Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science, Commerce, Baramati

(Empowered Autonomous)

DEPARTMENT OF CHEMISTRY

(Faculty of Science and Technology)

Two Year M.Sc. Degree Program Chemistry

M.Sc. II Analytical Chemistry
Semester-IV

(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.

Anekant Education Society's

Tuljaram Chaturchand College of Arts, Commerce & Science Baramati, Dist. Pune

(Empowered 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-652-MJM	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-662-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**

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Theory
Course Name	**:** Analytical methods for analysis of fertilizers, detergent, water, polymer, paint and pigment
Course Code	**:** CHA-651-MJM
No. of Lectures	**:**60 (48L+12T)
No. of Credits	**:**4 credits

Course Objective:

1. Students will gain proficiency in the sampling, preparation, and quantitative analysis of fertilizers, including nitrogen, phosphorus, and potassium content using advanced chemical methods.
2. Students will acquire the ability to perform detailed chemical analysis of soaps and detergents, including the determination of active ingredients, biodegradability, and spectroscopic analysis.
3. Students will learn to analyze water pollutants, assess water quality, and apply treatment methods, developing solutions for real-world water pollution challenges.
4. Students will gain foundational knowledge of polymer chemistry, including the classification and synthesis of polymers.
5. students will develop the skills to conduct chemical, physical, thermal, optical, and electrical testing of polymers, using techniques such as X-ray diffraction and thermal analysis.
6. Students will learn to determine the molecular weight and size of polymers using techniques like end group analysis, colligative properties, and solution viscosity measurements.
7. Students will master the analysis of paints and pigments, including the identification and quantification of binders, thinners, pigments, and additives.

Course Outcomes:

CO1. Demonstrate an in-depth understanding of analytical techniques and methodologies for the analysis of fertilizers, detergents, water, polymers, paints, pigments and understand the chemical composition and functional properties of various industrial products and pollutants, along with their environmental impact.

CO2. Acquire practical skills in sampling, preparation, and analysis of industrial products and pollutants using standard methods such as Kjeldahl's method, flame photometry, UV spectroscopy, and chromatographic techniques and apply professional standards in conducting chemical analyses and quality control tests on fertilizers, detergents, polymers, paints, and pigments.

CO3. Explore innovative analytical methods for improving product quality, safety, and environmental compliance in industries related to fertilizers, detergents, water treatment, polymers, and paints and understand the industrial relevance of analytical methods and their

role in enhancing product development, regulatory compliance, and market competitiveness.

CO4. Develop specialized analytical skills to solve complex problems related to the chemical composition, stability, and performance of industrial products and environmental samples and apply critical thinking to optimize analytical methods, troubleshoot experimental issues, and interpret results accurately.

CO5. Exhibit strong research and analytical reasoning skills in designing and conducting experiments, analysing data, and interpreting results in the context of industrial and environmental chemistry and conduct analyses with integrity, adhering to ethical standards and regulatory guidelines in the evaluation of industrial products and pollutants.

CO6. Take ownership of analytical projects, demonstrating autonomy in decision-making, method development, and resource management to ensure the timely and accurate completion of analyses and assume responsibility for the quality and reliability of analytical results, being accountable to stakeholders, regulatory authorities, and industry partners.

CO7. Utilize advanced analytical instruments, software tools, and digital platforms to enhance the accuracy, efficiency, and reproducibility of chemical analyses in industrial and environmental contexts and embrace technological advancements to improve analytical methods, data management, and reporting.

Topics and Learning Point

Unit 1. Analysis of Fertilizers (6L)

Sampling and sample preparation, water, total nitrogen: Kjeldahl's method, total nitrogen by reduced iron method, urea nitrogen, total Kjeldahl's nitrogen methods and spectrophotometric method, Ammonia nitrogen. Phosphorus: total phosphorus, available and non-available, alkali metric ammonium molybdophosphate method, water-soluble phosphorous, citrate insoluble phosphate, Potassium: potassium by sodium tetra phenyl borate method, flame photometric methods.

Unit 2. Analysis of soaps and detergents (8L)

General scheme of analysis, sampling, alcohol soluble materials, moisture and volatile matter, active ingredient, and equivalent combined SO_3.

Tests for soaps: total fatty acids, fatty anhydride combined alkali, and anhydrous soap, Unsaponified and unsaponifiable matter, Free alkali or free acid, titer test, Iodine value, saponification value, free glycerol.

Tests for synthetic detergents: Unsulfurated or unsulfured matter, ester SO_3, Combined alcohols, total combined SO_3, Alkalinity, chlorides, silicate, phosphate, borates.

UV spectroscopic analysis of detergents: Biodegradability of detergents, Determination of sodium alkyl benzene sulfonate, determination of sodium toluene sulfonate, determination of sodium xylene sulfonate, determination of germicides in soaps and detergents.

Unit 3. Water pollution and analysis of polluted water (10 L)

Water pollutants, wastewater treatment: domestic wastewater treatment, aerobic treatment process, anaerobic treatment process, industrial wastewater treatment, The purpose of chemical analysis, sampling of water, pH of water, specific conductance, determination of acidity and alkalinity, chemical oxygen demand, biological oxygen demand, dissolved oxygen, turbidity, determination of aluminum, arsenic, boron, cadmium, calcium, carbon dioxide, chloride, residual chlorine, chlorine demand, chromium, cyanide, total hardness, iron, lead manganese, Zn, methane, nitrate, nitrite, ammonia, nitrogen, phenols,

phosphates, silica, sulfate, sulfide, anionic detergents, tannin and lignin.

Unit 4. Introduction to polymers (2L)

Brief history of polymers, how polymers are made? classification of polymers

Unit 5. Analysis and testing of polymers (10L)

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

Unit 6. Measurement of molecular weight and size (4L)

End group analysis, Colligative properties measurements, solution viscosity, and Molecular size.

Unit 7. Analysis of Paints and Pigment (8L)

Introduction, test on the total coating, water content, separation of pigment binder and thinner of solvent type coating, separation of pigment binder, and thinner of latex paints, Identification of the binder, Identification of polymer resins and oils, Identification of plasticizer, Analysis of the vehicle, Identification and Analysis of pigments, Identification of inorganic pigments, Analysis of white and tinted pigments, outline of general procedure, HCL insoluble, Titanium dioxide, total lead, acid-soluble Al and Fe, acid-soluble calcium, total zinc, antimony oxide, total sulfate, total carbonate) analysis of colored pigments, Black pigments, and other pigments, identification, and analysis of thinners.

References

1. Standard methods of chemical analysis, F.J. Welcher volume 3, part-B
2. Standard methods of water and wastewater analysis A. K. De.
3. Environmental Chemistry, A. K. De
4. Textbook of polymer science F.W. Billmeyer 3rd edition (1994).
5. Principles of polymer systems by F. Rodrigue, Tata Mc Graw Hill, New Delhi.
6. Principles of polymer systems by P.J. Flory, Cornell University Press, New York.
7. Polymer chemistry introduction Seymour-Carraher-Marcel Dekker. Inc. New York.
8. Polymer Science by V.R. Gowarikar, N.B. Vishvanathane, New Age publisher (1998)
9. Polymer Science by Vasant Gowarikar, Wiley Eastern New York(1998).
10. Principle of polymer science, Bahadhur, and Shastri, Narosa publishing.

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Analytical methods for analysis of fertilizers, detergent, water, polymer, paint and pigment
Course Code: CHA-651-MJM
Weightage: 1= weak or low relation, 2= moderate or partial relation, 3= strong or direct relation

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	0	0	0	0	0	0	0	3	0
CO2	0	3	0	0	0	0	0	0	0	0
CO3	0	0	3	0	0	0	0	0	3	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	3
CO7	0	0	0	0	0	0	3	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Demonstrate an in-depth understanding of analytical techniques and methodologies for the analysis of fertilizers, detergents, water, polymers, paints, pigments, and understand the chemical composition and functional properties of various industrial products and pollutants, along with their environmental impact.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Acquire practical skills in sampling, preparation, and analysis of industrial products and pollutants using standard methods such as Kjeldahl's method, flame photometry, UV spectroscopy, and chromatographic techniques and apply professional standards in conducting chemical analyses and quality control tests on fertilizers, detergents, polymers, paints, and pigments.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO3: Explore innovative analytical methods for improving product quality, safety, and environmental compliance in industries related to fertilizers, detergents, water treatment, polymers, and paints and understand the industrial relevance of analytical methods and their role in enhancing product development, regulatory compliance, and market competitiveness.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO4: Develop specialized analytical skills to solve complex problems related to the chemical composition, stability, and performance of industrial products and environmental samples and apply critical thinking to optimize analytical methods, troubleshoot experimental issues, and interpret results accurately.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO5: Exhibit strong research and analytical reasoning skills in designing and conducting experiments, analyzing data, and interpreting results in the context of industrial and environmental chemistry and conduct analyses with integrity, adhering to ethical standards and regulatory guidelines in the evaluation of industrial products and pollutants.
Communication, Collaboration, and Leadership (PO6):
CO6: Take ownership of analytical projects, demonstrating autonomy in decision-making, method development, and resource management to ensure the timely and accurate completion of analyses and assume responsibility for the quality and reliability of analytical results, being accountable to stakeholders, regulatory authorities, and industry partners.
Digital Proficiency and Technological Skills (PO7):

CO7: Utilize advanced analytical instruments, software tools, and digital platforms to enhance the accuracy, efficiency, and reproducibility of chemical analyses in industrial and environmental contexts and embrace technological advancements to improve analytical methods, data management, and reporting.

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

CO1: Demonstrate an understanding of the environmental impact of various industrial products and pollutants.

CO3: Explore innovative methods for environmental compliance.

Autonomy, Responsibility, and Accountability (PO10):

CO6: Demonstrate autonomy in decision-making, method development, and resource management.

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Theory
Course Name	**:** Method of analysis and applications
Course Code	**:** CHA-652-MJM
No. of Lectures	**:**60 (48L+12T)
No. of Credits	**:**4 credits

Course Objective:

1. Students will learn to analyze geological materials, including dolomite, ilmenite, monazite, hematite, magnetite, pyrolusite, and bauxite, focusing on the determination of silicates, metals, and other key components.
2. Students will gain proficiency in the analysis of various alloys such as stainless steel, bronze, brass, solder, and aluminium-based alloys, focusing on the determination of elemental composition and material properties.
3. Students will develop the skills to perform comprehensive chemical analysis of soil, including the determination of organic content, nutrients, cation exchange capacity, and fertility indicators.
4. Students will understand the correct procedures for the collection, storage, and preservation of biological specimens such as blood, urine, and faces for subsequent analysis.
5. Students will acquire the ability to analyse blood and urine samples for glucose, ketone bodies, creatinine, bilirubin, cholesterol, and other critical components, using advanced analytical methods.
6. Students will learn to classify and determine the concentration of various vitamins in body fluids, such as retinol, vitamin D3, vitamin E, thiamine, riboflavin, and ascorbic acid, using spectrophotometric and fluorometric techniques.
7. Students will master immunoanalytical techniques such as radioimmunoassay and enzyme-linked immunosorbent assay (ELISA), understanding their principles, applications, and clinical significance.

Course Outcomes:

CO1. Gain a thorough understanding of the chemical analysis methods for various geological materials, alloys, and soil, and their significance in different scientific and industrial contexts and understand the principles and techniques involved in the analysis of biological specimens such as blood, urine, and vitamins in body fluids, as well as their applications in clinical diagnostics.

CO2. Develop practical skills in collecting, preserving, and analysing geological samples, alloys, and biological specimens using advanced analytical techniques such as spectrophotometry, fluorometry, and flame photometry and apply professional standards in conducting chemical analyses, ensuring accuracy and reliability in the determination of various elements and compounds in complex matrices.

CO3. Acquire specialized analytical skills to solve complex problems related to the determination of metals, minerals, and organic compounds in geological materials, alloys, soils, and biological

fluids and employ critical thinking to optimize analytical methods, interpret data accurately, and troubleshoot issues that arise during analysis.

CO4. Exhibit strong research and analytical reasoning skills in designing and conducting experiments, analyzing data, and interpreting results in the context of material analysis and clinical diagnostics and adhere to ethical standards and regulatory guidelines in the analysis and reporting of data, ensuring the integrity and credibility of analytical results.

CO5. Communicate analytical findings, methodologies, and their implications effectively to both technical and non-technical audiences through written reports, presentations, and discussions and collaborate with peers and professionals in the field, demonstrating leadership in managing analytical projects and contributing to the advancement of knowledge in material analysis and clinical diagnostics.

CO6. Utilize advanced analytical instruments, software tools, and digital platforms to enhance the accuracy, efficiency, and reproducibility of chemical analyses in the study of materials, soils, and biological fluids and embrace technological advancements to improve analytical methods, data management, and reporting.

CO7. Explore innovative analytical methods for improving product quality, safety, and environmental compliance in industries related to geology, metallurgy, agriculture, and healthcare and understand the industrial and clinical relevance of analytical methods and their role in enhancing product development, regulatory compliance, and market competitiveness.

Topics and Learning Point

Unit 1. Analysis of Geological materials (8L)

Dolomite (For silicate, Mg and Ca content), Ilmenite (for silicate, Ti and Fe content), Monazite (for rare earth metals), Hematite and Magnetite (silicate and Fe content), Pyrolusite (for silicate and Mn content) and bauxite (for Al and Silicate content).

Unit 2. Analysis of Alloys (8L)

Stainless Steel (for Fe, Cr, Ni, Co, Cu, Mn, W, Si, V, Mo, Ti, Pb, and Zr) Bronze and Gunmetal (for Cu, Sn), Brass (for Cu, Zn, Sn, Pb), Solder (for Pb and Sn), Nichrome (for Fe, Ni, Cr), Analysis of nickel Silver (Sn, Pb, Cu, Fe, Ni, and Zn) and Aluminum based alloys (Al, Mg,).

Unit 3. Analysis of Soil (8L)

i) Sampling, ii) Carbonate, Organic carbon, and organic matter, iii) Total nitrogen, ammonia, and nitrates , iv) silica and total combined oxides of iron, aluminum, and titanium, V) Determination Ca, Mg, Na, K, phosphate, boron, Co, Cu, Zn, vii) Exchangeable cations vi) Cation exchange capacity, vii) chemical analysis as a measure of soil fertility.

Unit 4. Collection of Specimens (2 L)

Blood: Collection of Blood specimens, storage, and preservation, Urine: Collection of Urine, physical characteristics of urea, preservation, and storage, Faces: Collection and preservation.

Unit 5. Analysis of Blood and urine (6 L)

Determination of blood and plasma glucose by glucose oxidase method, Determination of urine for glucose, Determination of ketone bodies in blood, Oral Glucose tolerance test, Determination of serum creatinine, estimation of serum bilirubin, Estimation of serum

cholesterol, Urate: determination of serum urate, Estimation of Na, K, Ca by flame photometry, inorganic phosphate by colorimetry.

Unit 6. Determination of vitamins in body fluid (8L)

Classification of vitamins For example, Each vitamin must be explained concerning functions, deficiency diseases, daily requirements, and analytical method
i) Retinol (determination of retinol and serum carotene in serum using TFA), Vitamin D3 (cholecalciferol), Vitamin E (Tocopherols, Determination of serum Tocopherols by spectrophotometry by dipyridyl method), Vitamin B1 (thiamine determination by fluorometry), Vitamin B2 (riboflavin, Photo fluorometric method), Vitamin B6 (Pyridoxine, Fluorometric determination of Xanthuria acid), Nicotinic acid and Niacin: determination by fluorometry, Ascorbic acid (vitamin C) Volumetric method using 2,6 dichlorophenol method,

Unit 7. Immunoanalytical Techniques (6L)

Radioimmunoassay, its principle, and applications, introduction for radio bioassay, clinical application of the radioimmunoassay of insulin, Estrogen, and progesterone, receptor techniques of breast cancer. Enzyme-linked immunosorbent assay (ELISA), Types of ELISA, principles, practical aspects, applications.

Unit 8. Organ function tests (2 L)

Liver function tests and kidney function tests

References

1. Standard methods of chemical analysis, F.J. Welcher Sixth Edition,
2. Quantitative Inorganic Analysis including Elementary Instrumental analysis, I. Vogel, 3rd, ELBS, 1964.
3. Practical Clinical Biochemistry, Gowen lock, CBS published, 6thEd. Biochemical.

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Method of analysis and applications **Course Code:** CHA-652-MJM
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	3	0
CO4	0	0	0	3	3	0	0	0	0	3
CO5	0	0	0	0	0	3	0	0	0	0
CO6	0	0	0	0	0	0	3	0	0	0
CO7	0	0	3	0	0	0	0	0	3	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Gain a thorough understanding of the chemical analysis methods for various geological materials, alloys, and soil, and their significance in different scientific and industrial contexts, and understand the principles and techniques involved in the analysis of biological specimens such as blood, urine, and vitamins in body fluids, as well as their applications in clinical diagnostics.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Develop practical skills in collecting, preserving, and analysing geological samples, alloys, and biological specimens using advanced analytical techniques such as spectrophotometry, fluorometry, and flame photometry, and apply professional standards in conducting chemical analyses, ensuring accuracy and reliability in the determination of various elements and compounds in complex matrices.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO7: Explore innovative analytical methods for improving product quality, safety, and environmental compliance in industries related to geology, metallurgy, agriculture, and healthcare, and understand the industrial and clinical relevance of analytical methods and their role in enhancing product development, regulatory compliance, and market competitiveness.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO3: Acquire specialized analytical skills to solve complex problems related to the determination of metals, minerals, and organic compounds in geological materials, alloys, soils, and biological fluids, and employ critical thinking to optimize analytical methods, interpret data accurately, and troubleshoot issues that arise during analysis.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO4: Exhibit strong research and analytical reasoning skills in designing and conducting experiments, analysing data, and interpreting results in the context of material analysis and clinical diagnostics, and adhere to ethical standards and regulatory guidelines in the analysis and reporting of data, ensuring the integrity and credibility of analytical results.
Communication, Collaboration, and Leadership (PO6):
CO5: Communicate analytical findings, methodologies, and their implications effectively to both technical and non-technical audiences through written reports, presentations, and discussions, and

collaborate with peers and professionals in the field, demonstrating leadership in managing analytical projects and contributing to the advancement of knowledge in material analysis and clinical diagnostics.

Digital Proficiency and Technological Skills (PO7):

CO6: Utilize advanced analytical instruments, software tools, and digital platforms to enhance the accuracy, efficiency, and reproducibility of chemical analyses in the study of materials, soils, and biological fluids, and embrace technological advancements to improve analytical methods, data management, and reporting.

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

CO7: Explore innovative analytical methods for improving product quality, safety, and environmental compliance in industries related to geology, metallurgy, agriculture, and healthcare.

Autonomy, Responsibility, and Accountability (PO10):

CO4: Adhere to ethical standards and regulatory guidelines in the analysis and reporting of data, ensuring the integrity and credibility of analytical results.

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Practical
Course Name	**:** Instrumental Methods of Analysis-II
Course Code	**:** CHA-653-MJM
No. of Lectures	**:** 60
No. of Credits	**:** 2 credits

Course Objectives:

1. Students will develop expertise in using Gas Chromatography to analyze Vitamin-A Acetate or Alpha-Tocopherol, following either the Indian Pharmacopoeia (IP) method or a laboratory-developed protocol.
2. Students will learn to determine the concentration of glucose in supplement samples using polarimetric methods, enhancing their understanding of optical rotation and its application in analytical chemistry.
3. Students will gain proficiency in using turbidimetry to estimate chloride content in water samples by constructing and interpreting calibration curves.
4. Students will learn to identify and quantify Nicotinamide in pharmaceutical formulations (tablets or capsules) using UV spectroscopy, applying principles of absorbance and transmittance.
5. Students will acquire the skills to perform Thermogravimetric Analysis (TGA) on compounds like copper sulfate, understanding the principles of thermal decomposition and weight loss measurement.
6. Students will learn to determine the concentration of minerals such as sodium, potassium, and calcium in food and dairy products using Flame Photometry, with an emphasis on the standard addition method.
7. Students will develop competence in various electrochemical techniques, including Potentiometry, Conductometry, and Cyclic Voltammetry, to analyze different chemical species and mixtures.

Course Outcomes:

CO1. Develop a comprehensive understanding of various instrumental techniques such as gas chromatography, UV spectroscopy, flame photometry, and electrochemical methods. Apply these techniques to analyse and quantify different substances, including vitamins, glucose, chlorides, and pharmaceutical compounds.

CO2. Gain hands-on experience in performing advanced analytical procedures such as thermogravimetric analysis, polarimetry, and cyclic voltammetry. Enhance skills in calibration and the use of standard addition methods for the precise determination of elements like sodium, potassium, and calcium.

CO3. Cultivate the ability to critically evaluate and interpret experimental data obtained from instruments such as turbidimeters, photo fluorometers, and pH meters. Engage in problem-solving by designing and optimizing methods for the analysis of complex mixtures, such as the determination of halides by potentiometry.

CO4. Understand the importance of adhering to standardized protocols, such as the IP method for vitamin analysis, ensuring the reliability and reproducibility of results. Demonstrate awareness of the ethical considerations in the handling, analysis, and reporting of chemical data, especially in pharmaceutical and environmental contexts.

CO5. Develop the ability to effectively communicate the results of instrumental analyses through detailed laboratory reports and presentations. Collaborate with peers in laboratory settings to ensure accurate and consistent analytical results, fostering teamwork and collective problem-solving.

CO6. Demonstrate professionalism in conducting laboratory experiments, ensuring precision, accuracy, and attention to detail in all analytical procedures. Take responsibility for the reliability and validity of experimental results, maintaining high standards of laboratory practice.

CO7. Explore innovative approaches to method development and validation, particularly in the analysis of novel or complex samples. Recognize opportunities for innovation in the field of instrumental analysis, potentially contributing to the development of new analytical methods or technologies.

Topics and Learning Point

1. Analysis of Vitamin-A Acetate or Alfa tocopherol by Gas Chromatography According to IP method or method developed in your laboratory.
2. Determination of Glucose supplement sample by polarimeter.
3. Estimation of Chloride from water sample by calibration curve method using Turbidimeter.
4. Identification and Assay of Nicotinamide from tablet or capsule by UV spectroscopy.
5. Thermogravimetric Analysis of copper sulphate.
6. Flame photometric determination of Na from given sample by standard addition method.
7. Flame Photometric determination of K from given sample by standard addition method.
8. Determination of Ca from Dairy Whitener using Flame Photometer.
9. Phototoflorimetric determination of Riboflavin from unknown sample.
10. Determination of Thiamine in urine sample by Photo fluorometry.
11. Determination of Quinine sulphate by standard addition method using Photo fluorometer.
12. To determine PKa and Dissociation constant of dibasic oxalic acid by PH metric titration using NaOH solution.
13. To determine maximum wavelength and concentration of copper sulphate ammonia complex by colorimetry.
14. To determine the strength of Acetic acid in Commercial Vinegar by conductometry.
15. Determination of Chain linkage in Poly vinyl alcohol from viscosity measurement.
16. To determine the amount of sulphate from given sample by nephelometric titration using standard Barium Nitrate solution.
17. To determine the amount of Sodium Thiosulphate in given solution by Amperometry titration with standard Iodine using Rotating Platinum Electrode.
18. Determination of amount of Chloride, Bromide, Iodide present in their mixture by Potentiometry.

(Note: Minimum 15 experiments should be completed in this course.)

References

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

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Instrumental Methods of Analysis-II **Course Code:** CHA-653-MJM

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	3	0	0	0
CO4	0	0	0	0	3	0	0	0	3	0
CO5	0	0	0	0	0	3	0	3	0	0
CO6	0	0	0	0	0	0	0	0	0	3
CO7	0	0	3	0	0	0	0	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Develop a comprehensive understanding of various instrumental techniques such as gas chromatography, UV spectroscopy, flame photometry, and electrochemical methods. Apply these techniques to analyse and quantify different substances, including vitamins, glucose, chlorides, and pharmaceutical compounds.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Gain hands-on experience in performing advanced analytical procedures such as thermogravimetric analysis, polarimetry, and cyclic voltammetry. Enhance skills in calibration and the use of standard addition methods for the precise determination of elements like sodium, potassium, and calcium.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO7: Explore innovative approaches to method development and validation, particularly in the analysis of novel or complex samples. Recognize opportunities for innovation in the field of instrumental analysis, potentially contributing to the development of new analytical methods or technologies.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO3: Cultivate the ability to critically evaluate and interpret experimental data obtained from instruments such as turbidimeters, photo fluorometers, and pH meters. Engage in problem-solving by designing and optimizing methods for the analysis of complex mixtures, such as the determination of halides by potentiometry.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO4: Understand the importance of adhering to standardized protocols, such as the IP method for vitamin analysis, ensuring the reliability and reproducibility of results. Demonstrate awareness of the ethical considerations in the handling, analysis, and reporting of chemical data, especially in pharmaceutical and environmental contexts.
Communication, Collaboration, and Leadership (PO6):
CO5: Develop the ability to effectively communicate the results of instrumental analyses through detailed laboratory reports and presentations. Collaborate with peers in laboratory settings to ensure accurate and consistent analytical results, fostering teamwork and collective problem-solving.
Digital Proficiency and Technological Skills (PO7):
CO3: Cultivate the ability to critically evaluate and interpret experimental data obtained from instruments such as turbidimeters, photo fluorometers, and pH meters. Engage in problem-solving by designing and optimizing methods for the analysis of complex mixtures.
Multicultural Competence, Inclusive Spirit, and Empathy (PO8):

CO5: Collaborate with peers in laboratory settings to ensure accurate and consistent analytical results, fostering teamwork and collective problem-solving.

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

CO4: Demonstrate awareness of the ethical considerations in the handling, analysis, and reporting of chemical data, especially in pharmaceutical and environmental contexts.

Autonomy, Responsibility, and Accountability (PO10):

CO6: Demonstrate professionalism in conducting laboratory experiments, ensuring precision, accuracy, and attention to detail in all analytical procedures. Take responsibility for the reliability and validity of experimental results, maintaining high standards of laboratory practice.

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Theory
Course Name	**:** Advance topics in analytical technique
Course Code	**:** CHA-661-MJE(A)
No. of Lectures	: 30 (24L + 6T)
No. of Credits	**:** 2 credits

Course Objective:

1. Students will gain a thorough understanding of the principles of Liquid-Liquid Extraction, including solvent selection and the challenges associated with the LLE process for aqueous samples.
2. Students will learn about different types of SPE media, apparatus, and operational methods, with an emphasis on factors influencing SPE performance and its automation in analytical processes.
3. Students will understand the instrumentation and applications of Microwave-Assisted Extraction, focusing on its efficiency and benefits in the extraction of analytes from complex matrices.
4. Students will acquire knowledge of Supercritical Fluid Extraction, including its instrumentation and applications in analytical chemistry, particularly for environmental and pharmaceutical samples.
5. Students will learn to apply Atomic Fluorescence Spectroscopy, understanding the underlying theory, instrumentation, and applications of AFS in detecting and quantifying trace elements in various samples.
6. Students will explore advanced spectroscopic techniques such as Resonant Ionization Spectroscopy and Laser-Enhanced Ionization, focusing on their applications in analytical chemistry for enhanced sensitivity and specificity.
7. Students will synthesize knowledge from various extraction and spectroscopic techniques, applying them to complex real-world analytical problems, thereby enhancing their problem-solving and critical thinking abilities.

Course Outcomes:

CO1. Comprehend the types, formats, and apparatus used in Solid Phase Extraction (SPE) and the operational methods. Apply knowledge of solvent selection and factors influencing SPE to optimize extraction processes and understand the role of automation and online SPE in modern analytical practices.

CO2. Describe the instrumentation and applications of Microwave Assisted Extraction, highlighting its advantages in analytical chemistry. Evaluate the efficiency and suitability of microwave-assisted extraction for different sample types and analytical purposes.

CO3. Understand the principles, instrumentation, and applications of Supercritical Fluid Extraction (SFE). Assess the benefits and limitations of SFE in comparison to other extraction techniques, particularly in the context of green chemistry.

CO4. Gain in-depth knowledge of Atomic Fluorescence Spectroscopy (AFS), including the apparatus, sources of electromagnetic radiation, and detection systems used. Explore Resonant

Ionization Spectroscopy and Laser-Enhanced Ionization Spectroscopy, understanding their theory, instrumentation, and applications in analytical chemistry.

CO5. Develop the ability to select appropriate extraction and detection methods for complex analytical problems, integrating classical and advanced techniques. Enhance problem-solving skills by applying theoretical knowledge to practical scenarios, particularly in the analysis of volatile organics and other challenging samples.

CO6. Encourage innovation in the selection and optimization of extraction techniques for specific analytical needs, considering both efficiency and environmental impact. Critically evaluate new developments in atomic spectroscopy, particularly those involving laser-based techniques, and their potential for improving analytical sensitivity and accuracy.

CO7. Develop hands-on experience with advanced extraction and atomic spectroscopy techniques through practical laboratory work. Demonstrate the ability to conduct experiments, analyse results, and present findings in a clear and scientifically rigorous manner.

Topics and Learning Point

Unit 1. Classical approach for aqueous extraction (6 L)

Introduction, Liquid-Liquid extraction (LLE) (Theory of LLE, selection of solvents, solvent extraction, problems with LLE process), purge and trap for volatile organics in aqueous samples.

Unit 2. Solid Phase Extraction (SPE) (6 L)

Introduction, Types of SPE media, SPE formats and apparatus, method for SPE operation, solvent selection, factors affecting SPE, selected methods of analysis for SPE, Automation and On-Line SPE

Unit 3. Microwave Assisted Extraction (3 L)

Introduction, Instrumentation, Applications

Unit 4. Supercritical Fluid Extraction (3 L)

Introduction, instrumentation, Applications

Unit 5. Atomic Fluorescence, Resonant Ionization and laser based-Enhanced Ionization (6L)

Atomic Fluorescence Spectroscopy (AFS): Atomic fluorescence, apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasmas, Wavelength selection for AFS, Detectors for AFS, Theory of AFS, Resonant Ionization Spectroscopy, Laser enhanced ionization spectroscopy.

References

1. Introduction to Instrumental Analysis, R. D. Broun, Mc. Graw Hill (1987)
2. Instrumental methods of chemical analysis, H. Willard, L. Merrit, J.A. Dean and F.A. Settle. Sixth edition CBS (1986)
3. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler,
4. Saunders college publishing, 6thedition
5. Principles of Instrumental Analysis, Skog, Holler, Nieman, (Sixth Ed.)
6. Vogel's Textbook of Quantitative analysis 6thEd.
7. Modern analytical techniques in the pharmaceutical and bio analysis Dr. Istvan Bak (Book Available Online).
8. Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (Book Available Online).
9. Extraction technique in analytical science, John R. Dean, Wiley (2009)

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Advance topics in analytical technique **Course Code:** CHA-661-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	0	0	0	3	0	0	0	0	0
CO3	0	0	0	0	0	0	3	0	3	0
CO4	3	0	0	0	0	0	0	0	0	0
CO5	0	0	0	3	0	0	0	0	0	0
CO6	0	0	3	0	0	0	0	3	0	0
CO7	0	3	0	0	0	3	0	0	0	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Comprehend the types, formats, and apparatus used in Solid Phase Extraction (SPE) and the operational methods. Apply knowledge of solvent selection and factors influencing SPE to optimize extraction processes and understand the role of automation and online SPE in modern analytical practices.
CO4: Gain in-depth knowledge of Atomic Fluorescence Spectroscopy (AFS), including the apparatus, sources of electromagnetic radiation, and detection systems used. Explore Resonant Ionization Spectroscopy and Laser-Enhanced Ionization Spectroscopy, understanding their theory, instrumentation, and applications in analytical chemistry.
Practical, Professional, and Procedural Knowledge (PO2):
CO7: Develop hands-on experience with advanced extraction and atomic spectroscopy techniques through practical laboratory work. Demonstrate the ability to conduct experiments, analyse results, and present findings in a clear and scientifically rigorous manner.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO6: Encourage innovation in the selection and optimization of extraction techniques for specific analytical needs, considering both efficiency and environmental impact. Critically evaluate new developments in atomic spectroscopy, particularly those involving laser-based techniques, and their potential for improving analytical sensitivity and accuracy.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO5: Develop the ability to select appropriate extraction and detection methods for complex analytical problems, integrating classical and advanced techniques. Enhance problem-solving skills by applying theoretical knowledge to practical scenarios, particularly in the analysis of volatile organics and other challenging samples.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO2: Describe the instrumentation and applications of Microwave Assisted Extraction, highlighting its advantages in analytical chemistry. Evaluate the efficiency and suitability of microwave-assisted extraction for different sample types and analytical purposes.
Communication, Collaboration, and Leadership (PO6):

CO7: Demonstrate the ability to conduct experiments, analyze results, and present findings in a clear and scientifically rigorous manner, promoting communication and collaboration with peers.

Digital Proficiency and Technological Skills (PO7):

CO3: Understand the principles, instrumentation, and applications of Supercritical Fluid Extraction (SFE). Assess the benefits and limitations of SFE in comparison to other extraction techniques, particularly in the context of green chemistry, demonstrating proficiency with advanced extraction technology.

Multicultural Competence, Inclusive Spirit, and Empathy (PO8):

CO6: Encourage innovation in the selection and optimization of extraction techniques considering efficiency and environmental impact, fostering a responsible and inclusive approach to sustainable practices.

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

CO3: Understand the principles, instrumentation, and applications of Supercritical Fluid Extraction (SFE) with emphasis on green chemistry, promoting environmental awareness and sustainability in analytical methods.

Autonomy, Responsibility, and Accountability (PO10):

CO7: Through practical laboratory work, develop autonomy in conducting experiments and take responsibility for the accuracy and reliability of analytical results, demonstrating accountability in the scientific process.

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Theory
Course Name	**:** Forensic Science
Course Code	**:** CHA-661-MJE(B)
No. of Lectures	**:**30 (24L+6T)
No. of Credits	**:**2 credits

Course Objectives:

1. Students will develop an understanding of both destructive and non-destructive forensic analysis techniques, including the interpretation of data obtained from forensic investigations.
2. Students will learn to preserve and analyze blood samples, including the study of blood components, exogenous substances, and blood stain patterns, to aid in forensic investigations.
3. Students will gain proficiency in DNA profiling methods such as RFLP, PCR, and STR, and understand their applications in forensic science, including paternity testing and criminal investigations.
4. Students will learn the legal background and methods for determining alcohol concentration in body fluids, using gas chromatography, infrared spectroscopy, and enzymatic analysis.
5. Students will acquire the skills to detect and analyze latent fingerprints using optical, physical, physicochemical, and chemical methods, including fingerprint detection in blood.
6. Students will develop expertise in identifying explosives and gunshot residues, learning analytical methods for post-blast debris and determining muzzle-to-target distances.
7. Students will learn to identify and analyze materials of forensic interest, such as explosives and gunshot residues, using advanced analytical techniques to support forensic investigations.

Course Outcomes:

CO1. Understand the fundamental principles of forensic analysis, including both destructive and non-destructive techniques, and their application in criminal investigations and gain a thorough understanding of the biochemical and genetic methods used in blood analysis and DNA profiling, including the interpretation of data for forensic purposes.

CO2. Develop technical skills in the preservation, sampling, and analysis of blood and body fluids, including the detection of alcohol, utilizing advanced techniques such as gas chromatography, infrared spectroscopy, and enzymatic methods and acquire proficiency in fingerprint analysis, including latent fingerprint detection using optical, physical, physicochemical, and chemical methods.

CO3. Engage in critical analysis of forensic evidence, applying scientific reasoning to interpret the results of DNA profiling, blood stain analysis, and material identification in forensic contexts and develop research skills by exploring advanced forensic techniques such as the identification of explosives and gunshot residues, contributing to the resolution of criminal cases.

CO4. Understand the legal framework surrounding forensic science, particularly in the context of

alcohol determination in body fluids, paternity testing, and evidence collection and adhere to ethical guidelines in the handling, analysis, and reporting of forensic evidence, ensuring the integrity and admissibility of findings in legal proceedings.

CO5. Effectively communicate forensic findings, both orally and in written reports, to law enforcement agencies, legal professionals, and other stakeholders in the criminal justice system and collaborate with multidisciplinary teams, including forensic scientists, law enforcement, and legal experts, to provide accurate and reliable forensic analysis.

CO6. Explore innovative forensic techniques and methodologies that can improve the detection, analysis, and interpretation of forensic evidence and understand the commercial and societal impact of forensic science, recognizing opportunities for innovation and entrepreneurship in forensic technology and services.

CO7. Demonstrate professionalism in forensic practice by maintaining the chain of custody, ensuring the accuracy of analytical methods, and taking responsibility for the reliability of forensic results and uphold accountability to the public and the criminal justice system, ensuring that forensic analyses contribute to fair and just legal outcomes.

Topics and Learning Point

Unit 1. Forensic analysis (3L)

Overview, destructive and non-destructive techniques, data interpretation

Unit 2. Blood analysis (3L)

Blood preservation and aging effects, analysis of blood components and exogenic substances, blood stain analysis.

Unit 3. DNA Profiling (4L)

DNA and its polymorphism, DNA typing procedures- RFLP, PCR, MVR-PCR, Dot–Plot, AMP-FLP, STR, other methods, paternity testing and applications.

Unit 4. Determination of alcohol in body fluids (4L)

Legal background, sampling and sample preservation, analysis G-, IR, enzymatic and other methods.

Unit 5. Fingerprint analysis (4L)

Latent fingerprints, optical, physical, physicochemical, and chemical detection methods, fingerprints in blood, fingerprint detection sequences

Unit 6. Materials of interest for forensic studies (6L)

a. **Explosives:** Types, and analytical methods for identification of low and high explosives in post-blast debris.
b. **Gunshot residues:** Composition of sources, detection on hands and its limitation, determination of muzzle-to-target distance, elemental and inorganic analysis.

References

1. ‘Forensic chemistry’ by Suzanne Bell, Pearson Prentice Hall Publishers,2006
2. Encyclopaedia of Analytical Chemistry, Volume 3, Academic Press,1995

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Forensic Science **Course Code:** CHA-661-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	3	0	0	0
CO3	0	0	0	3	0	0	0	0	0	0
CO4	0	0	0	0	3	0	0	0	3	0
CO5	0	0	0	0	0	3	0	0	0	0
CO6	0	0	3	0	0	0	0	0	0	0
CO7	0	0	0	0	0	0	0	0	0	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Understand the fundamental principles of forensic analysis, including both destructive and non-destructive techniques, and their application in criminal investigations, and gain a thorough understanding of the biochemical and genetic methods used in blood analysis and DNA profiling, including the interpretation of data for forensic purposes.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Develop technical skills in the preservation, sampling, and analysis of blood and body fluids, including the detection of alcohol, utilizing advanced techniques such as gas chromatography, infrared spectroscopy, and enzymatic methods, and acquire proficiency in fingerprint analysis, including latent fingerprint detection using optical, physical, physicochemical, and chemical methods.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO6: Explore innovative forensic techniques and methodologies that can improve the detection, analysis, and interpretation of forensic evidence and understand the commercial and societal impact of forensic science, recognizing opportunities for innovation and entrepreneurship in forensic technology and services.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO3: Engage in critical analysis of forensic evidence, applying scientific reasoning to interpret the results of DNA profiling, blood stain analysis, and material identification in forensic contexts, and develop research skills by exploring advanced forensic techniques such as the identification of explosives and gunshot residues, contributing to the resolution of criminal cases.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO4: Understand the legal framework surrounding forensic science, particularly in the context of alcohol determination in body fluids, paternity testing, and evidence collection, and adhere to ethical guidelines in the handling, analysis, and reporting of forensic evidence, ensuring the integrity and admissibility of findings in legal proceedings.
Communication, Collaboration, and Leadership (PO6):
CO5: Effectively communicate forensic findings, both orally and in written reports, to law enforcement agencies, legal professionals, and other stakeholders in the criminal justice system, and collaborate with

multidisciplinary teams, including forensic scientists, law enforcement, and legal experts, to provide accurate and reliable forensic analysis.

Digital Proficiency and Technological Skills (PO7):

CO2: Develop technical skills in the preservation, sampling, and analysis of blood and body fluids, including the detection of alcohol, utilizing advanced techniques such as gas chromatography, infrared spectroscopy, and enzymatic methods.

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

CO4: Adhere to ethical guidelines in the handling, analysis, and reporting of forensic evidence, ensuring the integrity and admissibility of findings in legal proceedings.

Autonomy, Responsibility, and Accountability (PO10):

CO7: Demonstrate professionalism in forensic practice by maintaining the chain of custody, ensuring the accuracy of analytical methods, and taking responsibility for the reliability of forensic results, and uphold accountability to the public and the criminal justice system, ensuring that forensic analyses contribute to fair and just legal outcomes.

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Practical
Course Name	**:** Analysis of material-II
Course Code	**:** CHA-662-MJE(A)
No. of Lectures	**:** 30
No. of Credits	**:** 2 credits

Course Objective:

1. Students will acquire skills in the analysis of various ores such as ilmenite and dolomite, focusing on the determination of key components like Ca, Mg, and silicates.
2. Students will learn to analyse the composition of alloys, including the determination of copper and tin in bronze and nickel and chromium in nichrome alloys.
3. Students will develop proficiency in determining organic carbon in soil samples and total cation concentration in wastewater, utilizing advanced analytical techniques like cation exchange resins.
4. Students will learn to determine specific compounds such as iron in detergent samples, magnesium in talcum powder, and cholesterol in serum samples, applying appropriate quantitative analysis methods.
5. Students will gain hands-on experience in performing limit tests for sulphate and chloride in pharmaceuticals, as well as analysing pigments for zinc and chromium content.
6. Students will develop the ability to separate and identify amino acids using two-dimensional paper chromatography and perform quantitative analysis of compounds like vitamin C or nitrobenzene using cyclic voltammetry.
7. Students will participate in an industrial visit or study tour, allowing them to apply theoretical knowledge in real-world contexts and gain insights into industrial analytical practices.

Course Outcomes:

CO1. Understand and apply various analytical techniques for the quantitative and qualitative analysis of different materials, including ores, alloys, and pigments. Gain expertise in the analysis of specific elements such as calcium, magnesium, nickel, chromium, copper, tin, and zinc within complex matrices like ilmenite, dolomite, and bronze.

CO2. Develop the ability to analyse environmental samples such as soil and water, focusing on the determination of organic carbon, total cation concentration, sulphate, and chloride levels. Apply analytical methods to assess industrial products like detergents and talcum powder, ensuring compliance with quality and safety standards.

CO3. Acquire practical experience in advanced instrumental techniques, including cyclic voltammetry, which is used for the quantitative analysis of compounds like vitamin C and nitrobenzene. Perform separation and identification of amino acids using two-dimensional paper chromatography, enhancing understanding of complex biochemical analyses.

CO4. Conduct limit tests for sulphates and chlorides in pharmaceutical products, such as paracetamol, ensuring adherence to regulatory standards. Demonstrate competence in the determination of cholesterol in serum samples using kit methods, relevant to clinical and pharmaceutical applications.

CO5. Develop critical thinking and problem-solving skills through the analysis of various materials, interpreting complex data, and troubleshooting analytical challenges. Enhance the ability to design, execute, and refine analytical experiments, particularly in the context of real-world industrial and environmental scenarios.

CO6. Apply theoretical knowledge in practical settings, such as industrial visits or study tours, gaining insights into the application of analytical techniques in the industry. Prepare and present detailed reports on industrial visits, demonstrating the ability to connect academic learning with industry practices.

CO7. Strengthen communication skills by reporting and presenting analytical findings clearly and effectively, both in written and oral formats. Collaborate with peers and industry professionals during laboratory sessions and industrial visits, fostering teamwork and professional networking.

Topics and Learning Point

1. Analysis of ilmenite ore
2. Analysis of Dolomite ore for Ca, Mg and silicate material
3. Analysis of Bronze with respect to copper and tin
4. Analysis of nichrome alloy with respect to nickel and chromium
5. Determination of organic carbon from soil sample
6. Determination of magnesium from talcum Powder
7. Determination of total cation concentration in waste water sample by cation exchange resin
8. Analysis of water with respect to sulphate and chloride
9. Limit test: i) sulphate and chloride from paracetamol.
10. Preparation of solid - state material: Nickel ferrite.
11. To estimate ketone bodies from given sample.
12. To separate out the given amino acids by using two-dimensional paper chromatography.
13. Quantitative analysis using cyclic Voltammetry of vitamin c.
14. Determination of cholesterol from serum sample by kit method.
15. Quantitative analysis using cyclic Voltammetry of nitrobenzene
16. Preparation of Cu (O-Phen)$_2$.
17. Determination of BOD from waste water sample.
18. Determination of glucose concentration from saline sample by polarimetry.

(Note: Minimum 15 experiments should be completed in this course.)

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 4thEd.Part -2, Beckette, Sten Lake.

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Analysis of material-II **Course Code:** CHA-662-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	0	0	0	3	0	0	0
CO4	0	0	0	0	3	0	0	0	0	0
CO5	0	0	0	3	0	0	0	0	0	0
CO6	0	0	3	0	0	0	0	0	0	0
CO7	0	0	0	0	0	3	0	0	0	0
CO8	0	0	0	0	0	0	0	3	0	0
CO9	0	0	0	0	0	0	0	0	3	3

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Understand and apply various analytical techniques for the quantitative and qualitative analysis of different materials, including ores, alloys, and pigments. Gain expertise in the analysis of specific elements such as calcium, magnesium, nickel, chromium, copper, tin, and zinc within complex matrices like ilmenite, dolomite, and bronze.
Practical, Professional, and Procedural Knowledge (PO2):
CO2: Develop the ability to analyze environmental samples such as soil and water, focusing on the determination of organic carbon, total cation concentration, sulphate, and chloride levels. Apply analytical methods to assess industrial products like detergents and talcum powder, ensuring compliance with quality and safety standards.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO6: Apply theoretical knowledge in practical settings, such as industrial visits or study tours, gaining insights into the application of analytical techniques in the industry. Prepare and present detailed reports on industrial visits, demonstrating the ability to connect academic learning with industry practices.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO5: Develop critical thinking and problem-solving skills through the analysis of various materials, interpreting complex data, and troubleshooting analytical challenges. Enhance the ability to design, execute, and refine analytical experiments, particularly in the context of real-world industrial and environmental scenarios.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO4: Conduct limit tests for sulphates and chlorides in pharmaceutical products, such as paracetamol, ensuring adherence to regulatory standards. Demonstrate competence in the determination of cholesterol in serum samples using kit methods, relevant to clinical and pharmaceutical applications.
Communication, Collaboration, and Leadership (PO6):
CO7: Strengthen communication skills by reporting and presenting analytical findings clearly and effectively, both in written and oral formats.
CO8: Collaborate with peers and industry professionals during laboratory sessions and industrial visits, fostering teamwork and professional networking.
Digital Proficiency and Technological Skills (PO7):
CO3: Acquire practical experience in advanced instrumental techniques, including cyclic voltammetry, used for the quantitative analysis of compounds like vitamin C and nitrobenzene. Perform separation and

identification of amino acids using two-dimensional paper chromatography, enhancing understanding of complex biochemical analyses.

Multicultural Competence, Inclusive Spirit, and Empathy (PO8):

CO8: Collaborate with peers and industry professionals during laboratory sessions and industrial visits, fostering teamwork and professional networking.

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

CO9: Uphold ethical standards in the analysis and reporting of data, ensuring accuracy, precision, and reliability in all experimental procedures. Understand the importance of safety and environmental considerations in the handling and disposal of chemicals used in material analysis.

Autonomy, Responsibility, and Accountability (PO10):

CO9: Uphold ethical standards in the analysis and reporting of data, ensuring accuracy, precision, and reliability in all experimental procedures. Understand the importance of safety and environmental considerations in the handling and disposal of chemicals used in material analysis.

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

Name of the Program	**:**M.Sc. Chemistry
Program Code	**:**CHE
Class	**:**M.Sc. II
Semester	**:**IV
Course Type	**:**Mandatory Practical
Course Name	**:** Innovative experiments in analytical chemistry
Course Code	**:** CHA-662-MJE(B)
No. of Lectures	**:** 60
No. of Credits	**:** 2 credits

Course Objectives:

1. Students will gain expertise in the chemical analysis of key ores such as Bauxite and Hematite, as well as determining the composition of alloys, particularly with respect to aluminum, magnesium, and iron content.
2. Students will learn the synthesis of semiconducting nanoparticles, such as Fe_2O_3, and develop an understanding of nanomaterial preparation methods and their significance in modern analytical and material science.
3. Students will develop the ability to analyze biological samples (e.g., determination of cholesterol, casein in milk, urea from serum) and environmental samples (e.g., estimation of Mn in tea leaves, pigment extraction from marigold flowers).
4. Students will synthesize and characterize inorganic compounds, such as dichloro (triphenyl phosphine) nickel (II) sulfate, potassium hexathiocyanatochromate (III), nickel oxide, and zinc ferrite, applying knowledge of solid-state material chemistry.
5. Students will perform Thermogravimetric Analysis (TGA) to determine the composition of mixtures such as $CuSO_4$ and NaCl, enhancing their understanding of thermal properties and decomposition processes in chemical compounds.
6. Students will conduct experiments to determine the anion and cation exchange capacities of ion exchange resins, emphasizing their applications in water treatment and chemical separation processes.
7. Students will prepare solid-state materials such as Nickel Oxide, Zinc Ferrite, and Chrome Alum, applying principles of solid-state chemistry and exploring their applications in materials science and industry.

Course Outcomes:

CO1. Understand and apply methods for analysing bauxite and hematite ores to determine their elemental composition. Develop skills in the quantitative analysis of metals like aluminium, magnesium, silicon dioxide, calcium, and iron in various materials such as cement and alloys.

CO2. Learn the techniques involved in synthesizing semiconducting nanoparticles, particularly iron oxide (Fe_2O_3), and their application in materials science.

CO3. Master the techniques for the analysis of biological samples, such as determining total casein content in milk and extracting pigments or oils from natural sources like marigold flowers. Gain proficiency in estimating cholesterol using the ferric chloride method and

analysing urea levels from serum samples using kit methods. Promote awareness of the ethical considerations in material analysis, ensuring accuracy and responsibility in reporting results. Understand the environmental impact of material extraction and synthesis processes, emphasizing sustainability in the lab.

CO4. Develop analytical techniques for assessing anion exchange capacity in resins and estimating trace metals, such as manganese in tea leaves and copper in fungicides. Understand the importance of metal ions in environmental and agricultural contexts through practical estimation methods.

CO5. Synthesize complex compounds such as dichloro (triphenylphosphine) nickel (II) sulphate and potassium hexathiocyanatochromate (III), gaining a practical understanding of coordination chemistry. Develop skills in synthesizing solid-state materials like nickel oxide and zinc ferrite, expanding the understanding of material properties.

CO6. Apply thermogravimetric analysis (TGA) for determining the composition of mixtures, such as $CuSO_4$ and NaCl, calculating the percentage of each component in mixed samples.

CO7. Learn and apply methods for the preparation of chrome alum, gaining insights into both traditional and advanced synthesis techniques. Gain hands-on experience in a variety of analytical methods and synthetic techniques, including the preparation of solid-state and coordination compounds. Develop the ability to conduct experiments, interpret data, and present findings with scientific accuracy and clarity.

Topics and Learning Point

1. Analysis of Bauxite ore from given sample.
2. Determination of aluminum and magnesium from alloy.
3. Analysis of cement with respect to silicon dioxide, calcium, Iron, magnesium and aluminum.
4. Synthesis of semiconducting Nanoparticles such as Fe_2O_3.
5. Determination of total casein in milk
6. Analysis of Hematite ore.
7. Estimation of cholesterol by ferric chloride method.
8. Extraction of pigment slash oil from Marigold flower.
9. Estimation of urea from serum by kit method.
10. Determination of anion exchange capacity of anion exchange resin.
11. Estimation of Mn from tea leaves.
12. Estimation of Cu from fungicide.
13. Preparation of dichloro (triphenyl phosphine) nickel (II) sulphate.
14. Preparation of potassium hexathiocyanato chromate (III).
15. Preparation of solid - state material: Nickel Oxide.
16. TGA for Analysis of $CuSO_4$ and NaCl find out the percentage of each constituent in mixture
17. Preparation of solid - state material Zinc Ferrite.
18. Preparation of chrome alum.

(Note: Minimum 15 experiments should be completed in this course.)

.Report on industrial visit or study tour

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 4thEd.Part -2, Beckette, Sten Lake.
9. Practical clinical biochemistry, Harold Varley (4^{th} edition), CBS publishers and distributers, New Delhi-110002
10. Analytical chemistry by Gary Christian, 6^{th} edition,2008
11. Experimental inorganic.chemistry by W.G Palmer
12. .The analysis of minerals and ores of rare elements: W.R. Schoeller, AR. Powell Charles, Griffin and , company limited.

Choice Based Credit System Syllabus
(NEP Pattern)

Class: M.Sc. II (SEM. IV) **Subject:** Analytical Chemistry
Course: Innovative experiments in analytical chemistry **Course Code:** CHA-662-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	0	3	0	0	0	0	0	0	0
CO3	0	3	0	0	3	0	0	3	3	0
CO4	0	0	0	3	0	0	0	0	0	0
CO5	0	0	0	0	0	0	0	0	0	3
CO6	0	0	0	3	0	0	3	0	0	0
CO7	0	0	0	0	3	3	0	0	0	0

Justification of Mapping

Comprehensive Knowledge and Understanding (PO1):
CO1: Understand and apply methods for analysing bauxite and hematite ores to determine their elemental composition. Develop skills in the quantitative analysis of metals like aluminium, magnesium, silicon dioxide, calcium, and iron in various materials such as cement and alloys.
Practical, Professional, and Procedural Knowledge (PO2):
CO3: Master the techniques for the analysis of biological samples, such as determining total casein content in milk and extracting pigments or oils from natural sources like marigold flowers. Gain proficiency in estimating cholesterol using the ferric chloride method and analysing urea levels from serum samples using kit methods. Promote awareness of the ethical considerations in material analysis, ensuring accuracy and responsibility in reporting results.
Entrepreneurial Mindset, Innovation, and Business Understanding (PO3):
CO2: Learn the techniques involved in synthesizing semiconducting nanoparticles, particularly iron oxide (Fe_2O_3), and their application in materials science.
Specialized Skills, Critical Thinking, and Problem-Solving (PO4):
CO4: Develop analytical techniques for assessing anion exchange capacity in resins and estimating trace metals, such as manganese in tea leaves and copper in fungicides. Understand the importance of metal ions in environmental and agricultural contexts through practical estimation methods.
CO6: Apply thermogravimetric analysis (TGA) for determining the composition of mixtures, such as $CuSO_4$ and NaCl, calculating the percentage of each component in mixed samples.
Research, Analytical Reasoning, and Ethical Conduct (PO5):
CO3: Master the techniques for biological sample analysis and promote awareness of ethical considerations in material analysis, ensuring accuracy and responsibility in reporting results.
CO7: Gain hands-on experience in a variety of analytical methods and synthetic techniques, including the preparation of solid-state and coordination compounds. Develop the ability to conduct experiments, interpret data, and present findings with scientific accuracy and clarity.
Communication, Collaboration, and Leadership (PO6):
CO7: Gain hands-on experience in analytical and synthetic methods, developing the ability to conduct and present experiments and data clearly.
Digital Proficiency and Technological Skills (PO7):
CO6: Apply thermogravimetric analysis (TGA) to determine the composition of mixtures and calculate percentages of components, showcasing the use of advanced instruments and techniques.

Multicultural Competence, Inclusive Spirit, and Empathy (PO8):
CO3: Promote ethical awareness in material analysis, encouraging responsibility and sustainability, highlighting empathy toward environmental impacts in lab practices.
Value Inculcation, Environmental Awareness, and Ethical Practices (PO9):
CO3: Highlight the environmental impact of material extraction and synthesis processes, emphasizing sustainability in lab practices.
Autonomy, Responsibility, and Accountability (PO10):
CO5: Synthesize complex compounds, including solid-state materials, demonstrating independent experimental work and responsibility for the accuracy and outcomes of the results.

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 : IV
Course Type : Project work
Course Name : Research Project
Course Code : CHA-621-RP
No. of Lectures : 90
No. of Credits : 6 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 analyse 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.

Topics and Learning Points

Project shall be started at the beginning of the SEM IV 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 encouraged to 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. IV) **Subject:** Analytical Chemistry
Course: Research Project **Course Code:** CHA-681-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.