraction Data, Distortions of Diffraction Spectra, Crystallite Size, Applications, Crystal-Phase Identification, Quantitative Measurement , Wide-Angle X-Ray Diffraction and Scattering, Wide-Angle Diffraction, Wide-Angle Scattering. Problem on XRD (Calculation of d values, assigning planes, calculation of crystal parameters) **Ref. 1: Pages 47-82**	10

References:

1. Materials Characterization - Introduction to Microscopic and Spectroscopic Methods, Second Ed. By Yang Leng, Wiley-VCH.
2. Nuclear and Radiochemistry: Fundamentals and Applications by Karl Heinrich Lieser, VCH Publishers, Inc., New York, NY (USA)
3. Immunology An Introductory Textbook by Anil K. Sharma, Pan Stanford Publishing Pvt. Ltd., Singapore.
4. Understanding Bioanalytical Chemistry - Principles and applications by Victor A. Gault and Neville H. McClenaghan, A John Wiley & Sons, Ltd.
5. Principles and Practice of Immunoassay by Christopher P. Price and David J. Newman, Macmillan Publishers Ltd, 1991.

Course/ Paper Title	**Project**
Course Code	**23SMAC41RP**
Semester	IV
No. of Credits	6 Credits

Aims & Objectives of the Course

Objectives
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 analyse 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 PROJECT

Title with Contents
The candidates should continue the project work in the Fourth Semester as mentioned in course 23SMAC31RP. Complete Project report copies must be submitted to department and guide at the time of examination. Project report must contain following point. 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. The submission of review paper with minimum 200 references is expected from the students. 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.