Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science, Commerce, Baramati

(Autonomous)

DEPARTMENT OF CHEMISTRY

(Faculty of Science and Technology)

Two Year M.Sc. Degree Program Chemistry

M.Sc. II Analytical Chemistry
Semester-III

(NEP 2023 Pattern)
Choice Based Credit System Structure and Syllabus
(As Per NEP 2020)

(To be implemented from June 2024)

Title of the Programme: M.Sc. (Chemistry)

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Chemistry and related subjects, the Board of Studies in Chemistry at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the third semester of M.Sc. Part-II Analytical Chemistry, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31stMay 2023.

A chemistry degree equips students with the knowledge and skills necessary for a diverse range of fulfilling career paths. Graduates in chemistry find opportunities in various fields, including This includes industries like glass, cement, paper, textile, leather, dye, etc. We also see huge chemistry applications in industries like paints, pigments, petroleum, sugar, plastics, and Pharmaceuticals.

Overall, revising the chemistry syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing healthcare need.

Anekant Education Society's
Tuljaram Chaturchand College
of Arts, Science & Commerce, Baramati.

Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati is an autonomous & dynamic institute and has successfully implemented the National Education Policy-2020 since the academic year 2023-24. We are updating our academic policies as per local needs keeping in view the global perspectives. Accordingly, we have updated our program outcomes as per the graduate attributes defined in New Education Policy.

Program Outcomes for M.Sc.

1. Comprehensive Knowledge and Understanding:

Postgraduates will possess a profound understanding of their field, encompassing foundational theories, methodologies, and key concepts within a multidisciplinary context.

2. Practical, Professional, and Procedural Knowledge:

Postgraduates will acquire practical skills and expertise necessary for professional tasks, including industry standards, regulations, and ethical considerations, with effective application in real-world scenarios.

3. Entrepreneurial Mindset, Innovation, and Business Understanding:

Postgraduates will cultivate an entrepreneurial mindset, identify opportunities, foster innovation, and understand business principles, market dynamics, and risk management strategies.

4. Specialized Skills, Critical Thinking, and Problem-Solving:

Postgraduates will demonstrate proficiency in technical skills, analytical abilities, effective communication, and leadership, adapting and innovating in response to changing circumstances.

5. Research, Analytical Reasoning, and Ethical Conduct:

Postgraduates will exhibit observational and inquiry skills, formulate research questions, utilize appropriate methodologies for data analysis, and adhere to research ethics while effectively reporting findings.

6. Communication, Collaboration, and Leadership:

Postgraduates will effectively communicate complex information, collaborate in diverse teams, demonstrate leadership qualities, and facilitate cooperative efforts toward common goals.

7. Digital Proficiency and Technological Skills:

Postgraduates will demonstrate proficiency in using ICT, accessing information sources, analyzing data using appropriate software, and adapting to technological advancements.

8. Multicultural Competence, Inclusive Spirit, and Empathy:

Postgraduates will engage effectively in multicultural settings, respect diverse perspectives, lead diverse teams, and demonstrate empathy and understanding of others' perspectives and emotions.

9. Value Inculcation, Environmental Awareness, and Ethical Practices:

Postgraduates will embrace ethical and moral values, practice responsible citizenship, recognize and address ethical issues, and promote sustainability and environmental conservation.

10. Autonomy, Responsibility, and Accountability:

Postgraduates will apply knowledge and skills independently, manage projects effectively, and demonstrate responsibility and accountability in work and learning contexts, contributing to societal well-being.

List of Members Present for the BOS Meeting

The following internal and external BOS members were attended the Board of Studies

Sr. No.	Name of Member	Designation
1.	**Dr. Sanjay R. Kale** Head & Professor, Department of Chemistry, T. C. College, Baramati.	Chairman
2.	**Dr. Namdeo N. Bhujbal** Professor, Department of Chemistry Magar College, Hadapsar, Pune	External Member VC Nominee.
3.	**Dr. D. M. Pore** Professor, Department of Chemistry Shivaji University, Kolhapur	External Member from other University
4.	**Dr.Shrikrushna T. Salunke** Associate Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
5.	**Mr. Bhimrao R. Torane** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
6.	**Mr. Maharudra A. Dudhe** Assistant Professor, Department of Chemistry, T. C. College, Baramati	Internal Member
7.	**Mr. Ravikiranamrut R. Gandhi** Assistant Professor, Department of Chemistry T. C. College, Baramati	Internal Member
8.	**Dr. Vaibhav P. Landage** Associate Professor, Department of Chemistry T. C. College, Baramati	Internal Member
9.	**Dr. Yogesh N. Indulkar** Assistant Professor, Department of Chemistry T. C. College, Baramati	Internal Member
10.	**Dr. Rahul S. Bhondwe.** Assistant Professor, Department of Chemistry T. C. College, Baramati	Internal Member
11.	**Dr. Nilam C. Dige** Assistant Professor, Department of Chemistry T. C. College, Baramati.	Internal Member
12.	**Mrs. Supriya S. Deokate** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
13.	**Mrs. Jyoti T. Waghmode** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
14.	**Ms. Geetanjali S. Bhunje** Assistant Professor, Department of Chemistry, T. C. College, Baramati	Internal Member

15.	**Mrs. Reshma T. Gadadare** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
16.	**Mrs. Swati A. Deokate** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
17.	**Mrs. Gaytri D. Pirale** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
18.	**Mrs. Sonali P. Nale** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
19.	**Ms. Farhin H. Shaikh** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
20.	**Ms. Anjali N. Bhong** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
21.	**Mr. Harshad J. Salunkhe** Assistant Professor, Department of Chemistry, T. C. College, Baramati.	Internal Member
22.	**Mr. Saurabh Pandhare** T. C. College, Baramati	PG Student
23.	**Mr. Niranjan Ghuge** T. C. College, Baramati	UG Student
24.	**Mr. Vijay Gorave** T. C. College, Baramati	UG Student

Anekant Education Society's
Tuljaram Chaturchand College of Arts, Commerce & Science Baramati, Dist. Pune
(Autonomous)
Course & Credit Structure for M.Sc. Analytical Chemistry (2023 Pattern as per NEP – 2020)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	Credits
III	Major Mandatory	CHA-601-MJM	Recent Advanced Characterization Technique	Theory	**04**
	Major Mandatory	CHA-602-MJM	Pharmaceutical analysis	Theory	**04**
	Major Mandatory	CHA-603-MJM	Instrumental methods of analysis	Practical	**02**
	Major Mandatory	CHA-604-MJM	Analysis of pharmaceutical, food and bio-analytical samples	Practical	**02**
	Major Elective	CHA-611-MJE(A)	Electrochemical methods	Theory	**02**
		CHA-611-MJE(B)	Food analysis		
	Major Elective	CHA-612-MJE(A)	Instrumental analysis	Practical	**02**
		CHA-612-MJE(B)	Analysis of material		
	Research Project (RP)	CHA-621-RP	Project	Practical	**04**
			Total Credits Semester-III		**20**
IV	Major Mandatory	CHA-651-MJM	Analytical methods for analysis of fertilizers, detergent, water, polymer, paint and pigment	Theory	**04**
	Major Mandatory	CHA-652MJM	Method of analysis and applications	Theory	**04**
	Major Mandatory	CHA-653-MJM	Instrumental methods of analysis II	Practical	**02**
	Major Elective	CHA-661-MJE(A)	Advance topics in analytical technique	Theory	**02**
		CHA-661-MJE(B)	Forensic Science		
	Major Elective	CHA-662-MJE(A)	Analysis of material-II	Practical	**02**
		CHA-612-MJE(B)	Innovative experiments in analytical chemistry		
	Research Project (RP)	CHA-681-RP	Research Project	Practical	**06**
			Total Credits Semester-IV		**20**
			Cumulative Credits Semester III + Semester IV		**40**

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CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**III
Course Type	**:**Mandatory Theory
CourseName	**:**Recent Advanced Characterization Technique
CourseCode	**:**CHA-601-MJM
No. of Lectures	**:**60 (48L+12T)
No.of Credits	**:**4 credits

Course Objectives:

1. Understand the principles of Electron Spectroscopy for Chemical Analysis (ESCA) and its applications.
2. Acquire knowledge of X-ray methods, including absorption, fluorescence, and diffraction, for chemical analysis.
3. Explore surface characterization techniques using various microscopes, including X-ray and electron microscopy.
4. Grasp the laws of photochemistry and principles of chemiluminescence, including measurement and applications.
5. Understand the principles of fluorescence and phosphorescence, their apparatus, andejjvb3wx applications in analysis.
6. Comprehend the principles of supramolecular chemistry and its applications, especially in photosystems.
7. Acquire proficiency in NMR spectroscopy, including ^{1}H and ^{13}C nuclei, for qualitative and quantitative analysis.

Course Outcomes:

CO1. Develop a comprehensive understanding of advanced characterization techniques, including microscopy, electron spectroscopy, X-ray methods, and photoluminescence, within a multidisciplinary context.

CO2. Acquire practical skills in operating advanced instrumentation used in electron spectroscopy, such as ESCA, X-ray methods, and fluorescence spectroscopy, ensuring adherence to industry standards, regulations, and ethical considerations.

CO3. Foster an entrepreneurial mindset by identifying opportunities for innovation in the application of advanced characterization techniques, understanding business principles relevant to analytical instrumentation, and exploring potential market applications.

CO4. Demonstrate specialized skills in critical thinking and problem-solving by analyzing and interpreting data obtained from advanced characterization techniques, effectively communicating findings, and adapting methodologies to address research questions.

CO5. Apply research methodologies and ethical conduct in designing and conducting experiments using advanced characterization techniques, adhering to research ethics while reporting findings accurately and transparently.

CO6. Enhance communication, collaboration, and leadership skills by effectively presenting complex analytical information, collaborating in diverse teams for research projects, and demonstrating leadership qualities in analytical contexts.

CO7. Develop proficiency in utilizing digital tools and technological advancements relevant to advanced characterization techniques, accessing information sources, analyzing data using appropriate software, and adapting to emerging technologies in the field.

Topicsand Learning Point

Unit 1. **An Introduction to Microscopy (surface characterization techniques) (8 L)**
Limitations of the Human Eye, the X-ray Microscope, the Transmission Electron Microscope, the Scanning Electron Microscope, Scanning Transmission Electron Microscope, Analytical Electron Microscopy, Scanning-Probe Microscopes, the transmission electron microscope**.**

Unit 2. **Electron spectroscopy: (6 L)**
Introduction, principle of electron spectroscopy for chemical analysis (ESCA). Satellite peaks, spectral splitting, chemical shifts in ESCA. Apparatus used for ESCA, X-ray source, samples, Analyzers, Detectors, Chemical analysis using ESCA, Applications, Auger electron microscopy and Ultraviolet photoelectron spectroscopy.

Unit 3. **X- ray Methods of Analysis (10 L)**
Principle, Theory- X-ray spectral lines, X-ray tube, X-ray emission, Absorptive Apparatus: Sources, Collimation, sample handling, wavelength dispersive devices, Energy dispersive devices, detectors, readout device, Chemical analysis using X-ray absorption, X-ray Fluorescence- instrumentation and chemical analysis, X-ray Diffraction, Chemical analysis with X-ray diffraction, numerical problems.

Unit 4. **Photochemistry (2 L)**
Introduction, Laws of Photochemistry, interaction of radiation with matter, Theory of Photoluminescence, Jablonski diagram

Unit 5. **Chemiluminescence (6L)**
Introduction, principle, types. Measurement of chemiluminescence, Instrumentation, quantitative chemiluminescence, Gas phase Chemiluminescence analysis, Chemiluminescent titrations, electro-chemiluminescence.

Unit 6. **Fluorescence and phosphorescence (4L)**
Introduction, Fluorescence, electron transitions during photoluminescence, factors affecting photoluminescence, luminescent apparatus, optical excitative sources, wavelength selectors, detectors ad readout devices, photo luminescent spectra, photo luminescent analysis, analysis of non-photoluminating compounds, specific examples of analysis using photoluminescence, problems

Unit 7. **Nuclear magnetic resonance spectroscopy (12 L)**

^{1}H-NMR: Introduction, theory, Instrumentation, 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 ^{13}C NMR spectra, Chemical shifts, Spin coupling, quantitative analysis, problems.

2-D NMR: introduction, ^{1}H - ^{1}H connectivity, ^{1}H - ^{13}C connectivity, ^{13}C - ^{13}C connectivity, through space ^{1}H - ^{1}H proximity, option and how to use them, problems.

References:

1. Introduction to instrumental analysis, R.D. Braun, MC. Graw Hill-Interl. edn.
2. Analytical spectroscopy, Kamlesh Bansal- First edition.
3. Instrumental methods of chemical analysis, Willard, Dean and Merittee- Sixth edition.
4. Analytical chemistry principles, John H Kenedey- 2nd edn, Saunders college publ.
5. Spectroscopic identification of organic compounds Silverstrine, Bassler, Morrill, 5th edn. John Wiley and sons.
6. Analytical chemistry, Ed by kellner. Mermet, otto, Valcarcel, Widmer, Second Ed., Wiley- VCH.
7. Vogel's Textbook of quantitative Chemical Analysis, Mendham, Denney, Barnes, Thomas, Sixth Ed ,Pub: Pearson Education.
8. Electron microscopy in the study of material, P.J Grundy and G.A.Jones, Edward Arnol

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Recent Advanced Characterization Technique **Course Code:** CHA-601-MJM

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Mapping of Course Outcomes with Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	0	0	0	0	0	0	0
CO2	2	2	0	0	0	0	2	0	0	0
CO3	0	0	3	0	0	0	0	0	0	0
CO4	0	2	0	2	0	0	0	0	0	0
CO5	0	0	0	0	3	0	0	0	0	0
CO6	0	2	0	0	0	2	0	0	0	0
CO7	0	2	0	0	0	0	2	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop a comprehensive understanding of advanced characterization techniques, including microscopy, electron spectroscopy, X-ray methods, and photoluminescence, within a multidisciplinary context.
CO2: Acquire practical skills in operating advanced instrumentation used in electron spectroscopy, such as ESCA, X-ray methods, and fluorescence spectroscopy, ensuring adherence to industry standards, regulations, and ethical considerations.
CO5: Apply research methodologies and ethical conduct in designing and conducting experiments using advanced characterization techniques, adhering to research ethics while reporting findings accurately and transparently.
CO6: Enhance communication, collaboration, and leadership skills by effectively presenting complex analytical information, collaborating in diverse teams for research projects, and demonstrating leadership qualities in analytical contexts.
CO7: Develop proficiency in utilizing digital tools and technological advancements relevant to advanced characterization techniques, accessing information sources, analyzing data using appropriate software, and adapting to emerging technologies in the field.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Acquire practical skills in operating advanced instrumentation used in electron spectroscopy, such as ESCA, X-ray methods, and fluorescence spectroscopy, ensuring adherence to industry standards, regulations, and ethical considerations.
CO4: Demonstrate specialized skills in critical thinking and problem-solving by analyzing and interpreting data obtained from advanced characterization techniques, effectively communicating findings, and adapting methodologies to address research questions.
CO6: Enhance communication, collaboration, and leadership skills by effectively presenting complex analytical information, collaborating in diverse teams for research projects, and demonstrating leadership qualities in analytical contexts.
CO7: Develop proficiency in utilizing digital tools and technological advancements relevant to advanced characterization techniques, accessing information sources, analyzing data using appropriate software, and adapting to emerging technologies in the field.

Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO3: Foster an entrepreneurial mindset by identifying opportunities for innovation in the application of advanced characterization techniques, understanding business principles relevant to analytical instrumentation, and exploring potential market applications.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO4: Demonstrate specialized skills in critical thinking and problem-solving by analyzing and interpreting data obtained from advanced characterization techniques, effectively communicating findings, and adapting methodologies to address research questions.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO5: Apply research methodologies and ethical conduct in designing and conducting experiments using advanced characterization techniques, adhering to research ethics while reporting findings accurately and transparently.
Communication, Collaboration, and Leadership (PO6):
CO6: Enhance communication, collaboration, and leadership skills by effectively presenting complex analytical information, collaborating in diverse teams for research projects, and demonstrating leadership qualities in analytical contexts.
Digital Proficiency and Technological Skills (PO7):
CO7: Develop proficiency in utilizing digital tools and technological advancements relevant to advanced characterization techniques, accessing information sources, analyzing data using appropriate software, and adapting to emerging technologies in the field.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme :M.Sc. Chemistry
Program Code :CHE
Class :M.Sc. II
Semester :III
Course Type :Mandatory Theory
Course Name :Pharmaceutical Analysis
Course Code :CHA-602-MJM
No. of Lectures :60 (48L+12T)
No. of Credits :4 credits

Course Objectives:

1. Develop proficiency in handling laboratory apparatus for pharmaceutical tests and assays, with a focus on proper cleaning of glassware.
2. Understand the definitions of drugs and cosmetics, substandard drugs, and the role of the FDA in pharmaceutical industries, particularly in the development and approval of new drugs.
3. Acquire skills in conducting biological assays, including tests for heparin sodium, amylase activity, photolytic activity, insulin, tetanus antitoxin, and undue toxicity.
4. Develop proficiency in microbiological tests for antibiotics, including standard preparation, assay designs, and tests for sterility.
5. Master physical tests and determinations, such as disintegration and dissolution tests, moisture content determination, limit tests for various substances, and various methods of sterilization.
6. Learn the techniques for sampling and analyzing vegetable drugs, including assessments of foreign organic matter, ash values, and alkaloid extraction.
7. Develop skills in the standardization and quality control of raw materials and dosage forms, including the analysis of raw materials for identification, related substances, loss on drying, and assay.

Course Outcomes:

CO1. Develop proficiency in handling and cleaning laboratory glassware, understanding the importance of maintaining cleanliness and accuracy in pharmaceutical analysis to ensure reliable results.
CO2. Gain insight into the regulatory role of the FDA in the pharmaceutical industry, including the process of new drug development, submission to regulatory authorities, stability studies, and shelf-life determination, ensuring compliance with regulatory standards.
CO3. Acquire knowledge and skills in conducting biological tests and assays, including the determination of activity for various pharmaceutical substances such as heparin sodium, amylase, photolytic activity, insulin, and tetanus antitoxin, ensuring the safety and efficacy of pharmaceutical products.
CO4. Demonstrate competence in microbiological testing methods for antibiotics, including standard preparation, assay design, cylinder-plate or cup-plate method, two-level fractional assay, and testing for sterility, ensuring the quality and effectiveness of pharmaceutical formulations.
CO5. Develop proficiency in conducting physical tests, determinations, limit tests, and sterilization methods for pharmaceutical products, including disintegration and dissolution tests, moisture content determination, limit tests for impurities, and various sterilization techniques, ensuring product quality and safety.
CO6. Understand the sources of impurities in pharmaceutical raw materials and finished products, including methods of manufacture, atmospheric and microbial contamination, and the effects of temperature and physical changes, enabling effective quality control and management of

pharmaceutical products throughout their shelf life.

CO7. Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.

Topics and Learning Points

Unit 1. **A) Apparatus for test and assay, cleaning of glassware** **(6 L)**

B) Role of FDA in Pharmaceutical Industries:

Definitions of Drug & Cosmetics, Substandard Drugs, Role of FDA, Introduction to New Drug, Development of New Drugs- Selection of Area Phase I, Phase II, Phase III Applications to FDA for formulation and marketing of new drug. Stability studies and Shelf life fixation.

Unit 2. **Biological Tests & Assay:** **(5 L)**

Introduction to biological assay, Biological assay of Heparin sodium, Determination of Amylase activity, Determination of Photolytic Activity, Test for Insulin in solution, Biological Assay of Tetanus Antitoxin, Test for Undue Toxicity.

Unit 3. **Microbiological Tests and Assays:** **(7 L)**

Microbiological test for Antibiotics. Standard preparation and units of activity, Test organisms and Inoculums, Cylinder-plate assay receptacles, Turbidimetric assay receptacles, Assay Designs, Cylinder plate or Cup-plate method, Two level fractional assay, Test for Sterility.

Unit 4. **Physical Test, Determinations, Limit tests and Sterilization:** **(6 L)**

A) Disintegration Test for Tablets and CapsulesB) Dissolution Test for Tablets and Capsules, C) moisture / water content by Karl-Fischer titration, limit tests for arsenic, heavy metals, iron, lead, sulphate, chloride, D) Ash, sulphated ash, E) Methods for Sterilization Steam Sterilization, Dry heat sterilization, Sterilization by Filtration, Gas Sterilization, Sterilization by Ionizing radiation, Sterilization by heating with Bactericides, Water for Pharmaceutical use.

Unit 5. **Analysis of vegetable Drugs** **(4 L)**

Vegetable drugs: Sampling, foreign organic matter, ash value, acid soluble ash, acid insoluble ash, sulphated ash, Extraction of alkaloids.

Unit 6. **Sources of Impurities in Pharmaceutical raw materials & finished products, Shelf life of pharmaceutical product:** **(5 L)**

Raw materials, Method of manufacture, Atmospheric contaminations, Cross contamination, Microbial contamination, Container contamination, Packaging errors, Chemical instability, Temperature effect and Physical changes, shelf life of pharmaceutical product and determination of shelf life.

Unit 7. Standardization and quality control of different raw materials and dosage form: (15 L)

Analysis of raw materials with respect to identification, other or related substances, loss on drying, and Assay as per IP, i) adrenaline, ii) paracetamol. Problems based on assay of these materials. Brief introduction to different dosage forms with the IP requirements Analytical methods for the following- Tablets, different types of tablets, uniformity in weight (aspirin) capsules, types of capsules, (Rifampicin) Powders (Sodium benzoate), Solutions (saline NaCl) Suspensions (barium sulphate –limit test for impurity) Mouthwashes, (Ointments (salicylic acid) and creams Dimethicone by IR) Injections (Mannitol), Aerosols (salbutamol), Problems based on assay of these materials.

References:

1. Indian Pharmacopeia, Volume I and II.
2. Practical Pharmaceutical chemistry, A.H.Beckett & J.B.Stenlake, third edition,volume 1.
3. Remington‘s Pharmaceutical sciences.
4. Ansel’s Pharmaceutical Analysis

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Pharmaceutical Analysis **Course Code:** CHA-602-MJM
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Mapping of Course Outcomes with Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	0	0	0	0	0	0	0	0
CO2	0	3	2	0	0	0	0	0	0	0
CO3	0	2	0	0	0	0	0	0	0	0
CO4	0	2	0	2	2	0	0	0	0	0
CO5	0	2	0	0	2	0	0	0	0	0
CO6	0	0	0	2	0	2	0	0	0	0
CO7	0	0	0	2	2	2	2	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop proficiency in handling and cleaning laboratory glassware, understanding the importance of maintaining cleanliness and accuracy in pharmaceutical analysis to ensure reliable results.
CO2: Gain insight into the regulatory role of the FDA in the pharmaceutical industry, including the process of new drug development, submission to regulatory authorities, stability studies, and shelf-life determination, ensuring compliance with regulatory standards.
CO3: Acquire knowledge and skills in conducting biological tests and assays, including the determination of activity for various pharmaceutical substances such as heparin sodium, amylase, photolytic activity, insulin, and tetanus antitoxin, ensuring the safety and efficacy of pharmaceutical products.
CO4: Demonstrate competence in microbiological testing methods for antibiotics, including standard preparation, assay design, cylinder-plate or cup-plate method, two-level fractional assay, and testing for sterility, ensuring the quality and effectiveness of pharmaceutical formulations.
CO5: Develop proficiency in conducting physical tests, determinations, limit tests, and sterilization methods for pharmaceutical products, including disintegration and dissolution tests, moisture content determination, limit tests for impurities, and various sterilization techniques, ensuring product quality and safety.
CO6: Understand the sources of impurities in pharmaceutical raw materials and finished products, including methods of manufacture, atmospheric and microbial contamination, and the effects of temperature and physical changes, enabling effective quality control and management of pharmaceutical products throughout their shelf life.
CO7: Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.
Practical, Professional, and Procedural Knowledge (PO2):
CO1: Develop proficiency in handling and cleaning laboratory glassware, understanding the importance of maintaining cleanliness and accuracy in pharmaceutical analysis to ensure reliable results.
CO3: Acquire knowledge and skills in conducting biological tests and assays, including the determination of activity for various pharmaceutical substances such as heparin sodium, amylase, photolytic activity, insulin, and tetanus antitoxin, ensuring the safety and efficacy of pharmaceutical

products.
CO4: Demonstrate competence in microbiological testing methods for antibiotics, including standard preparation, assay design, cylinder-plate or cup-plate method, two-level fractional assay, and testing for sterility, ensuring the quality and effectiveness of pharmaceutical formulations.
CO5: Develop proficiency in conducting physical tests, determinations, limit tests, and sterilization methods for pharmaceutical products, including disintegration and dissolution tests, moisture content determination, limit tests for impurities, and various sterilization techniques, ensuring product quality and safety.
CO6: Understand the sources of impurities in pharmaceutical raw materials and finished products, including methods of manufacture, atmospheric and microbial contamination, and the effects of temperature and physical changes, enabling effective quality control and management of pharmaceutical products throughout their shelf life.
CO7: Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.

Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):

CO2: Gain insight into the regulatory role of the FDA in the pharmaceutical industry, including the process of new drug development, submission to regulatory authorities, stability studies, and shelf-life determination, ensuring compliance with regulatory standards.

Specialized Skills, Critical Thinking, and Problem-Solving (PO4):

CO4: Demonstrate competence in microbiological testing methods for antibiotics, including standard preparation, assay design, cylinder-plate or cup-plate method, two-level fractional assay, and testing for sterility, ensuring the quality and effectiveness of pharmaceutical formulations.
CO5: Develop proficiency in conducting physical tests, determinations, limit tests, and sterilization methods for pharmaceutical products, including disintegration and dissolution tests, moisture content determination, limit tests for impurities, and various sterilization techniques, ensuring product quality and safety.
CO6: Understand the sources of impurities in pharmaceutical raw materials and finished products, including methods of manufacture, atmospheric and microbial contamination, and the effects of temperature and physical changes, enabling effective quality control and management of pharmaceutical products throughout their shelf life.
CO7: Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.

Research, Analytical Reasoning, and Ethical Conduct (PO5):

CO5: Develop proficiency in conducting physical tests, determinations, limit tests, and sterilization methods for pharmaceutical products, including disintegration and dissolution tests, moisture content determination, limit tests for impurities, and various sterilization techniques, ensuring product quality and safety.
CO7: Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.

Communication, Collaboration, and Leadership (PO6):

CO6: Understand the sources of impurities in pharmaceutical raw materials and finished products, including methods of manufacture, atmospheric and microbial contamination, and the effects of temperature and physical changes, enabling effective quality control and management of pharmaceutical products throughout their shelf life.
CO7: Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to

pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.

Digital Proficiency and Technological Skills (PO7):

CO7: Acquire skills in the standardization and quality control of different raw materials and dosage forms, including analysis methods for identification, assay, and impurity testing according to pharmacopeial standards, ensuring the quality, safety, and efficacy of pharmaceutical products in compliance with regulatory requirements.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Nameof theProgramme	**:**M.Sc.Chemistry
ProgramCode	**:**CHE
Class	**:**M.Sc.II
Semester	**:**III
Course Type	**:**Mandatory Practical
Course Name	**:**Instrumental methods of analysis
Course Code	**:**CHA-603-MJM
No. of Lectures	**:**30 (24L+6T)
No. of Credits	**:**2 credits

CourseObjectives:

1. Develop proficiency in determining the amount of each p-nitrophenol from a given sample using spectrophotometric titration.
2. Master the determination of the strength of phosphoric acid through potentiometric titration using a standard solution of sodium hydroxide.
3. Acquire skills in determining sodium (Na) and potassium (K) concentrations in a water sample using flame photometry, employing the binary/internal standard method.
4. Learn the method of determining boric acid concentration using conductometry.
5. Understand and apply the conductivity measurement method to determine the relative strength of acetic acid, chloroacetic acid, and trichloroacetic acid through measuring their Ka values.
6. Develop proficiency in determining the amount of copper and bismuth or copper and iron (III) from a given mixture using spectrophotometric titration with standard EDTA solution.
7. Master the pH metric titration technique for anthranilic acid and glycine with NaOH.

CourseOutcomes:

CO1. Develop proficiency in conducting spectrophotometric titrations to determine the amount of specific compounds in samples, demonstrating accurate analytical techniques and data interpretation skills.

CO2. Acquire practical skills in potentiometric titration methods using standard solutions, demonstrated through the determination of phosphoric acid strength and the application of sodium hydroxide titration.

CO3. Demonstrate competency in flame photometry for the determination of sodium and potassium concentrations in water samples using the binary method, showcasing proficiency in instrumental analysis techniques.

CO4. Understand the principles of conductometry and its application in the determination of boric acid concentration, showcasing the ability to perform analytical measurements using conductivity methods.

CO5. Gain knowledge of conductivity measurements for determining the relative strength of acids, exemplified by measuring the Ka values of acetic acid, chloroacetic acid, and trichloroacetic acid, demonstrating analytical reasoning and interpretation skills.

CO6. Develop expertise in spectrophotometric titration methods for the quantification of copper and bismuth in mixtures using standard EDTA solutions, demonstrating proficiency in analytical techniques and data analysis.

CO7. Acquire practical skills in spectrophotometry for determining the concentration of Riboflavin in samples, demonstrating the ability to apply spectroscopic methods for quantitative analysis.

Topics and Learning Points

1. To determine amount of each p-nitrophenol from the given sample by spectrophotometric titration.
2. Determination of strength of phosphoric acid by potentiometric titration using standard solution of sodium hydroxide.
3. Determination of Na and K from water sample by flame photometry binary method.
4. Determination of boric acid by conductometry.
5. Determination of relative strength of acetic acid, chloroacetic acid and trichloro acetic acid through measuring their Ka value by conductivity measurement method.
6. Determination of amount each copper and bismuth from given mixture by spectrophotometric titration using standard EDTA solution.
7. Determine the concentration of Riboflavin in the given sample by spectrophotometry.
8. P^H metric titration of anthranilic acid with NaOH.
9. Determination of commercial vinegar by potentiometric titration.
10. Analysis of alcohol from wine by GC.
11. Analysis of caffeine by spectrophotometric method
12. Analysis of paracetamol/metformin hydrochloride by HPLC
13. Determination of sulphate and chloride and turbidimetric method
14. Determination of sulphamethoxazole content in co-trimoxazole tablet.
15. Cyclic voltametric study of Fe(II)/Fe(III) system basic principles and calculation of basic parameters from CV
16. Estimation of heavy metals from waste water sample by AAS.
17. Determination of Ranitidine content in tablet.

I) Report on Industrial Visit

References:

1. Lab manual: selected experiments of pharmaceutical analysis, Anees A Siddiqui.
2. Experiments in chemistry, D.V.Jahagirdar.
3. Pharmacopeia of India
4. Vogel's textbook of quantitative chemical analysis, sixth Ed.
5. Environmental chemistry by A.K.De.
6. Biochemical methods, Sadashivam and Manickem, Narosa publication
7. Senior practical physical chemistry. B.D. Khosla and V.S. Garge (R.Chand and Co).
8. Analytical chemistry by Gary Christian, 6th edition, 2008

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Instrumental Methods of Analysis **Course Code:** CHA-603-MJM

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Mapping of Course Outcomes with Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	0	3	0	0	0	0	0	0
CO2	3	3	0	3	0	0	0	0	0	0
CO3	3	3	0	3	0	0	0	0	0	0
CO4	3	3	0	3	0	0	0	0	0	0
CO5	3	3	0	3	0	0	0	0	0	0
CO6	3	3	0	3	0	0	0	0	0	0
CO7	3	3	0	3	0	0	0	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):

CO1: Develop proficiency in conducting spectrophotometric titrations to determine the amount of specific compounds in samples, demonstrating accurate analytical techniques and data interpretation skills.

CO2: Acquire practical skills in potentiometric titration methods using standard solutions, demonstrated through the determination of phosphoric acid strength and the application of sodium hydroxide titration.

CO3: Demonstrate competency in flame photometry for the determination of sodium and potassium concentrations in water samples using the binary method, showcasing proficiency in instrumental analysis techniques.

CO4: Understand the principles of conductometry and its application in the determination of boric acid concentration, showcasing the ability to perform analytical measurements using conductivity methods.

CO5: Gain knowledge of conductivity measurements for determining the relative strength of acids, exemplified by measuring the Ka values of acetic acid, chloroacetic acid, and trichloroacetic acid, demonstrating analytical reasoning and interpretation skills.

CO6: Develop expertise in spectrophotometric titration methods for the quantification of copper and bismuth in mixtures using standard EDTA solutions, demonstrating proficiency in analytical techniques and data analysis.

CO7: Acquire practical skills in spectrophotometry for determining the concentration of Riboflavin in samples, demonstrating the ability to apply spectroscopic methods for quantitative analysis.

Practical, Professional, and Procedural Knowledge (PO2):

CO1: Develop proficiency in conducting spectrophotometric titrations to determine the amount of specific compounds in samples, demonstrating accurate analytical techniques and data interpretation skills.

CO2: Acquire practical skills in potentiometric titration methods using standard solutions, demonstrated through the determination of phosphoric acid strength and the application of sodium hydroxide titration.

CO3: Demonstrate competency in flame photometry for the determination of sodium and potassium concentrations in water samples using the binary method, showcasing proficiency in instrumental analysis techniques.

CO4: Understand the principles of conductometry and its application in the determination of boric acid concentration, showcasing the ability to perform analytical measurements using conductivity methods.

CO5: Gain knowledge of conductivity measurements for determining the relative strength of acids,

exemplified by measuring the Ka values of acetic acid, chloroacetic acid, and trichloroacetic acid, demonstrating analytical reasoning and interpretation skills.
CO6: Develop expertise in spectrophotometric titration methods for the quantification of copper and bismuth in mixtures using standard EDTA solutions, demonstrating proficiency in analytical techniques and data analysis.
CO7: Acquire practical skills in spectrophotometry for determining the concentration of Riboflavin in samples, demonstrating the ability to apply spectroscopic methods for quantitative analysis..

Specialized Skills, Critical Thinking, and Problem-Solving (PO4):

CO1: Develop proficiency in conducting spectrophotometric titrations to determine the amount of specific compounds in samples, demonstrating accurate analytical techniques and data interpretation skills.
CO2: Acquire practical skills in potentiometric titration methods using standard solutions, demonstrated through the determination of phosphoric acid strength and the application of sodium hydroxide titration.
CO3: Demonstrate competency in flame photometry for the determination of sodium and potassium concentrations in water samples using the binary method, showcasing proficiency in instrumental analysis techniques.
CO4: Understand the principles of conductometry and its application in the determination of boric acid concentration, showcasing the ability to perform analytical measurements using conductivity methods.
CO5: Gain knowledge of conductivity measurements for determining the relative strength of acids, exemplified by measuring the Ka values of acetic acid, chloroacetic acid, and trichloroacetic acid, demonstrating analytical reasoning and interpretation skills.
CO6: Develop expertise in spectrophotometric titration methods for the quantification of copper and bismuth in mixtures using standard EDTA solutions, demonstrating proficiency in analytical techniques and data analysis.
CO7: Acquire practical skills in spectrophotometry for determining the concentration of Riboflavin in samples, demonstrating the ability to apply spectroscopic methods for quantitative analysis.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc.II
Semester	**:**III
Course Type	**:**Major Practical
Course Name	**:**Analysis of pharmaceutical and food samples
Course Code	**:**CHA-604-MJM
No .of Lectures	**:**30 (24L+6T)
No. of Credits	**:**2 credits

Course Objectives:

1. Develop skills in chromatographic separation andidentification techniques.
2. Acquire competency in various analytical methods for compound analysis.
3. Develop proficiency in quantitative analysis techniques for determining compound concentrations.
4. Master the principles and applications of spectrophotometry in compound analysis.
5. Gain proficiency in titration methods for determining compound concentrations and properties.
6. Develop competency in chemical analysistechniques for compound identification and quantification.
7. Master various laboratory techniques for sample preparation, analysis, and data interpretation.

Course Outcomes (COs):

CO1. Demonstrate proficiency in performing analytical techniques accurately and efficiently.
CO2. Develop competency in interpreting analytical data and drawing meaningful conclusions.
CO3. Demonstrate proficiency in conducting experiments, recording data, and analyzing results.
CO4. Master quantitative analysis methods for precise determination of compound concentrations.
CO5. Demonstrate proficiency in spectrophotometric techniques for compound analysis.
CO6. Acquire competence in titration methods for accurate determination of compound properties.
CO7. Demonstrate proficiency in applying various laboratory techniques effectively and safely.

Topicsand Learning Points

1. Chromatographic separation and identification of sugars/ aminoacid
2. Estimation of total carbohydrates by anthrone method.
3. Assay of thiamine from a given sample.
4. Analysis of quinine sulfate from the given tablet by photo fluorometry.
5. Estimation of tannin from a given sample.
6. Analysis of caffeine from given tablet as per IP with respect to identification, and assay.
7. Estimation of protein from food sample by Lowry method.
8. Analysis of paracetamol as per IP with respect to Identification, and assay.
9. Estimation of Fe from syrup sample by spectrophotometric method.
10. Estimation of HMF from honey.
11. Estimation of reducing sugar from food sample by spectrophotometry.
12. Determination of total acidity in juice.
13. Determination of glucose from gluconD by titration with the Fehling method.
14. Moisture content in pharmaceutical/food sample by Karl Fischer titration method
15. Determination of adulterants in milk.
16. Estimation of lycopene from food sample.
17. Determination of glucose from blood sample by using glucose oxidase method.

References:

1. Lab manual: selected experiments of pharmaceutical analysis, Anees A Siddiqui.
2. Experiments in chemistry, D.V.Jahagirdar.
3. Pharmacopeia of India
4. Vogel's textbook of quantitative chemical analysis, sixth Ed.
5. Environmental chemistry by A.K.De.
6. Biochemical methods, Sadashivam and Manickem, Narosa publication
7. Senior practical physical chemistry. B.D. Khosla and V.S. Garge (R. Chand and Co. Delhi)
8. Practical pharmaceutical chemistry 4th Ed .Part -2, Beckette, Stenlake.
9. Practical clinical biochemistry, Harold Varley (4th edition) , CBS publishers and distributers, New Delhi-110002
10. Analytical chemistry by Gary Christian, 6th edition, 2008

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Analysis of pharmaceutical and food samples **Course Code:** CHA-604-MJM
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

Mapping of Course Outcomes with Program Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	1	2	3	1	1	1	0	1	3
CO2	0	2	3	1	1	1	0	1	1	2
CO3	1	0	2	2	2	2	0	2	1	3
CO4	2	1	1	3	2	2	0	0	0	3
CO5	2	0	0	3	2	1	1	0	1	3
CO6	1	2	2	3	1	3	0	0	1	3
CO7	0	2	1	1	1	2	0	0	1	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop proficiency in chromatographic techniques for the separation and identification of sugars and amino acids, enhancing skills in chromatographic analysis methods for complex organic mixtures.
CO3: Gain expertise in the assay of thiamine from a given sample, employing appropriate analytical techniques to determine the concentration of thiamine in organic compounds.
CO4: Understand and apply photo fluorometry for the analysis of quinine sulphate from tablets, developing proficiency in spectroscopic methods for pharmaceutical analysis.
CO5: Develop skills in the estimation of tannin from samples, utilizing appropriate chemical methods for the quantification of tannin content in organic materials.
CO6: Acquire practical knowledge in the analysis of caffeine from tablets as per IP standards, including identification and assay procedures, enhancing expertise in pharmaceutical analysis techniques.

Practical, Professional, and Procedural Knowledge (PO2):
CO2: Acquire practical skills in the anthrone method for the estimation of total carbohydrates, enabling accurate quantification of carbohydrate content in various samples through colorimetric analysis.
CO7: Gain proficiency in the Lowry method for the estimation of protein content in food samples, employing colorimetric analysis to determine protein concentrations accurately.

Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO3: Gain expertise in the assay of thiamine from a given sample, employing appropriate analytical techniques to determine the concentration of thiamine in organic compounds.

Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO1: Develop proficiency in chromatographic techniques for the separation and identification of sugars and amino acids, enhancing skills in chromatographic analysis methods for complex organic mixtures.
CO2: Acquire practical skills in the anthrone method for the estimation of total carbohydrates, enabling accurate quantification of carbohydrate content in various samples through colorimetric analysis.
CO3: Gain expertise in the assay of thiamine from a given sample, employing appropriate analytical techniques to determine the concentration of thiamine in organic compounds.
CO4: Understand and apply photo fluorometry for the analysis of quinine sulphate from tablets, developing proficiency in spectroscopic methods for pharmaceutical analysis.
CO5: Develop skills in the estimation of tannin from samples, utilizing appropriate chemical methods for the quantification of tannin content in organic materials.

CO6: Acquire practical knowledge in the analysis of caffeine from tablets as per IP standards, including identification and assay procedures, enhancing expertise in pharmaceutical analysis techniques.
CO7: Gain proficiency in the Lowry method for the estimation of protein content in food samples, employing colorimetric analysis to determine protein concentrations accurately.

Research, Analytical Reasoning, and Ethical Conduct (PO5):

CO4: Understand and apply photo fluorometry for the analysis of quinine sulphate from tablets, developing proficiency in spectroscopic methods for pharmaceutical analysis.
CO5: Develop skills in the estimation of tannin from samples, utilizing appropriate chemical methods for the quantification of tannin content in organic materials.
CO6: Acquire practical knowledge in the analysis of caffeine from tablets as per IP standards, including identification and assay procedures, enhancing expertise in pharmaceutical analysis techniques.
CO7: Gain proficiency in the Lowry method for the estimation of protein content in food samples, employing colorimetric analysis to determine protein concentrations accurately.

Communication, Collaboration, and Leadership (PO6):

CO6: Acquire practical knowledge in the analysis of caffeine from tablets as per IP standards, including identification and assay procedures, enhancing expertise in pharmaceutical analysis techniques.
CO7: Gain proficiency in the Lowry method for the estimation of protein content in food samples, employing colorimetric analysis to determine protein concentrations accurately.

Digital Proficiency and Technological Skills (PO7):

CO9: Develop expertise in spectrophotometric methods for the estimation of iron (Fe) content in syrup samples, enhancing skills in quantitative analysis using spectroscopic techniques.
CO10: Acquire practical skills in the estimation of Hydroxymethylfurfural (HMF) from honey samples, utilizing appropriate analytical methods for the quantification of HMF levels in food products.
CO11: Understand and apply spectrophotometric methods for the estimation of reducing sugars in food samples, employing colorimetric analysis techniques to quantify reducing sugar concentrations accurately.

Value Inculcation, Environmental Awareness, and Ethical Practices (PO9):

CO5: Develop skills in the estimation of tannin from samples, utilizing appropriate chemical methods for the quantification of tannin content in organic materials.
CO7: Gain proficiency in the Lowry method for the estimation of protein content in food samples, employing colorimetric analysis to determine protein concentrations accurately.

Autonomy, Responsibility, and Accountability (PO10):

CO1: Develop proficiency in chromatographic techniques for the separation and identification of sugars and amino acids, enhancing skills in chromatographic analysis methods for complex organic mixtures.
CO3: Gain expertise in the assay of thiamine from a given sample, employing appropriate analytical techniques to determine the concentration of thiamine in organic compounds.
CO4: Understand and apply photo fluorometry for the analysis of quinine sulfate from tablets, developing proficiency in spectroscopic methods for pharmaceutical analysis.
CO5: Develop skills in the estimation of tannin from samples, utilizing appropriate chemical methods for the quantification of tannin content in organic materials.
CO6: Acquire practical knowledge in the analysis of caffeine from tablets as per IP standards, including identification and assay procedures, enhancing expertise in pharmaceutical analysis techniques.
CO7: Gain proficiency in the Lowry method for the estimation of protein content in food samples, employing colorimetric analysis to determine protein concentrations accurately.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc.II
Semester	**:**III
Course Type	**:**Elective theory
Course Name	**:**Electrochemical methods
Course Code	**:**CHA-611-MJE(A)
No.of Lectures	**:**30 (24L+6T)
No.of Credits	**:**2 credits

Course Objectives:

1. Grasp the principles and methods of coulometric analysis, including instrumentation and applications.
2. Develop proficiency in voltametric and polarographic methods, including principles, instrumentation, and applications in qualitative and quantitative analysis.
3. Understand and apply different excitation signals in pulse polarography, including differential pulse polarography and square wave polarography, for analytical purposes.
4. Gain expertise in cyclic voltammetry, including understanding the principles, interpreting voltammograms, and recognizing reversible and irreversible electrochemical reactions.
5. Acquire practical knowledge of amperometry techniques, including instrumentation, typical applications, and their role in titrations and chronoamperometry.
6. Develop proficiency in operating and understanding the instrumentation used in coulometry, voltammetry, polarography, and amperometry.
7. Develop problem-solving skills by addressing challenges related to electrolysis, electrode potential control, and interpreting electrochemical data in various analytical contexts.

Course Outcomes:

CO1. Develop a comprehensive understanding of coulometric methods, including the current-voltage relationship during electrolysis, Faraday's laws, and instrumentation techniques for constant current and constant voltage coulometry.

CO2. Acquire proficiency in voltammetry and polarographic methods, encompassing principles, instrumentation, and applications such as polarography, hydrodynamic voltametry, pulse polarography, and cyclic voltammetry.

CO3. Gain practical skills in polarography, including the interpretation of polarograms, factors affecting polarographic waves, and the application of polarographic methods in qualitative and quantitative analysis of various analytes.

CO4. Understand the principles and applications of hydrodynamic voltametry, including its use in chromatography, flow injection analysis, and amperometric titration, enhancing analytical capabilities in electrochemical analysis.

CO5. Develop expertise in pulse polarography techniques, including differential pulse polarography, square wave polarography, and stripping methods, enabling the analysis of various analytes such as heavy metals and organic compounds.

CO6. Acquire knowledge of cyclic voltammetry principles and its applications, including the

interpretation of cyclic voltammograms, criteria for reversibility of electrochemical reactions, and the differentiation between reversible and irreversible processes.

CO7. Gain proficiency in amperometry, including its principles, instrumentation, typical applications, and its use in amperometric titrations, chronoamperometry, and chrono-potentiometry, enhancing skills in electrochemical analysis techniques.

Topics and Learning Points

Unit 1. Coulometry (6 L)

Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, Electrolysis at constant working electrode potential, Coulometric methods of analysis, Faradays laws of electrolysis, Instrumentations-Constant current and constant voltage instruments, potentiostatic coulometry-Instrumentation and applications, coulometric titrations (Amperostatic coulometry)-Apparatus and applications, advantages and limitations, problems.

Unit 2. Voltammetry and polarographic methods of analysis (14 L)

A) Polarography (linear scan polarography): Polarographic principles, Instrumentation (different types of microelectrode such as dropping mercury electrode, the static drop mercury electrode, rotating disc and ring disc electrode, cell for polarography, reference and counter electrode and circuit diagram), polarogram and polarographic currents, charging or capacitive current, role of supporting electrolyte, factors affecting on polarographic wave, Ikavic Equation, advantages and disadvantages of DME, polarographic maxima and maxima suppressors, interference due to dissolved oxygen, Applications (qualitative analysis, quantitative analysis by calibration curve and standard addition methods), specific examples of analysis – analysis of Cu, Cd, Zn, Pb, etc. from tap water and alloys., problems.

B) Hydrodynamic Voltametry and its applications:

Volatametric detectors in chromatography, flow injection analysis, Volatametric oxygen sensors, amperometric titration).

C) Pulse Polarography:

Different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, Stripping method. VoltametryWithultra microelectrode, Applications of these technique 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.

D) Cyclic Voltametry:

Principle of cyclic Voltammetry, cyclic voltamogram of K3[Fe(CN)6] and parathion, criteria of reversibility of electrochemical reactions, quasireversible and irreversible processes.

Unit 3. Amperometry: (4 L)

Principle, Instrumentation, typical applications, amperometry titrations, chronoamperometry and chrono-potentiometry

References:

1. Biochemical Methods, S Sadashivan, A.Manickam; New Age Publication, 3rd Edn
2. Introduction to instrumental analysis, R. D. Broun, Mc Graw Hill (1987)
3. Instrumental methods of chemical analysis, H. willard, L.Merrit, J.A. Dean andF.A.Settle. Sixth edition CBS (1986)
4. Fundamentals of analytical chemistry, D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992)
5. Principles of Instrumental Analysis, Skoog, West, Niemann.
6. Vogel Text Book of quantitative analysis 6th Ed.
7. J. chemical education, 60,302 to 308 (1983)
8. Cyclic Voltammetry and frontiers of electrochemistry, N.Noel and K.I. Vasu IBH, New Delhi (1990)

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Electrochemical Methods **Course Code:** CHA-611-MJE(A)
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

(Cos)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	3	0	0	0	0	0	0
CO2	3	0	0	3	0	0	0	0	0	0
CO3	3	1	0	0	0	0	0	0	0	0
CO4	1	0	0	3	0	0	0	0	0	0
CO5	1	0	0	3	0	0	0	0	0	0
CO6	1	0	0	3	0	0	0	0	0	0
CO7	1	1	0	3	0	0	0	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):

CO1: Develop a comprehensive understanding of coulometric methods, including the current-voltage relationship during electrolysis, Faraday's laws, and instrumentation techniques for constant current and constant voltage coulometry.

CO2: Acquire proficiency in voltammetry and polarographic methods, encompassing principles, instrumentation, and applications such as polarography, hydrodynamic voltametry, pulse polarography, and cyclic voltammetry.

CO3: Gain practical skills in polarography, including the interpretation of polarograms, factors affecting polarographic waves, and the application of polarographic methods in qualitative and quantitative analysis of various analytes.

CO4: Understand the principles and applications of hydrodynamic voltametry, including its use in chromatography, flow injection analysis, and amperometric titration, enhancing analytical capabilities in electrochemical analysis.

CO5: Develop expertise in pulse polarography techniques, including differential pulse polarography, square wave polarography, and stripping methods, enabling the analysis of various analytes such as heavy metals and organic compounds.

CO6: Acquire knowledge of cyclic voltammetry principles and its applications, including the interpretation of cyclic voltammograms, criteria for reversibility of electrochemical reactions, and the differentiation between reversible and irreversible processes.

CO7: Gain proficiency in amperometry, including its principles, instrumentation, typical applications, and its use in amperometric titrations, chronoamperometry, and chrono-potentiometry, enhancing skills in electrochemical analysis techniques.

Practical, Professional, and Procedural Knowledge (PO2):

CO3: Gain practical skills in polarography, including the interpretation of polarograms, factors affecting polarographic waves, and the application of polarographic methods in qualitative and quantitative analysis of various analytes.

CO7: Gain proficiency in amperometry, including its principles, instrumentation, typical applications, and its use in amperometric titrations, chronoamperometry, and chrono-potentiometry, enhancing skills in electrochemical analysis techniques.

Specialized Skills, Critical Thinking, and Problem-Solving (PO4):

CO1: Develop a comprehensive understanding of coulometric methods, including the current-voltage relationship during electrolysis, Faraday's laws, and instrumentation techniques for constant current and constant voltage coulometry.

CO2: Acquire proficiency in voltammetry and polarographic methods, encompassing principles,

instrumentation, and applications such as polarography, hydrodynamic voltametry, pulse polarography, and cyclic voltammetry.
CO4: Understand the principles and applications of hydrodynamic voltametry, including its use in chromatography, flow injection analysis, and amperometric titration, enhancing analytical capabilities in electrochemical analysis.
CO5: Develop expertise in pulse polarography techniques, including differential pulse polarography, square wave polarography, and stripping methods, enabling the analysis of various analytes such as heavy metals and organic compounds.
CO6: Acquire knowledge of cyclic voltammetry principles and its applications, including the interpretation of cyclic voltammograms, criteria for reversibility of electrochemical reactions, and the differentiation between reversible and irreversible processes.
CO7: Gain proficiency in amperometry, including its principles, instrumentation, typical applications, and its use in amperometric titrations, chronoamperometry, and chrono-potentiometry, enhancing skills in electrochemical analysis techniques.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Nameof theProgramme	**:**M.Sc.Chemistry
Program Code	**:**CHE
Class	**:**M.Sc.II
Semester	**:**III
Course Type	**:**Elective theory
Course Name	**:**Food Analysis
Course Code	**:**CHA-611-MJE (B)
No. of Lectures	**:**30 (24L+6T)
No. of Credits	**:**2 credits

Course Objectives:

1. Gain knowledge of the definition, classification, and functions of carbohydrates, along with the various methods for their analysis in food samples.
2. Develop proficiency in protein analysis techniques, including Kjeldahl's method, Lowry method, and colorimetric estimation of amino acids, to assess protein content and quality.
3. Acquire skills in lipid analysis, including the estimation of oil content in oilseeds, determination of saponification value, iodine value, acid value, peroxide value, and identification of fatty acids.
4. Understand the definition and legislation related to food preservatives, including SO2, nitrate, nitrites, boric acid, benzoic acid, 4-hydroxybenzoate, and ascorbic acid, and learn methods for their determination.
5. Develop proficiency in analytical techniques such as volumetric determination, colorimetric analysis, gravimetric analysis, and spectrophotometry for the quantification of carbohydrates, proteins, lipids, and food preservatives.
6. Apply analytical methods to assess the quality and safety of food products, including the determination of methionine content, protein digestibility, and the identification of sweeteners and colors.
7. A comprehensive understanding of food analysis techniques, including their principles, instrumentation, limitations, and applications in food quality control and safety assessment.

Course Outcomes:

CO1. Demonstrate proficiency in analysing carbohydrates in food samples using various methods such as volumetric determination, colorimetric analysis, and gravimetric methods.

CO2. Assess protein content accurately in food samples using Kjeldahl's method, Lowry method, and colorimetric estimation techniques, ensuring food quality and nutritional value.

CO3. Analyse lipid composition in food samples by determining oil content, saponification value, iodine value, acid value, peroxide value, and identifying fatty acids, contributing to nutritional and safety evaluations.

CO4. Ensure compliance with food safety regulations by accurately determining the levels of preservatives such as SO_2, nitrate, nitrites, boric acid, benzoic acid, and ascorbic acid in food products.

CO5. Apply analytical skills to address real-world challenges in food analysis, including assessing the quality, safety, and nutritional composition of various food products.

CO6. Implement quality control measures through the accurate quantification of food components, ensuring adherence to quality standards and regulations.

CO7. Critically analyse analytical data and interpret results effectively to make informed decisions regarding food quality, safety, and compliance with regulatory standards.

Topicsand Learning Points

Unit 1. Carbohydrates: (7L)

Definition, classification, and functions, Analysis of carbohydrates from food sample by different method

i) volumetric determination by Fehling's solution, ii) Colorimetric analysis of carbohydrates by Folin Wu method, Nelson Somyogi method, iii) total carbohydrates by Anthrone method, iv) Estimation of starch by anthrone method, v) Determination of amylase, vi) Estimation of pectic substances (gravimetric and colorimetric method), vii) Estimation of crude fibers

Unit 2. Proteins: (6 L)

Definitions and functions, Analysis of proteins by Kjedahl's method, analysis of protein by Lowry method, Estimation of amino acids by colorimetric method, Estimation of food grain for methionine content, Protein digestibility in vitro, Protein efficiency and net protein ratio, Determination of net protein utilization, digestibility and biological value.

Unit 3. Analysis of Lipids (4 L)

Estimation of oil in oilseeds, Estimation of free fatty acids, Saponification value of oils, iodine value, Determination of acid value of oil, determination of peroxide value of oil, Identification and quantification of fatty acids.

Unit 4. Determination of food preservatives: (7 L)

Definition, SO2 legislation and determination by Tanners method, Nitrate and nitrites legislation and determination, boric acid legislation and determination, Benzoic acid legislation and determination, 4-hydroxybenzoate legislation and determination, ascorbic acid legislation and determination. Sweeteners: Saccharine identification and determination, Colors: Identification by general methods, Natural colors.

References:

1. Biochemical Methods, S Sadashivan, A.Manickam; New Age Publication, 3rd Edn
2. Introduction to instrumental analysis, R. D. Broun, Mc Graw Hill (1987)
3. Instrumental methods of chemical analysis, H. willard, L.Merrit, J.A. Dean andF.A.Settle. Sixth edition CBS (1986)
4. Fundamentals of analytical chemistry, D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992)
5. Principles of Instrumental Analysis, Skoog, West, Niemann.
6. Vogel Text Book of quantitative analysis 6th Ed.
7. J. chemical education, 60,302 to 308 (1983)
8. Cyclic Voltammetry and frontiers of electrochemistry, N.Noel and K.I. Vasu IBH, New Delhi (1990)

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Food Analysis **Course Code:** CHA-611-MJE (B)

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

(COs)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	0	0	0	0	0	0	0
CO2	0	0	0	3	0	0	0	0	0	0
CO3	0	0	3	0	0	0	0	0	0	0
CO4	0	0	0	3	0	0	0	0	0	0
CO5	0	0	0	0	3	0	0	0	0	0
CO6	0	0	0	0	0	3	0	0	0	0
CO7	0	0	0	0	0	0	0	0	0	3

Justification of Mapping

Comprehensive Knowledge and Understanding:
CO1: Demonstrate proficiency in analysing carbohydrates in food samples using various methods such as volumetric determination, colorimetric analysis, and gravimetric methods.

Entrepreneurial Mindset, Innovation, and Business Understanding:

CO3: Analyse lipid composition in food samples by determining oil content, saponification value, iodine value, acid value, peroxide value, and identifying fatty acids, contributing to nutritional and safety evaluations.

Specialized Skills, Critical Thinking, and Problem-Solving:

CO2: Assess protein content accurately in food samples using Kjeldahl's method, Lowry method, and colorimetric estimation techniques, ensuring food quality and nutritional value.

CO4: Ensure compliance with food safety regulations by accurately determining the levels of preservatives such as SO_2, nitrate, nitrites, boric acid, benzoic acid, and ascorbic acid in food products.

Research, Analytical Reasoning, and Ethical Conduct:

CO5: Apply analytical skills to address real-world challenges in food analysis, including assessing the quality, safety, and nutritional composition of various food products.

Communication, Collaboration, and Leadership:

Implement quality control measures through the accurate quantification of food components, ensuring adherence to quality standards and regulations.

Autonomy, Responsibility, and Accountability:

CO7: Critically analyse analytical data and interpret results effectively to make informed decisions regarding food quality, safety, and compliance with regulatory standards.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**III
Course Type	**:**Elective Practical
Course Name	**:**Instrumental Analysis
Course Code	**:**CHA-612-MJE(A)
No. of Lectures	**:**30 (24L+6T)
No. of Credits	**:**2 credits

Course Objectives:

1. Develop proficiency in flame photometry for the determination of sodium (Na) and potassium (K) in water samples using the internal standard method, ensuring accurate and precise quantification.
2. Acquire skills in spectrophotometric titration techniques for the simultaneous determination of copper and iron (III) in mixtures using standard EDTA solution, demonstrating competency in analytical methods.
3. Gain proficiency in the spectrophotometric analysis of caffeine in various samples, understanding the principles and techniques involved in quantitative caffeine determination.
4. Understand the principles of cyclic voltammetry through the study of the cyclic voltammogram of $K_3[Fe(CN)_6]$, allowing for the interpretation of electrochemical behavior and redox processes.
5. Develop skills in the determination of iron content in detergent samples using suitable analytical methods, ensuring compliance with quality standards and regulations.
6. Enhance proficiency in interpreting IR, NMR, and UV-Visible spectra through table work, enabling the identification and characterization of chemical compounds.
7. Learn the Molybdenum Blue Method for the determination of phosphoric acid in cold drinks, ensuring accurate assessment of phosphoric acid co ntent for quality control purposes.

Course Outcomes:

CO1. Develop a profound understanding of various instrumental analysis techniques and their principles, including flame photometry, spectrophotometry, cyclic voltammetry, potentiometric titration, and turbidimetric method. Gain insight into the application of instrumental methods for quantitative analysis and determination of chemical species in complex matrices.

CO2. Acquire practical skills in operating instrumentation such as flame photometer, spectrophotometer, potentiometer, and conductometer for accurate chemical analysis.Understand the professional protocols and procedural techniques involved in instrumental analysis, ensuring adherence to industry standards and regulatory requirements.

CO3. Develop proficiency in interpreting instrumental data, analyzing experimental results, and troubleshooting instrumental issues.Cultivate critical thinking skills to select appropriate analytical techniques and methodologies for specific sample matrices and analyte concentrations.

CO4. Apply analytical reasoning to design and conduct experiments for chemical analysis,

employing instrumental methods with precision and accuracy.Uphold ethical standards in data collection, analysis, and reporting, ensuring integrity and reliability in scientific research and experimentation.

CO5. Effectively communicate analytical findings, experimental methodologies, and results to peers, stakeholders, and industry professionals.Collaborate with team members in laboratory settings, demonstrating leadership qualities in coordinating analytical activities and problem-solving.

CO6. Demonstrate proficiency in utilizing advanced instrumentation software for data acquisition, processing, and analysis.Adapt to technological advancements in instrumental analysis, leveraging digital tools and techniques to enhance analytical capabilities.

CO7. Work autonomously in laboratory settings, demonstrating responsibility and accountability in conducting instrumental analysis experiments. Manage instrumental analysis projects effectively, demonstrating initiative and proactive problem-solving to ensure project completion within specified timelines and quality standards.

Topics and Learning Points

1. Determination of Na and K from water sample by flame photometry internal standard method
2. Determination of amount each copper and iron (III) from given mixture by spectrophotometric titration using standard EDTA solution
3. Analysis of caffeine by Spectrophotometric method.
4. Study of cyclic voltammogram of k3[fe(CN)6].
5. Determination of Iron in Detergents sample.
6. Table work for IR- Spectra, NMR, UV- Visible spectra.
7. To determine Phosphoric Acid in Cold Drink by Molybdenum Blue Method .
8. Determination of Commercial Vinegar by Potentiometric Titration method .
9. Analysis of Rock salt for Chloride content by Conductometric Titration method.
10. Determination of Copper and Zinc in Brass alloy by Polarography.
11. Determination of Sulphate and Chloride by Turbidimetric Method.
12. Determination of Calcium from Plaster of Paris.
13. Estimation of glucose from blood sample by using glucose oxidase method.
14. Determination of cholesterol from serum sample by kit method.
15. Magnetic susceptibility - $MnSO_4$.
16. Determination of Sulphur content in Sulphur fungicide.
17. Determination of alcohol from given sample by spectrophotometry.

References:

1. Lab manual: selected experiments of pharmaceutical analysis, Anees A Siddiqui.
2. Experiments in chemistry, D.V.Jahagirdar.
3. Pharmacopeia of India
4. Vogel’s textbook of quantitative chemical analysis, sixth Ed.
5. Environmental chemistry by A.K.De.
6. Biochemical methods, Sadashivam and Manickem, Narosa publication
7. Senior practical physical chemistry. B.D. Khosla and V.S. Garge (R. Chand and Co. Delhi)
8. Practical pharmaceutical chemistry 4th Ed .Part -2, Beckette, Stenlake.
9. Practical clinical biochemistry, Harold Varley (4th edition) , CBS publishers and distributers, New Delhi-110002
10. Analytical chemistry by Gary Christian, 6th edition, 2008

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Instrumental Analysis **Course Code:** CHA-612-MJE (A)
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	0	0	0	0	0	0	0
CO2	0	3	0	0	0	0	0	0	0	0
CO3	0	0	0	3	0	0	0	0	0	0
CO4	0	0	0	3	0	0	0	0	3	3
CO5	0	0	0	0	3	0	0	0	0	0
CO6	0	0	0	0	0	3	3	0	0	0
CO7	0	0	0	0	0	0	3	0	3	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop a profound understanding of various instrumental analysis techniques and their principles, including flame photometry, spectrophotometry, cyclic voltammetry, potentiometric titration, and turbidimetric method. Gain insight into the application of instrumental methods for quantitative analysis and determination of chemical species in complex matrices.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Acquire practical skills in operating instrumentation such as flame photometer, spectrophotometer, potentiometer, and conductometer for accurate chemical analysis. Understand the professional protocols and procedural techniques involved in instrumental analysis, ensuring adherence to industry standards and regulatory requirements.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO3: Develop proficiency in interpreting instrumental data, analyzing experimental results, and troubleshooting instrumental issues. Cultivate critical thinking skills to select appropriate analytical techniques and methodologies for specific sample matrices and analyte concentrations.
CO4: Apply analytical reasoning to design and conduct experiments for chemical analysis, employing instrumental methods with precision and accuracy. Uphold ethical standards in data collection, analysis, and reporting, ensuring integrity and reliability in scientific research and experimentation.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO5: Effectively communicate analytical findings, experimental methodologies, and results to peers, stakeholders, and industry professionals. Collaborate with team members in laboratory settings, demonstrating leadership qualities in coordinating analytical activities and problem-solving.
Communication, Collaboration, and Leadership (PO6):
CO5: Collaborate with team members in laboratory settings, demonstrating leadership qualities in coordinating analytical activities and problem-solving.
Digital Proficiency and Technological Skills (PO7):
CO6: Demonstrate proficiency in utilizing advanced instrumentation software for data acquisition, processing, and analysis. Adapt to technological advancements in instrumental analysis, leveraging digital tools and techniques to enhance analytical capabilities.
Value Inculcation, Environmental Awareness, and Ethical Practices (PO9):
CO4: Uphold ethical standards in data collection, analysis, and reporting, ensuring integrity and reliability in scientific research and experimentation.
CO7: Work autonomously in laboratory settings, demonstrating responsibility and accountability in conducting instrumental analysis experiments. Manage instrumental analysis projects effectively, demonstrating initiative and proactive problem-solving to ensure project completion within specified timelines and quality standards.

Autonomy, Responsibility, and Accountability (PO10):
CO7: Work autonomously in laboratory settings, demonstrating responsibility and accountability in conducting instrumental analysis experiments. Manage instrumental analysis projects effectively, demonstrating initiative and proactive problem-solving to ensure project completion within specified timelines and quality standards.

CBCS Syllabus CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme.	**:** M.Sc. Chemistry
Program Code	**:** CHE
Class	**:** M.Sc. II
Semester	**:** III
Course Type	**:** Elective Practical
Course Name	**:** Analysis of material
Course Code	**:** CHA-612-MJE (B)
No. of Lectures	**:** 30 (24L+6T)
No. of Credits	**:** 2 credits

Course Objectives:

1. Develop skills in volumetric determination techniques for carbonate and bicarbonate ions, ensuring accurate quantification of these species in various samples.
2. Apply analytical techniques for the determination of silicon (Si), titanium (Ti), calcium (Ca), and fluoride in toothpaste formulations, demonstrating competency in sample preparation and analysis.
3. Acquire proficiency in the determination of magnesium content in milk of magnesia samples, ensuring precise quantification using suitable analytical methods.
4. Develop skills in the determination of phosphorus and potassium content in fertilizers, ensuring accurate assessment of nutrient levels for agricultural applications.
5. Gain proficiency in the determination of zinc (Zn) and manganese (Mn) in soil samples using atomic absorption spectroscopy (AAS), demonstrating competency in trace metal analysis.
6. Acquire skills in the determination of nitrogen content in fertilizer samples, ensuring accurate quantification of this essential nutrient for plant growth.
7. Learn the Ninhydrin method for the estimation of amino acids in various samples, demonstrating proficiency in colorimetric analysis techniques.

Course Outcomes:

CO1. Develop a comprehensive understanding of various analytical techniques and methods for the quantitative determination of components in materials, including volumetric analysis, spectroscopic methods, chromatography, and electrophoresis.Gain insights into the principles underlying the determination of different elements and compounds in diverse matrices such as toothpaste, fertilizer, soil, oil, and biological samples.

CO2. Acquire practical skills in performing volumetric analysis, spectroscopic measurements using AAS (Atomic Absorption Spectroscopy), and separation techniques like gel electrophoresis. Understand the professional protocols and procedural techniques involved in sample preparation, analysis, and data interpretation to ensure accurate and reliable results.

CO3. Develop specialized skills in selecting and applying appropriate analytical methods for the determination of specific components in materials, considering factors such as sample matrix, concentration range, and detection limits.Cultivate critical thinking and problem-solving abilities to troubleshoot analytical challenges, optimize experimental conditions, and interpret complex data sets accurately.

CO4. Apply analytical reasoning and scientific principles to design and execute experiments for material analysis, ensuring adherence to ethical standards and research integrity.Demonstrate proficiency in formulating research questions, designing experimental

protocols, and conducting systematic investigations to address analytical objectives effectively.

CO5. Effectively communicate analytical findings, experimental methodologies, and research outcomes to peers, supervisors, and stakeholders through oral presentations, written reports, and data visualization techniques.Collaborate with interdisciplinary teams and demonstrate leadership qualities in coordinating analytical activities, fostering teamwork, and achieving common research goals.

CO6. Utilize advanced analytical instruments and software tools for data acquisition, processing, and analysis, demonstrating proficiency in digital techniques and technological applications relevant to material analysis.Adapt to emerging technologies and digital advancements in analytical instrumentation, leveraging digital platforms and resources to enhance analytical capabilities and research outcomes.

CO7. Work autonomously and responsibly in laboratory settings, demonstrating accountability for experimental design, execution, and outcome evaluation.Take ownership of analytical projects, manage resources effectively, and demonstrate initiative in addressing challenges and ensuring project completion within specified timelines and quality standards.

Topicsand Learning Points

1. Volumetric determination of Carbonate and Bicarbonate.
2. Determination of Si,Ti,Ca and floride from Toothpaste.
3. Determination of Magnesium from milk of Magnesia.
4. Determination of ,Phosphorous and Potassium from fertilizer.
5. Determination of Zn ,Mn from soil by AAS method.
6. Determination of Nitrogen from Fertilizer sample.
7. Estimation of Amino acid by Ninhydrin method .
8. Estimation of free fatty acids in oil by titrarion method .
9. Separation of protein by Polyacyrl amine Gel Electrophoresis.
10. Determination of percent purity of lactic acid .
11. Determination of saponification value of oil .
12. Determination of iodine value of oil.
13. Estimation of total carbohydrate by Anthron method .
14. Estimation of protein from food sample by lowery method .
15. Estimation of creatine from urine sample by kit method.
16. Determination of COD from waste water sample.
17. Analysis of zinc chrome pigment for Zinc and Chromium.

References:

1. Labmanual: selectedexperiments of Pharmaceuticalanalysis, AneesA Siddiqui.
2. Experiments in chemistry, D.V. Jahagirdar.
3. PharmacopeiaofIndia
4. Vogel's textbook of quantitative chemicalanalysis, sixth Ed.
5. Environmental chemistry by A. K. De.
6. Biochemical methods, Sadashivam and Manickem, Narosa publication
7. Quantitative inorganic analysis: Elementary Instrul. Analysis A.Vogel,3rd ed.ELBS

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Analysis of Material **Course Code:** CHA-612-MJE (B)
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	0	0	0	0	0	0	0
CO2	0	3	0	0	0	0	0	0	0	0
CO3	0	0	0	3	0	0	0	0	0	0
CO4	0	0	0	3	0	0	0	0	3	3
CO5	0	0	0	0	3	0	0	0	0	0
CO6	0	0	0	0	0	3	3	0	0	0
CO7	0	0	0	0	3	0	0	0	3	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop a comprehensive understanding of various analytical techniques and methods for the quantitative determination of components in materials, including volumetric analysis, spectroscopic methods, chromatography, and electrophoresis. Gain insights into the principles underlying the determination of different elements and compounds in diverse matrices such as toothpaste, fertilizer, soil, oil, and biological samples.

Practical, Professional, and Procedural Knowledge (PO2):
CO2: Acquire practical skills in performing volumetric analysis, spectroscopic measurements using AAS (Atomic Absorption Spectroscopy), and separation techniques like gel electrophoresis. Understand the professional protocols and procedural techniques involved in sample preparation, analysis, and data interpretation to ensure accurate and reliable results.

Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO3: Develop specialized skills in selecting and applying appropriate analytical methods for the determination of specific components in materials, considering factors such as sample matrix, concentration range, and detection limits. Cultivate critical thinking and problem-solving abilities to troubleshoot analytical challenges, optimize experimental conditions, and interpret complex data sets accurately.
CO4: Apply analytical reasoning and scientific principles to design and execute experiments for material analysis, ensuring adherence to ethical standards and research integrity. Demonstrate proficiency in formulating research questions, designing experimental protocols, and conducting systematic investigations to address analytical objectives effectively.

Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO5: Effectively communicate analytical findings, experimental methodologies, and research outcomes to peers, supervisors, and stakeholders through oral presentations, written reports, and data visualization techniques. Collaborate with interdisciplinary teams and demonstrate leadership qualities in coordinating analytical activities, fostering teamwork, and achieving common research goals.

Communication, Collaboration, and Leadership (PO6):
CO5: Collaborate with interdisciplinary teams and demonstrate leadership qualities in coordinating analytical activities, fostering teamwork, and achieving common research goals.
CO6: Utilize advanced analytical instruments and software tools for data acquisition, processing, and analysis, demonstrating proficiency in digital techniques and technological applications relevant to material analysis.

Digital Proficiency and Technological Skills (PO7):
CO6: Utilize advanced analytical instruments and software tools for data acquisition, processing, and analysis, demonstrating proficiency in digital techniques and technological applications relevant to material analysis.
Value Inculcation, Environmental Awareness, and Ethical Practices (PO9):
CO4: Apply analytical reasoning and scientific principles to design and execute experiments for material analysis, ensuring adherence to ethical standards and research integrity. Demonstrate proficiency in formulating research questions, designing experimental protocols, and conducting systematic investigations to address analytical objectives effectively.
CO7: Work autonomously and responsibly in laboratory settings, demonstrating accountability for experimental design, execution, and outcome evaluation. Take ownership of analytical projects, manage resources effectively, and demonstrate initiative in addressing challenges and ensuring project completion within specified timelines and quality standards.
Autonomy, Responsibility, and Accountability (PO10):
CO7: Work autonomously and responsibly in laboratory settings, demonstrating accountability for experimental design, execution, and outcome evaluation. Take ownership of analytical projects, manage resources effectively, and demonstrate initiative in addressing challenges and ensuring project completion within specified timelines and quality standards.

CBCS Syllabus as per NEP 2020 for M.Sc. II Analytical Chemistry (NEP Pattern)

Name of the Programme	**:** M.Sc. Chemistry
Program Code	**:** CHE
Class	**:** M.Sc. II
Semester	**:** III
Course Type	**:** Project work
Course Name	**:** Project
Course Code	**:** CHA-621-RP
No. of Lectures	**:** 60
No. of Credits	**:** 4 credits

Course Objectives:

1. Enable students to apply analytical chemistry principles to real-world research projects.
2. Cultivate skills in experimental design, data analysis, and interpretation within the realm of analytical chemistry.
3. Encourage students to explore advanced analytical techniques and methodologies.
4. Foster independent thinking and problem-solving abilities in the context of analytical chemistry research.
5. Promote effective communication of research findings through oral presentations and written reports.
6. Facilitate collaboration and teamwork among students in conducting research projects.
7. Prepare students for further academic or professional pursuits in analytical chemistry or related fields.

Course Outcomes:

CO1. Develop a profound understanding of the chosen research topic or project scope, encompassing relevant theories, methodologies, and key concepts within the field of study.Acquire multidisciplinary insights and knowledge from diverse sources, literature reviews, and experimental data to inform the research design and objectives effectively.

CO2. Gain practical skills and expertise necessary for conducting high-quality research, including experimental design, data collection, analysis, and interpretation.Adhere to professional standards, ethical considerations, and procedural guidelines throughout the research process, ensuring rigor, accuracy, and reproducibility of results.

CO3. Cultivate an entrepreneurial mindset by identifying research opportunities, fostering innovation, and exploring novel approaches or solutions to address scientific challenges or knowledge gaps. Understand the broader implications of the research findings, including potential applications, market relevance, and implications for industry or society.

CO4. Demonstrate proficiency in specialized research techniques, analytical methods, and experimental protocols relevant to the chosen research area or project objectives.Apply critical thinking and problem-solving abilities to overcome research obstacles, troubleshoot experimental issues, and adapt methodologies to achieve research goals effectively.Exhibit observational and analytical reasoning skills to formulate research hypotheses, design experimental protocols, and analyze data systematically. Conduct research with integrity, adhering to ethical principles, responsible conduct guidelines, and regulatory requirements to ensure the ethical conduct of research and reporting of findings.

CO5. Effectively communicate research findings, methodology, and implications to both technical and non-technical audiences through written reports, oral presentations, and visual aids.Collaborate with peers, advisors, and stakeholders to leverage diverse perspectives,

resources, and expertise, demonstrating leadership qualities in coordinating research efforts and driving progress toward project objectives.

CO6. Utilize digital tools, software platforms, and technological resources to support research activities, data analysis, and knowledge dissemination throughout the project lifecycle.Embrace technological advancements and digital methodologies to enhance research efficiency, productivity, and the quality of outputs, including publications and presentations.

CO7. Take ownership of the research project, demonstrating autonomy in decision-making, project management, and resource allocation to ensure progress and timely completion.Assume responsibility for project outcomes, including the quality of research outputs, adherence to timelines, and effective utilization of resources, while being accountable to stakeholders, collaborators, and regulatory bodies.

Topicsand Learning Points

Project shall be started at the beginning of the SEM III and will be accessed by monthly for progress and continues evaluation will be made. High standard research work is expected from the project and students are encouragedto publish it in national or international journal of high repute. External and internal examiner will examine the jointly at the time of practical examination.

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. III) **Subject:** Analytical Chemistry
Course: Project **Course Code:** CHA-621-RP

Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	0	0	0	0	0	0	0
CO2	0	3	0	0	0	0	0	0	0	0
CO3	0	0	3	0	0	0	0	0	0	0
CO4	0	0	0	3	3	0	0	0	3	3
CO5	0	0	0	0	3	0	0	0	0	0
CO6	0	0	0	0	0	3	3	0	0	0
CO7	0	0	0	0	3	0	0	0	3	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop a profound understanding of the chosen research topic or project scope, encompassing relevant theories, methodologies, and key concepts within the field of study. Acquire multidisciplinary insights and knowledge from diverse sources, literature reviews, and experimental data to inform the research design and objectives effectively.

Practical, Professional, and Procedural Knowledge (PO2):
CO2: Gain practical skills and expertise necessary for conducting high-quality research, including experimental design, data collection, analysis, and interpretation. Adhere to professional standards, ethical considerations, and procedural guidelines throughout the research process, ensuring rigor, accuracy, and reproducibility of results.

Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO3: Cultivate an entrepreneurial mindset by identifying research opportunities, fostering innovation, and exploring novel approaches or solutions to address scientific challenges or knowledge gaps. Understand the broader implications of the research findings, including potential applications, market relevance, and implications for industry or society.

Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO4: Demonstrate proficiency in specialized research techniques, analytical methods, and experimental protocols relevant to the chosen research area or project objectives. Apply critical thinking and problem-solving abilities to overcome research obstacles, troubleshoot experimental issues, and adapt methodologies to achieve research goals effectively.

Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO4: Conduct research with integrity, adhering to ethical principles, responsible conduct guidelines, and regulatory requirements to ensure the ethical conduct of research and reporting of findings.
CO5: Effectively communicate research findings, methodology, and implications to both technical and non-technical audiences through written reports, oral presentations, and visual aids. Collaborate with peers, advisors, and stakeholders to leverage diverse perspectives, resources, and expertise, demonstrating leadership qualities in coordinating research efforts and driving progress toward project objectives.

Communication, Collaboration, and Leadership (PO6):
CO5: Collaborate with peers, advisors, and stakeholders to leverage diverse perspectives, resources, and expertise, demonstrating leadership qualities in coordinating research efforts and driving progress toward project objectives.
CO6: Utilize digital tools, software platforms, and technological resources to support research activities, data analysis, and knowledge dissemination throughout the project lifecycle.

Digital Proficiency and Technological Skills (PO7):
CO6: Utilize digital tools, software platforms, and technological resources to support research activities, data analysis, and knowledge dissemination throughout the project lifecycle.
Value Inculcation, Environmental Awareness, and Ethical Practices (PO9):
CO4: Conduct research with integrity, adhering to ethical principles, responsible conduct guidelines, and regulatory requirements to ensure the ethical conduct of research and reporting of findings.
CO7: Take ownership of the research project, demonstrating autonomy in decision-making, project management, and resource allocation to ensure progress and timely completion. Assume responsibility for project outcomes, including the quality of research outputs, adherence to timelines, and effective utilization of resources, while being accountable to stakeholders, collaborators, and regulatory bodies.
Autonomy, Responsibility, and Accountability (PO10):
CO7: Take ownership of the research project, demonstrating autonomy in decision-making, project management, and resource allocation to ensure progress and timely completion. Assume responsibility for project outcomes, including the quality of research outputs, adherence to timelines, and effective utilization of resources, while being accountable to stakeholders, collaborators, and regulatory bodies.