University of Mumbai

No. AAMS_UGS/ICC/2024-25/150

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the Board of Deans at its meeting held on 3rd September, 2024 **vide** item No. 6.8(N) have been accepted by the Hon'ble Vice Chancellor as per the power confirmed upon him under section 12(7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus for **M.Sc. (Analytical Chemistry) (Sem – III & IV) for University Department of Chemistry (Autonomous)** as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
21st September, 2024

(Dr. Prasad Karande)
REGISTRAR

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

BOD 6.8(N) 03/09/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science,
3) The Chairman, **Board of Studies in Chemistry**
4) The Director, Board of Examinations and Evaluation,
5) The Director, Department of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	**Faculty of Humanities,** **Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Associate Dean** 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, **Dean** 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in **Associate Dean** 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology **Dean** 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in **Associate Dean** 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, **Dean** 1.Dr. Anil K. Singh aksingh@trcl.org.in **Associate Dean** 2.Prin.Chadrashekhar Ashok Chakradeo cachakradeo@gmail.com
3	Chairman, Board of Studies,
4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

BOD – 3/9/2024
12 (7) of M.P.U.A. 2016
Item No. – 6.8 (N)

As Per NEP 2020

University of Mumbai

Title of the P.G. Program
M.Sc. (Analytical Chemistry)

Syllabus for

Semester – Sem.- III & IV

Department of Chemistry (Autonomous)

Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	Title of program O:_____	M.Sc. (Analytical Chemistry)
2	Scheme of Examination R: _____	NEP 50% Internal 50% External, Semester End Examination Individual Passing in Internal and External Examination
3	Standards of Passing R: _____	40%
4	Credit Structure R: SPA – 35 B	Attached herewith
5	Semesters	Sem. III & IV
6	Program Academic Level	6.5
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic Year	2024-25

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

Preamble

1) Introduction

This program is designed to provide a comprehensive and in-depth understanding of the fascinating world of Analytical Chemistry. Through a rigorous academic curriculum and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. The M.Sc. (Analytical Chemistry) course is structured to equip students with a strong theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of chemistry. Our esteemed faculty members are experts in their respective fields, with a passion for both teaching and research. They are committed to providing a nurturing learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences.

We envision our M.Sc. (Analytical Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry. Whether your passion lies in research, industry, education, or beyond, our program aims to provide the knowledge and skills necessary to excel in your chosen path.

2) Aims and Objectives

The aims and objectives of M.Sc. (Analytical Chemistry) course are designed to provide students with a well-rounded and advanced education in the field of Analytical chemistry. These goals focus on equipping students with a deep understanding of chemical principles, fostering research and analytical skills, and preparing them for successful careers in various sectors of the chemical sciences.
The M.Sc. (Analytical Chemistry) course aims to produce skilled and knowledgeable professionals who can contribute to scientific research, industrial innovation, and the betterment of society through their expertise in Analytical chemistry.

3) Learning Outcomes

The learning outcomes of an M.Sc. (Analytical Chemistry) course are designed to equip students with a comprehensive and advanced understanding of the field of chemistry. These learning outcomes reflect the knowledge, skills, and competencies that students are expected to gain upon successful completion of the program.

4) Any other point (if any) : The skills and knowledge acquired during this master's program will make the students well-equipped for diverse roles.

5) Credit Structure of the M.Sc. (Analytical Chemistry) (Sem I, II, III & IV) (Table as per परिशिष्ट-1 with sign of HOD and Dean)

R _____

Post Graduate Program: M.Sc. (Analytical Chemistry)

परिशिष्ट-1

Year	Level	Sem	Major				RM	OJT/ FP	RP	Cum. Cr.	Degree
			Mandatory			Electives					
1	6.0	Sem I	3*4+ 2=14			4	4		-	22	PG Diploma (after 3 Years Degree)
			Physical Chemistry-I (112016150111)	TH	4	Organic Chemistry-I (112016150311) **(OR)** Applied Industrial Chemistry-I (CHEM 50512)/ 112016150512	Research Methodology (112016150611)				
			Inorganic Chemistry-I (112016150211)	TH	4						
			Analytical Chemistry-I (112016150511)	TH	4						
			Chemistry Practical-I (112016150411)	PR	2						
		Sem II	3*4+ 2=14			4	-	4 (11201625121 1)	-	22	
			Physical Chemistry-II (112016250711)	TH	4	Organic Chemistry-II (112016250911) **(OR)** Applied Industrial Chemistry-II (112016251112)					
			Inorganic Chemistry-II (112016250811)	TH	4						
			Analytical Chemistry-II (112016251111)	TH	4						
			Chemistry Practical-II (112016251011)	PR	2						
Cum. Cr. For PG Diploma			28			8	4	4		44	
Exit Option: PG Diploma (44 credits) after Three Year UG Degree											

R: SPA – 35 B

Year	Level	Sem (2yr)	Major				RM	OJT/FP	RP	Cum. Cr.	Degree
2	6.5	Sem III	3*4+ 2=14			4	-	-	4 (CHEM 666)	22	PG Degree after 3-yr UG or PG Degree after 4-yr UG
			Separation Techniques (CHEM 661)	TH	4	Special Topics in Analytical Chemistry - I (CHEM 66511) OR Special Topics in Analytical Chemistry - II(CHEM 66512)					
			Spectroscopic Techniques (CHEM 662)	TH	4						
			Electrochemical Techniques Sensors and Environmental Management (CHEM 663)	TH	4						
			Analytical Chemistry Practical (CHEM 664)	PR	2						
		Sem IV	3*4=12			4	-	-	6 (CHEM 671)	22	
			Quality In Analytical Chemistry and Pharmaceutical Analysis (CHEM 667)	TH	4	Intellectual Property Rights and Chemoinformatics (CHEM 67011) **(OR)** Special Topics In Analytical Chemistry-I (CHEM 67012) **(OR)** Special Topics In Analytical Chemistry-II (CHEM 67013)					
			Advanced Instrumental Techniques and nanotechnology (CHEM 668)	TH	4						
			Analysis of Ores, Food, Agro / Agriculture (CHEM 669)	TH	4						
Cum. Cr. For 1 Yr PG Degree			26			8			10	44	
Cum. Cr. For 2 Yr PG Degree			54			16	4	4	10	88	

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, identify and accomplish a solution to problems encountered in the field of research and analysis.

2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry.

5. Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

6. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

7. Exhibit professional work ethics and norms of scientific development.

Syllabus for
M.Sc. (Analytical Chemistry)
(Sem. III & IV)

Semester – III

PROGRAM(s): M.Sc.-II	SEMESTER: III
Course: Paper-I	Course Code: CHEM 661 Course Title:- Separation Techniques

Teaching Scheme			Evaluation Scheme	
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. To understand the extraction equlibria using liquid ion exchangers and crown ether and the parameters influencing extraction and the applicability of solvent extraction.
2. To learn principles of supercritical fluid extraction, solid phase microextraction with their applications.
3. To learn the various chromatographic techniques with their applications.
4. To learn the basic principles of microfiltration, ultrafiltration, reverse osmosis, dialysis, electrodialysis and liquid membranesfor various separations.

Course Outcomes:

1. At the end of the course, the students will learn the use of solvent extraction, supercritical fluid extraction and solid phase microextraction for various applications.
2. The students will be made to understand ion exchange chromatography, ion chromatography, supercritical fluid chromatography as an analytical tool and method development in HPLC, and concept of preparative chromatography and UPLC. Students also learn the use of various membrane methods for separations.

Semester – III

Paper -I

Course Code: CHEM 661
SEPARATION TECHNIQUES

Unit I **[15L]**

1.1 Solvent Extraction: Extraction equilibria of Liquid cation exchangers, liquid anion exchangers and crown ethers. Nature of extracted species. Parameters influencing extraction including e.g. role of diluents, aggregation, third phase formation and counter ion. Applications of liquid-liquid extraction in metallurgy and biotechnology.

Unit II **[15L]**

2.1 Supercritical Fluid Extraction: Principles, instrumentation and applications. [5L]

2.2 Solid Phase Micro Extraction: Sorbents, methodology, applications and automation. [3L]

2.3 Ion Exchange Chromatography: Synthetic resin based ion exchangers. Type of resin matrices. Breakthrough volume and capacity. Inorganic ion exchangers, chelating ion exchangers, imprinted functional polymers, ligand exchange for separation of organic molecules and enantiomers. [7L]

3.1 **Unit III** **[15L]**

Ion Chromatography: Suppressor reactions, instrumentation, standard operating conditions, single column ion chromatography, coupled ion-chromatography. Applications. [7L]

3.2 Size Exclusion Chromatography: Theory, type of packings, molecular mass determination. Large scale purification of large bio molecules. [4L]

3.3 Super Critical Fluid Chromatography: Instrumentation, effect of pressure, mobile phases, comparison with LC and GC. Applications. [4L]

4.1 **Unit IV** **[15L]**

Method development in HPLC: Selection of stationary phases and mobile phases, gradient elution, polarity index, comparison of detectors, hybrid columns, chiral chromatography, separations in pharmaceuticals and agrochemicals and PLRP-S. Concept of Preparative chromatography and UPLC. [7L]

4.2 Membrane based Separations: Principles and applications of microfiltration, ultrafiltration, reverse osmosis, dialysis and [8L]

electrodialysis. Liquid membranes.

Text/ References:

1. Solvent Extraction Separation of Elements with Liquid Ion Exchangers, S. M. Khopkar, New Age Science Ltd., (2009).
2. Solvent Extraction Principles and Practice, 2nd Edition, J. Rydberg, M. Cox, C. Musikas, G. Choppin, Marcel Dekker, New York, (2004).
3. Solvent Extraction in Biotechnology, K. Schugert, Springer-Verlag Berlin Heidelberg, New York, (1994).
4. Solvent Extraction Chemistry, T. Sekine, Y. Hasegawa, Marcel Dekker, New York, (1977).
5. Supercritical Fluid Extraction, L. Taylor, John Wiley, New York, (1996).
6. Membrane Separation Process, K. Nath, PHI learning Pvt. Ltd., (2008).
7. Analytical Separation Science (Volume 1-5), J. L. Anderson, A. Berthod, V. Pino, A. M. Stalcup, WILEY-VCH, (2015).
8. Ion Exchange Materials Properties and Applications, 1st Edition, A. A. Zagorodni, Elsevier, (2007).
9. Introduction to Instrumental Analysis, R. D. Brown, McGraw Hill, (1987).
10. Instrumental Methods of Analysis , H. H. Willard, L. L. Meritt, J. A. Dean, Affiliated East-West Press, (1977).
11. Introduction to Modern Liquid Chromatography, L. R. Snyder, J. J. Kirkland, J. W. Doland, John Wiley, New Jersey (2010).
12. Practical HPLC Method Development, L. R. Snyder, J. J. Kirkland, J. L. Glajch (2nd edition) John Wiley (1997).
13. A practical Handbook of Preparative HPLC, D. A. Wellings, Elsevier (2006)
14. Ultra-High Perofrmance Liquid Chromatography and its Applications, Q. A. Xu (ed), John Wiley (2013).
15. Selection of the HPLC Method in Chemical Analysis, S. C. Moldoveanu, V. David, Elsevier, (2017).
16. Principles of Instrumental Analysis, D. A. Skoog, F. James Hollier, T. A. Naiman, Harcourt College Publishers, Harcourt India Pvt. Ltd., (1998).
17. Chemical Separations and Measurements Introduction to Separation Science, B. L. Kauger, L. R. Snyder, C. Howath, John Wiley, New York, (1973).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Paper-II	Course Code: CHEM 662 Course Title:- Spectroscopic Techniques			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To understand the characteristic absorption vibrational frequencies of functional groups,present in organic compounds along with correlation between IR and Raman spectra.
2. To grasp the various concepts of nuclear magnetic resonance spectroscopy particularly with reference to the ^{1}H and ^{13}C NMR nuclei.
3. To learn the different kinds of terminologies and concepts involved in the mass spectrometry with special emphasis on fragmentation pattern.
4. To develop the problem-solving ability amongst the students for identification of correct structure of organic compounds based on data availability such as ^{1}H, ^{13}C, IR and mass.

Course outcomes:

1. At the end of the course, the students will learn the conceptual IR and Raman spectroscopy with the mastery in interpretation of IR spectra.
2. Students will understand the concepts and terminologies involved in NMR, Mass, and ESR spectroscopic techniques.
3. Postgraduates will apply the learned concepts of these techniques for spectral interpretation which help them to find out the structure of synthesized unknown organic compounds.
4. This course will also help the student in project component of the master course for structural elucidation of unknown organic compounds.
5. Students will develop the problem-solving ability for the identification of the correct structure of organic compounds based on data availability such as ^{1}H, ^{13}C, IR and mass.

Paper II

Course Code: CHEM 662
SPECTROSCOPIC TECHNIQUES

1.1 **Infra-Red Spectroscopy** **[15]**

Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds), Effect of hydrogen bonding, Solvent effect on vibrational frequencies, Overtones and Combination bands. [10L]

1.2 **Raman Spectroscopy** [5L]

Classical and Quantum theory of Raman Scattering, Experimental Methods, Correlation of Infrared and Raman Spectra, Normal Modes of vibrations.

Unit II: **[15]**

2.1 **Nuclear Magnetic Resonance Spectroscopy (^{1}H NMR)** [8L]

Chemical and magnetic equivalent protons, Chemical shift, Spin-spin coupling, Different types of coupling, Factors affecting to coupling constant, Karplus equation, Spin system (AB, AX, ABX, AMX), Shift reagents, Nuclear Overhouser Effect (NOE).

2.2 **Nuclear Magnetic Resonance Spectroscopy (^{13}C NMR)** [7L]

Introduction, Chemical shift of aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon, Effect of substituents on chemical shift.

Unit III: **[15]**

3.1 **Mass spectrometry**

Introduction, Ion analysis, Ion abundance, Factors affecting to the fragmentation, Fragmentation of different functional groups, Molecular ion peak, Isotopic peak, Metastable peak, Nitrogen rule, MacLafferty rearrangement, Retro-Diels-Alder reaction.

Unit IV: **[15L]**

4.1 **Problems:** Based on joint applications of IR, ^{1}H NMR, ^{13}C NMR, and Mass spectrometric techniques. [10L]

4.2 **Electron Spin Resonance Spectroscopy**

Introduction, Principle of ESR spectroscopy, Instrumental aspect, The 'g' factor, Factors affecting to the 'g' value, Hyperfine splitting in various structures, Zero field splitting, Kramers degeneracy, Applications to free radicals and transition metal complexes. [5L]

Text/ References:

1. Donald Pavia; Gary Lampman, Introduction to Spectroscopy, 4th Edition.
2. Barbara H. Stuart, Infra-red Spectroscopy: Fundamentals and Applications.
3. R. M. Silverstein; F. X. Webster, Spectroscopic Identification of Organic Compounds, 6th Edition, John Wiley and Sons.
4. William Kemp, Organic Spectroscopy

5. Harald Gunther, NMR Spectroscopy, Basic principles, Concepts and Applications in Chemistry.
6. Atta-Ur-Rehman; Verlag; Nuclear Magnetic Resonance: Basic Principles (1986).
7. Phillip Crews; Rodriguez; Jaspars; Organic structure Analysis, Oxford University Press (1998).
8. Joseph B. Lambert; Shurvell; Lightner; Cooks, Organic Structural Spectroscopy, Prentice-Hall (1998).
9. Jackmann and Sternhell S, NMR Spectroscopy of Organic compounds.
10. R. K. Harris, Nuclear magnetic Resonance, Pitman, London, 1983.
11. D. N. Sathyanarayana,Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR, I K International Publishing House Pvt. Ltd 2009.
12. Edmond de Hoffmann; Vincent Stroobant, Mass Spectrometry: Principles and Applications, 3rd Edition.

	PROGRAM(s): M.Sc.-II			**SEMESTER: III**
	Course: Paper-III			**Course Code: CHEM 663** **Course Title:- Electrochemical Techniques Sensors and Environmental Management**
	Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**–**	**04**	**50**	**50**

Course Objectives:

1. Students will learn the fundamental theory that supports electroanalytical measurements. Modern techniques used for chemical analysis and mechanistic studies will be presented so that real world analysis problems can be investigated.
2. To discuss need of sensors, their classification, advantages and disadvantages. Also discuss working of different types of chemical, optical, thermal, biochemical sensors and recent trends in sensor technology and their selection.
3. To learn solid waste characteristics and its sources, different methods of treatment of solid waste, discuss the significance of recycling reuse and reclamation of solid wastes, relationships between environmental guidelines, human activities and quality of impacted soil, water and air.

Course Learning Outcomes.

After completing the course students will be able to:

1. Apply electrochemical methods such as: polarography, cyclic voltammetry, chronoamperometry, chronopotentiometry, chronocoulometry etc for the investigation of various analytical samples.
2. Get familiar with the constructions and working principle of different types of sensors and aware about and measuring instruments and understand the functioning of various sensors for different analyte measurements.
3. The student should be able to state solid waste characteristics and its sourcesidentify and analyze different methods of treatment of solid waste andillustrate Industrial practices in solid waste management.

Paper III

Course Code: CHEM 663

ELECTROCHEMICAL TECHNIQUES SENSORS AND ENVIRONMENTAL MANAGEMENT

Unit I: **[15L]**

1. **Voltammetry and polarography:**Necessity and development of new voltammetric techniques and their comparison with classical DC polarography, Current sampled (TAST) polarography, Pulse (normal, differential and differential double pulse) Polarography, AC and square wave, linear sweep voltammetry and cyclic voltammetry, criteria of reversibility of electrochemical reactions, Quasi reversible and irreversible processes.

Unit II: **[15L]**

2..1 Stripping voltammetry, adsorptive stripping voltammetry, voltammetry with ultra micro electrodes chemically modified electrodes. Applications of electrochemical methods in organic synthesis.

2.2 **Chronotechniques:**Chronopotentiometry and Chronoamperometry, Chronocoulometry

2.3 **Quartz crystal microbalance:** Principles, methodology and applications.

Unit III:

Chemical Sensors: **[15L]**

3.1 Introduction to principles of chemical sensing: Signal transduction; Physico-chemical and biological transducers; Sensor types and technologies. Screen-printed electrodes

3.2 **Physico-chemical sensors and transducers:**Thermal sensors; Electrochemical sensors (amperometric, potentiometric, conductimetric); Semiconductor transducers (ISFET); Optical transducers (absorption, fluorescence, bio/chemiluminescence, SPR); Piezoelectric and acousticwave transducers; An Overview of Performance and Applications.

3.3 **Biochemical sensors**

Enzymes; Oligonucleotides and Nucleic Acids; Lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors.

3.4 **Applications:**

Environmental monitoring; Technological process control; Food quality control; Clinical chemistry; Test-strips for glucose monitoring; Screen printed electrodes; Implantable sensors for long-term monitoring; Forensic science.

Unit IV:

Environmental Management: [15L]

4.1 Solid waste management: Objectives of solid waste management, Hazardous wastes: Bio- medical, radioactive and E-waste, concept of recycle, reuse and recovery, disposal and management of solid industrial waste. Bioremediation and phytoremediation.

4.2 Environmental impact assessment: concept, process and evaluation methodology for the same.

Reference Books:

1. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York (1980).
2. Electrochemical Methods, A. J. Bard and L. R. Faulkner, John Wiley, New York (1980).
3. Electrochemical Methods, Allen J. Bard, Larry R. Faulkner and Henry S. White, Fundamentals and Applications, 3rd Edition, John Wiley, New York (2022).
4. Electrochemistry for Chemists, 2nd Ed., Donald T. Sawyer, A. Sobkowiak and J. L. Roberts, Jr., John Wiley, New York (1994).
5. Cyclic Voltammetry and the frontiers of Electrochemistry, M. Noel and K. I. Vasu, IBH, New Delhi. (1990).
6. Technique and Mechanism in Electrochemistry, P. A. Christensen and A. Hamnett, Blackie Academic and Professional (1994).
7. Electroanalytical Chemistry, Ed. A.J. Bard, Marcel Dekker, New York, A Series of volumes.
8. Electroanalytical Chemistry, J.J. Lingane, 2nd Ed., Interscience, New York (1958).
9. Principles of Instrumental Analysis, D.A. Skoog, F.J. Holler, and J.A. Nieman 5th Edition (1998).
10. Jiri Janata, Principles of Chemical Sensors, Plenum Press, 1990
11. Principles of Chemical and Biological Sensors, D. Diamond Editor, John Wiley& Sons, 2000.
12. Chemical Sensors and Biosensors, Brian Eggins, John Willey & Sons, 2002.
13. Sensors, Nanoscience, Biomedical Engineering, and Instruments. Richard Dorf Editor, CRC Taylor & Francis, 2006
14. Optical Biosensors. Present & Future. Editors: F. Ligler, C. Rowe Taitt, Elsevier, 2002.
15. Introduction to Bioanalytical Sensors, Alice Cunningham, John Wiley& Sons, 1998.
16. Chemical Sensors and Biosensors for Medical and Biological Applications, Ursula Spichiger-Keller,Wiley-VCH, 1998.
17. Environmental Chemistry, A.K. De, 2nd Ed., Wiley, 1989.
18. Fundamentals of Environmental Chemistry. S.E. Manahan, 3rd Ed., CRC Press, 2009.
19. Solid and Hazardous Waste Management. S.C. Bhatia, Atlantic Publishers & Distributers (P) Ltd. New Delhi, 2007.
20. Environmental pollution and Control. J. J. Peirce, R. F. Weiner and P. A. Vesilind, 4thEdn. Butterworth-Heinemann, USA, 1998.
21. E-waste: implications, regulations, and management in India and current global best practices. Rakesh Johri, TERI Press, New Delhi, 2009.

Paper IV

Course Code: CHEM 664
ANALYTICAL CHEMISTRY PRACTICAL I

	PROGRAM(s): M.Sc.-II			**SEMESTER: III**
	Course: Paper IV			**Course Code: CHEM 664** **Course Title:-Analytical Chemistry Practical**
	Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**–**	**02**	**50**	**50**
	Course Objectives: The students will gain familiarity with the principles and particularly applications of fundamental procedures and advanced spectroscopic, electroanalytical, chromatographic techniques in analysis of organic compounds, medicinal and food products, blood/serum, ores and alloys, metals etc.			
	Course Learning Outcomes. After completing the course students will be able to: 1. Select the Non-instrumental and instrumental analytical methods for assay/analysis of variety of samples like pharmaceutical formulations, food products, organic materials, biological samples, ores and alloys to check the purity and main constituents along with the impurities present in the samples. 2. Learners will train to handle instruments like UV-Visible spectrophotometer, Colorimeter, potentiometer, Atomic absorption spectrophotometerand Electrochemical potentiostat.			

[Students have to perform any eight experiments from the following]

Organic, medicinal, food, detergents, biochemical, electroanalytical:

Organic analysis:

1. Determination of Sulphur compounds eg. Methyleneblue.

Analysis of medicinal:

2. Complete pharmacopoeial assay of acetyl salicylic acid. (I.P.).

3. Benzoic acid and salicylic acid in Whitfield ointment.

Analysis of food products:

4. Fe, Ca, and P in milk powder in milk by Spectrophotometric method.

Biochemical analysis: Determination of the following in serum/blood.

5. Uric acid/Sugar/Cholesterol.

Electroanalytical methods:

6. Determination of mixture of acids eg. HCl and phosphoric acid potentiometrically using glass electrode.
7. Determination of reversibility of a redox system and area of an electrode by cyclic voltammetry.

Minerals, Ores, Alloys, Spectrometry and Column Chromatography:

Ores &Alloy:

8. Bauxite: Al (gravimeric), Fe (volumetric), Ti (colorimetric).
9. Ilmenite : Ti (gravimetric/volumetric), Fe (colorimetric).
10. Steel and stainless steel: Ni (homogeneous precipitation), Cr (volumetric), Mn (spectrophotometric).

Spectrophotometry:

11. Determination of copper and bismuth of a mixture using EDTA spectrophotometrically.
12. Determination of copper by extractive photometry using diethyldithiocarbamate.

Column Chromatography:

13. Separation of cadmium and zinc on an anion exchanger.
14. Determination of capacity of cation exchange resin.

List of References/Books for Practical:

1. Vogel's textbook of Quantitative Inorganic analysis, 5th ED. ELBS (1991).
2. Quantitative Organic Analysis, Part III, A. I. Vogel, 2nd Ed. CBS (1987).
3. Colorimetric Analytical Methods, 9th Ed. L. C. Thomas and G. J. Chamberlin, The Tintometer Salisbury, England (1980).
4. Spectrometric Identification of Organic compounds, T. C. Morrili, R. H. Silverstein and G.C. Bossler, Wiley (1981).
5. Indian Pharmacopeia 2010, Vol. I, II, III and Addendum 2012, 6th Ed. The Indian Pharmacopoeia Commission, Ghaziabad, 2010.
6. British Pharmacopeia.
7. Chemical Analysis of Food and Food Products, H. B. Jacob, Van Nostrand Reinhold (1958).
8. Encyclopedia of Industrial Chemical Analysis, Eds. F. D. Snell and L. S. Etter, Interscience, A series of Volumes.

9. Manual of food quality central, food analysis quality, Adulteration and tests of identity, a series of volumes, F.A.O. Rome (1986).

10. Food Analysis, A.G. Woodman. McGraw Hill (1941).

11. Analytical Biochemistry, D.J. Holme and H. Peck, Longman (1983).

12. Bioanalytical Chemistry, S. R. Mikkelsen and E. Corton, John Wiley and sons, 2004.

13. Hawk's Physiological Chemistry, Mc Graw Hill.

14. Vogel's Textbook of Quantitative Chemical Analysis, 3rd Edition.

15. Vogel's Textbook of Quantitative Chemical Analysis, 5rd Edition.

16. Standard methods of Chemical Analysis, Vol. 2, (Part A& B), 5th ed, F. J. Welcher, Von Nostrand& Robert E. Krieger Publishing Co. New York, (1975).

17. Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC), 14th Ed., (1984).

Elective-I

Course Code: CHEM 66511

SPECIAL TOPICS IN ANALYTICAL CHEMISTRY-I

PROGRAM(s): M.Sc.-II			**SEMESTER: III**
Course: Paper- Elective -I			**Course Code: CHEM 66511** **Course Title:-Special Topics in Analytical Chemistry-I**
Teaching Scheme			**Evaluation Scheme**
Lectures (Hours per week)	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**04**	**50**	**50**

Course Objectives:

1. To enable learners to have comprehensive knowledge of body fluids and its constituents, Immunological methods, human nutrition and metabolites and metabolomics.
2. The students will learn about Clinical Chemistry, applications of Bioanalytical approach to medicines,Biologics, Nuclear medicines andNanomedicines.
3. The learners study role of Analytical methods and techniques in Forensic Science, study of biological fluids and analytical toxicology related to different crimes.
4. The students get exposure to Membrane Science and Technology, types of membranes, membrane based separations, chemical sensors.

Course Learning Outcomes.

After completion of this Course, the learner will be able to:

1. Able to understand constitutes of biological fluids like blood and urine, immunological studies, estimation of biological materials like enzymes, proteins, amino acids etc., and application of analytical techniques for metabolites .
2. Learn drugs as biologics, use of MRI, CT scan for various disease diagnosis, radiopharmaceutical for cancer treatment and use of nanomedicines.
3. Students will be able to select a method for analysis of biological stain materials, isolation, estimation and analysis of narcotics, metabolites of drugs in blood and urine and heavy metals in viscera.
4. Learners understand about types of membranes and its applications in water treatment, recovery of valuables from wastes and in chemical and nuclear technology

Unit-I ANALYTICAL BIOCHEMSITRY **[15L]**

1.1 **Body fluids:**

Composition of body fluids and detection of abnormal level of certain constituents leading to diagnosis of diseases.

Physiological and nutritional significances of water and fat soluble vitamins and minerals.

Analyses for constituents of physiological fluids, viz., urine & blood.

Analytical techniques for vitamins.

1.2 **Immunological methods:**

General Processes of immune response, Antigen-antibody reactions, Precipitation reactions, radio, enzyme, and fluoro-immuno assays, affinity chromatography.

1.3 **Human nutrition:**

Biological values and estimation of enzymes, carbohydrates, essential amino acids, proteins, and lipids.

1.4 Metabolites and Metabolomics

Analytical tools for measurement – NMR, HPLC, LC-MS (examples to be discussed)

Unit-II:CLINICAL CHEMISTRY: (APPLICATIONS OF BIOANALYTICAL APPROACH TO MEDICINES) **[15L]**

2.1 **Biologics:**

Brief introduction of drugs to biologics (pathway)

2.2 **Nuclear medicines:**

Role of radiopharmaceuticals in vivo metabolism of radiopharmaceuticals.
Uses and adverse side effects.

Principles of various instruments used for diagnosis of various diseases eg. MRI, CT scan, etc.

Radiopharmaceuticals used in disease treatment (doses regulation) eg. For chemotherapy of cancer.

2.3 **Nanomedicines:**

Importance of nanomedicines: Analytical techniques for quantification of nanoparticles uptake by cells (transmission electron microscopy and flow cytometry).

Bioequivalence of nanomedicines.

Unit-IIIANALYTICAL CHEMISTRY IN FORENSIC SCIENCE **[15L]**

General idea

3.1 **Biological:** Analysis of biological stains and materials including blood, semen and saliva (qualitative and quantitative).

3.2 **Analytical toxicology:** isolation, identification and determination of the following:

Narcotics: Heroin, morphine and cocaine.

Stimulants: amphetamines, cocaine and caffeine.

Depressants: benzodiazepines, Barbiturates and mandrax.

Hallucinogens: LSD and Cannabis.

Metabolites of Drugs in blood and urine of addicts.

Viscera, stomach wash, vomit, and post-mortem blood, for poisons like cyanide, arsenic, mercury, insecticides, and pesticides.

Unit-IVMEMBRANE SCIENCE & TECHNOLOGY [15]

4.1 Membranes for saline water treatment

4.2 Ceramic membrane

4.3 Recovery of valuables from waste using liquid membrane methods

4.4 Membrane based separations in chemical and nuclear technology

4.5 Membrane based chemical sensors.

4.6 Track etched membrane.

Reference books:

1. West, E S & Todd, W R, Textbook of Biochemistry,Published by The Macmillan Co, 1956.
2. Parikh's text book of medical Jurisprudence and toxicology, C.K. Parikh, CBS Publishers (1990).
3. Clarke's Isolation and identification of Drugs in Pharmaceuticals, body fluids and post-mortem material, Clarke E.G.C., The Pharmaceutical Press, London.
4. Analytical methods in Forensic chemistry Ed. Math. Ho, Ellis Horwood (1990).
5. Methods of Forensic Science, Ed. F. Landquist, Interscience (1962).
6. High performance liquid chromatography in Forensic Chemistry. E.S. Lurie and J.W. Wittner, Jr, Marcel Dekker N.Y. (1983).
7. Analytical Toxicology Methods Manual Ed. H. Stahr, Iowa State University Press (1977).
8. Official Methods of Analysis of the Association of official Analytical Chemists (AOAC), 14^{TH} Ed. (1984).
9. Linda Fossati Wood, MaryAnn Foote, Targeted regulatory writing techniques: Clinical documents for drugs and biologics.
10. Jeanne Yang: A Pathway to Follow-On Biologics, Hasting Science & Technology Law Journal.
11. Gopal Subramanian, Society of Nuclear Medicine, Radiopharmaceuticals.
12. Harry F. Tibbals, Medical Nanotechnology and Nanomedicine.

Elective-II

Course Code: CHEM 66512

SPECIAL TOPICS IN ANALYTICAL CHEMISTRY-II

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-II</td><td>SEMESTER: III</td></tr>
<tr><td colspan="3">Course: Paper- Elective -II</td><td>Course Code: CHEM 66512
Course Title:-Special Topics in Analytical Chemistry-II</td></tr>
<tr><td colspan="3">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (Hours per week)</td><td>Credit</td><td>Continuous Assessment (CA)
(Marks- 50)</td><td>Semester End Examination
(Marks- 50)</td></tr>
<tr><td>04</td><td>04</td><td>50</td><td>50</td></tr>
<tr><td colspan="4">Course Objectives:
1. To learn the effect, concept, parameters and applications of Mossbauer spectroscopy.
2. To know the various component present in coal and petroleum products (quantitatively) and various methods for the analysis of coal and petroleum products.
3. Students should understand the concept of radioactivity, nuclear threats, explosion devices, hazards of radiation, and safety measures. Also, the concept of neutron activation analysis.
4. To understand the principle, instrumentation and applications of electrogravimetry and turbidimetry.</td></tr>
<tr><td colspan="4">Course Learning Outcomes.
1. After the accomplishment of this course, the students will learn concept, instrumentation part and application of Mossbauer spectroscopy.
2. Students will understand what are components present in coal and petroleum product and to analyze them by various analytical methods.
3. Postgraduates will learn the concepts of radioactivity, various nuclear threats the devices and hazards also the safety hazards of nuclear radiations. Learner will gain the knowledge about neutron activation analysis.
4. At the end of this course the students will get mastery over the electrogravimetry andturbidimetry techniques.</td></tr>
</table>

1	**Unit I: Mossbauer Spectroscopy**	**[15 L]**
1.1	Introduction to Mossbauer Effect, recoilless emission & absorption of X–rays.	[4]
1.2	Instrumentation, Spectral parameters of Mossbauer spectra such as Isomer shift, Quadruple splitting and Hyperfine interactions.	[6]
1.3	Application of Mossbauer Effect for the investigations of compounds of iron and tin.	[5]
2	**Unit II: Coal & Petroleum product analysis**	**[15 L]**
2.1	Coal Analysis: Analysis of moisture, ash, volatile matter, fixed carbon. Analysis of carbon, hydrogen, sulphur, nitrogen, and oxygen content. Combustion of carbonaceous fuel-flue gas, calorific value and its unit, Bomb calorimeter.	[5]
2.2	Petroleum product analysis: Petroleum products, adulterants, detection of adulterants of gasoline, diesel and engine oils. Analysis of recycled engine oils, analysis of dye of petrol and kerosene, engine oils by gas chromatography. Detection of adulterants by flash point, boiling point, ignition and distillation method.	[10]
3	**Unit III: Nuclear Chemistry**	**[15 L]**
3.1	Radioactivity, radioactive decay and half-life, methods for detection of radioactivity by Geiger Muller (GM) and Scintillation counter, applications of radioisotopes.	[5]
3.2	Introduction to nuclear forensic, nuclear threats, nuclear explosion devices, hazards of radiation, safety measures.	[5]
3.3	Neutron Activation Analysis: Principle, instrumentation, steps involved in neutron activation analysis. Radiochemical and instrumentation methods of analysis of nuclear active species.	[5]
4	**Unit IV: Electrogravimetry & Turbidimetry**	**[15 L]**
4.1	Electrogravimetry: Theory of Electrolysis, Instrumentation, electrode reaction, decomposition potential, overvoltage. Characteristics of deposits and completion of deposition. Applications of Electrogravimetry in separation of metals.	[8]
4.2	Turbidometry: Concept of scattering of light, instrumentation of turbidometry, Turbidometric titration, application of turbidometry in forensic science.	[7]

References:

1. Mossbauer Spectroscopy- Principle and applications of the technique by Alfred G. Maddock, Harward Chemical Science Series, Publisher-Woodhead publishing, 1st Edition, (1997).

2. Mossbauer Spectroscopy and Transition Metal Chemistry- Fundamental and applications by Philip Gutlich, Eckhard Bills, Alfred X. Trautwein, Publisher- Springer-Verlag Berlin Heidelberg, Edition number 1, (2011).
3. Mossbauer Spectroscopy by N. N. Greenwood and T. C. Gibbs, Publisher- Springer reprint of the original 1st edition 1971. (2011).
4. Advances in Mossbauer Spectroscopy- Applications to Physics, Chemistry & Biology Edited by-B. V. Thosar, J. K. Srivastava, P. K. Iyengar, S. C. Bhargava, Publisher- Elsevier Science Ltd (1983).
5. Handbook of Petroleum Product Analysis (Chemical Analysis: A Series of monograph on Analytical Chemistry & its applications) By James G. Speight, Publisher-John Wiley & Sons Inc., 2nd Edition (2015).
6. Encyclopedia of Petroleum Products and Fluids: Extraction processes, properties and applications by Vikas Debprakash Dixit, Publisher-Auris Press (2015).
7. Coal: Its Properties, Analysis, Classification, Geology, Extraction, Uses and Distribution by Elwood S. Moore, Publisher- Forgotten Books, (2018).
8. An Introduction to Nuclear Chemistry by Y. Mido and M. Satake, Publisher- Discovery Publishing Pvt. Ltd., 1st Edition (2010).
9. Essentials of Nuclear Chemistry by H. J. Arnikar, Publisher- New Age International Publishers, 4th Edition, (2011)
10. Nuclear Chenistry by Maheshwar Sharon and Madhuri Sharon, Publisher- Springer, 2nd Edition (2021).
11. A textbook of Instrumental Methods of Analysis Volume Two (Electrogravimetry, Electrophoretic and Chromatographic methods) by Melaku Zigde Haile, Publisher- Lap Lambert Academic Publishing (2021).
12. Calorimetric, Turbidity and Titration methods Used in Soil Investigations by Oswald Schereiner, Publisher- Forgotton Books (2018).

PROGRAM(s): M.Sc.-II	SEMESTER: III			
Course: Research Project	**Course Code: CHEM 666** **Course Title:-Research Project**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
	–	**04**		

Learning Objectives:

1. To understand and discuss the new research topics in the field of chemistry.
2. To understand the importance, relevance, and procedure to gather back ground literature information from various scientific database.
2. To display, organize and represent correlation between different types of data.
3. To summarize and provide a concise summary of research projects carried out.
4. Demonstrate a capacity to communicate research results clearly and comprehensively.

Course outcomes: -

1. Students will define a research question, design objectives and appropriate hypothesis for their project.
2. Students will find and evaluate relevant literature and back ground information related to their project.
3. Students will learn and use the techniques needed to do their experiments.
4. Students will learn and follow appropriate protocols for documenting their research as well to analyse the experimental data.
5. Students will be able to use logic and evidence to draw conclusions and future scope of the research work done.

Course Code: CHEM 666

Paper-Research Project

CHEM 666: Research Project

Guidelines for the conducting the research project.

1. Each student will perform project separately.
2. **Students should devote enough time to their project work (08 hours each week).**
3. Select a topic that is relevant to your interests and social relevance considering the constraints of available resources and time.
4. Consult with faculty members or mentors to select a relevant research topic that has the potential to contribute to the discipline of chemistry.
5. Literature survey for the research project is suggested to be from Journals indexed in globally recognised databases including recently published research papers.
6. Participation in national and international conferences and other project competitions is encouraged.
7. Project report must be written systematically and presented in bound form.
8. Continuous evaluation of the research project will be done by the internal examiner or mentor.
9. Student must do presentation of the research work in external exam.

Evaluation of Research Project Semester - III

Internal Continuous Assessment: 50% (50 Marks)

Sr. No.	Criteria for evaluation	Marks
1.	Attendance (DPR to be maintained)	10
2.	Literature Survey	25
3.	Scheme/ Outline of project / Methodology	15
	Total	**50**

Semester End External Examination: 50% (50 Marks)

Sr. No.	**Criteria for evaluation**	**Marks**
1.	Presentation	15
2.	Dissertation	20
3.	Viva	15
	Total	**50**

Semester – IV

SEMESTER: IV

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Paper-I	Course Code: CHEM 667 Course Title:-Quality in Analytical Chemistry and Pharmaceutical Analysis			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. The learners study need of quality in analysis, principles of quality assurance and control, proper sampling, preparation of samples and selection of methods for analysis and calibration of equipments.
2. To learn about Data treatment, Documentation and its management and Signal to noise ratio in instruments.
3. To study fundamentals of pharmaceutical analysis and pharmacopoeia, to know the sources of impurities and methods to determine the impurities, the identification of organic compounds by classical and instrumental methods, role of FDA, GMP and ISO standards in pharmaceutical industry.

Course outcomes:-

1. At the end of this course learners understand about reliable results in analysis, quality management, best practices, proper sampling, analysis of samples and standards of equipments.
2. The students will be able to know treatment of data, record management, standards for laboratories and proper working of equipments.
3. The students will learn about the functioning of Pharmaceutical industry and the preparation, identification and assay of API's and impurities in pharmaceutical formulations and functioning of regulatory bodies like FDA and GMP.

Course Code: CHEM 667

Paper-I

CHEM 667:Quality in Analytical Chemistry and Pharmaceutical Analysis

UNIT I:Quality in Analytical Chemistry: **[15L]**

1.1 The need for reliable results: Social and economic impact of wrong analysis, concept of quality, customer requirement, purpose of analysis.

1.2 Principle of quality assurance quality control: Quality management system, quality assurance and quality control, different standards and their main features, best practice.

1.3 Sampling: Definition, types of samples, sampling plan, sub-sampling, sample registration and storage, acceptance sampling- inspection by attributes.

1.4 Preparation for analysis: Method selection, Sources of methods, Factors to consider in choosing a method, performance criteria for methods to determine analytes by selected techniques, reasons for incorrect analytical results, method validation.

1.5 Making Measurements: Good laboratory practice, calibration of measurement, chemical standards and reference materials, quality control, environment, equipment, chemicals, consumables, maintenance and calibration of equipments.

UNIT II: **[15L]**

2.1 Data treatment: Control charts, measurement uncertainty: Definition and evaluation of uncertainty; putting uncertainty to use.

2.2 Documentation and its management: Quality manual, record management and reporting results.

2.3 Managing quality: Management system, Standards available for laboratories, audit, review, responsibilities of laboratory staff for quality.

2.4 **Signals and Noise:**

Signal to noise ratio, sources of noise in instrumental analysis, signal to noise enhancement, hardware devices and software methods for noise reduction.

UNIT III:Pharmaceutical Analysis I: **[15L]**

3.1 General idea regarding pharmaceutical industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms.

3.2 Sources of impurities in pharmaceutical chemicals and raw materials.

3.3 Standardization of finished products and their characteristics,

official methods of control, use of pharmacopoeia.

3.4 Analysis of compounds based on functional groups (eg. Aspirin, paracetamol, ascorbic acid, vitamin-A), classical and instrumental methods of drug analysis, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests.

UNIT IV:Pharmaceutical Analysis II: **[15L]**

4.1 Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies.

4.2 Pharmaceutical legislation: Introduction to drug acts, drug rules (schedules), FDA and ISO standards, ISO 9000 and its requirements, introduction to GMP.

4.3 Introduction to drug development.

Text/ References:

1. Quality assurance in Analytical Chemistry, Elizabeth Prichard and Vicki Barwick, LGC, Teddington, UK, 2007.
2. Quality Assurance in Analytical Chemistry W. Funk, V. Dammann, G. Donnevert VCH Weinheim (1995).
3. Principles of Instrumental Analysis, D.A. Skoog, F.J. Holler, and J.A. Nieman 5th Edition (1998).
4. Good Laboratory practice, Eds. W.Y. Garner, M.S. Barge and J.P. Ussary, ACS Professional Refernce Book (1992).
5. Quantitative Organic Analysis Via functional groups, 3rd Ed. S. Sigia. John Wiley, N.Y. (1972).
6. Pharmaceutical Drug Analysis (Methodology-Theory-Instrumentation Pharmaceutical assays-Cognate Assays), AshutoshKar, New Age Int. Pvt. Ltd. New Delhi (2010).
7. Indian Pharmacopeia 2010, Vol. I, II, III and Addendum 2012, 6th Ed. The Indian Pharmacopoeia Commission, Ghaziabad, 2010.
8. British Pharmacopeia.
9. Pharmaceutical Analysis, T. Higuchi and E. Brochmann- Hanssen, Interscience (1961).
10. The quantitative analysis of drugs, D.C. Garratt, Chapman and Hall (1964).
11. Pharmaceutical Analysis, A.H. Beckett and J.B. Stenlake, Chapman and Hall.
12. Methods of Drug Analysis, B.F. Granbowshi, Lea and Feniger.
13. Analysis of Drugs and Chemicals, N. Evers, W. Smith and C. Grifin.
14. Hawk's Physiological Chemistry, Mc Graw Hill.
15. ICH Guidelines.

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Paper-II	**Course Code: CHEM 668** **Course Title:-Advanced Instrumental Techniques and Nanotechnology**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. The course aims to provide the student with an overview of the current techniques used for the physicochemical characterization of materials with special reference to the principles, practice and applications of ESCA, Auger, EMP, Reflectance and Photoacoustic spectroscopy.
2. To learn the electron microscopy technique with special emphasis on SEM, TEM and AFM, also to learn the chemiluminescence and polarimetry (CD & ORD) methods for chemical analysis.
3. To learn the hyphenated techniques with reference to GC-IR and ICP-MS and applications of hyphenated techniques in the analysis agrochemicals, fine chemicals, petrochemicals and pharmaceutical products.
4. To learn the basics of nanotechnology, nanomaterials their synthesis by various methods, properties and applications of nanomaterials in various fields.

Course outcomes:-

On successful completion of this course, the students will be able to:

1. Explain the principles and operation of a range of advanced techniques such as ESCA, Auger, EMP, Reflectance and Photoacoustic spectroscopy currently used in characterization of various materials and compounds.
2. At the end of the course, the students will learn the microscopic techniques to see the morphology of nanomaterials by SEM, TEM and AFM along with the chemiluminescence and polarimetry (CD & ORD) techniques for the chemical analysis.

3. To make the students, to understand the concept of hyphenation and hyphenated techniques and the applications in the analysis of agrochemicals, fine chemicals, petrochemicals and pharmaceutical products.
4. Students also learn the nanotechnology in terms of various synthetic methods, their characterization, properties and applications of nanomaterials in various fields.

Course Code: CHEM 668

Paper-II

CHEM 668:Advanced Instrumental Techniques and Nanotechnology

Unit I: **[15L]**

Principles, instrumentation and applications of followings:

1.1 Electron spectroscopy: AUGER &XPS (ESCA)

1.2 Electron microprobe method.

1.3 Reflectance spectroscopy

1.4 Photoacoustic spectroscopy

Unit II: **[15L]**

Principles, instrumentation and applications of followings:

2.1 Electron microscopy: Scanning electron microscopy, Scanning probe microscopes: The Scanning Tunneling Microscope, Atomic force Microscope.

2.2 Chemiluminescence method.

2.3 Polarimetry: ORD, CD**.**

Unit III: **[15L]**

Hyphenated Techniques:

3.1 Introduction, need for hyphenation, possible hyphenation, Interfacing devices and applications of the following: GC-IR, ICP-MS, Spectroelectrochemistry and radio-chromatography.

Application of GC-MS, MS-MS, to Agrochemicals, fine chemicals and Petrochemicals

Application of HPLC-MS and MS-MS to pharmaceuticals and bio molecules

Unit IV: **[15L]**

Nanotechnology: Introduction and Applications of Nanomaterials

4.1 Types of nanomaterials, Classification, General preparative methods for various nanomaterials.

4.2 Some important properties on nanomaterials: optical, magnetic properties, Structural and chemical properties.

4.3 Some special nanomaterials: Carbon nanotubes and quantum dots, Preparation and applications.

4.4 Applications of nanomaterials in electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense.

4.5 Analytical techniques for characterization of nanomaterials.

Reference Books:

1. Hofmann, Siegfried, Auger- and X-Ray Photoelectron Spectroscopy in Materials Science Springer-Verlag Berlin Heidelberg.
2. S. J. B. Reed, I. M. Romanenko, D. S. Woolum, P. Trocellier, Microprobe Analysis.
3. Kuo, John, Electron Microscopy: Methods and Protocols, Humana Press.
4. Gustav Kortüm,Reflectance Spectroscopy: Principles, Methods, Springer; Softcover reprint of the original 1st ed. 1969 edition (January 1, 1969).
5. John W. Birks Chemiluminescence and Photochemical Reaction Detection in Chromatography, Wiley-VCH; (July 26, 1989)
6. Lihong V. Wang, Photoacoustic Imaging and Spectroscopy, CRC press.
7. Douglas A. Skoog; F. James Holler; Stanley R. Crouch; Principles of Instrumental Analysis6th Edition.
8. Handbook of GC/MS Fundamentals and Applications, H. J. Hubschmann, Wienheim, Germany, Wiley VCH, 2001
9. Modern practice of Gas Chromatography, R. L. Grab and E. F.Berry, 4th Edition, Wiley Interscience, New York, 2004.
10. LC/MS: A Practical User Guide, W. C. McMaster, Hooken, Wiley, New Jersey, 2005.
11. Technologies and Applications of Tandem Mass Spectrometry, K. L. Busch, G. L. Glish and S. A. McLuckey, New York, VCH, 1998.
12. Inductively coupled Mass Spectrometry, A. Montaser (Ed), Wiley VCH, Chinchester, 1998, New York.
13. Nanotechnology: Principles and Practices, J. K. Kulkarni, Capital Publishing Co., 2007

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Paper-III	Course Code: CHEM 669 Course Title:-Analysis of Ores, Food, Agro /Agriculture			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. To understand the sampling and analysis of copper based alloys, stainless steel, bauxite and monazite and biomining.
2. To learn sampling and analysis of soil and fertlizers, the soil microorganism interactions and organic fertilizers.
3. To learn concepts of food quality and analysis of additives and contaminants.
4. To learn food processing and analysis of dairy products, fruits and vegetables.
5. To learn about pesticide formulation and its analysis in real samples.

Course outcomes:-

1. At the end of the course, the students will learn analysis of alloys, ores, soil and fertilizers.
2. The students will be made to understand the analysis of food for ash, fibre, proteins, carbohydrates, lipids and fats. They will also understand the analysis of food for colour, flavor and heavy metals.
3. The students will understand the quality control and processing of milk, butter, cheese, ice cream, carbonated and alcoholic beverages and the analysis of dairy products, oils, fruits and vegetables. They will also learn about pesticides and their determination in water, beverages, food products and soil by chromatographic methods.

Course Code: CHEM 669

Paper-III

CHEM 669:Analysis of Ores, Food, Agro /Agriculture

Unit I: Analysis of Minerals, Ores and alloys **[15L]**

1.1 Analytical treatment of minerals and ores: Sampling, analytical treatment, dissolution of ores. Biomining.

1.2 Analyses of ores: bauxite and monazite.

1.3 Analysis of alloys: steel and stainless steel and copper based alloys.

Unit II: Soil and Fertiliser Analysis **[15L]**

2.1 Soil health card scheme. Sampling and preparation of soil samples for analysis, solid texture estimation. pH, electrical conductance, macro and micro nutrients, organic carbon, $CaCO_3$ (free lime), cation exchange capacity, gypsum requirements, micro and macro nutrients in soil. Soil miro-organisms and their functions.

2.2 Different types of synthetic fertilizers and introduction to organic fertilizers and their analysis and interaction with different components of soil.

2.3 Degradation of different insecticides, fungicides and weedicides in soil.

Unit III: Food Quality Concepts **[15L]**

3.1 General idea regarding moisture content, ash, fibre, proteins, carbohydrates, lipids and fats in food analysis.

3.2 Food standards – their importance and limitations. Food preservatives, adulterants and contaminants.

3.3 Analysis-

Additives: flavours and colour.

3.4 Contaminant: heavy metals and pesticide residues

Unit IV: Food Analysis &Pesticide Analysis **[15L]**

4.1 Processing and quality control requirements of milk and milk products (butter, cheese, ice cream), carbonated and alcoholic beverages.

4.2 Analysis of dairy products, oils, fruits and vegetables.

4.3 Pesticide Analysis-

Pesticide formulation– Application test.

4.4 Pesticideresidue analysis in water, beverages, food products and soil by GC/HPLC/GC-MS.

Texts/ references:

1. Standard methods of Chemical Analysis, Vol. 2, (Part A& B), 5th ed, F. J. Welcher, Von Nostrand& Robert E. Krieger Publishing Co. New York, (1975).
2. Quantitative Organic Analysis, Part III, 2nd Ed., A. I. Vogel, CBS, (1987).
3. Chemical Analysis of Food and Food Products, H. B. Jacob, Van Nostrand Reinhold, (1958).
4. Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC), 14th Ed., (1984).

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Elective I	**Course Code: CHEM67011** **Course Title:- Intellectual Property Rights and Chemoinformatics**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours perweek)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. To understand the Ethics and concepts of intellectual property rights in research.
2. To the fundamentals of patent laws and drafting procedure.
3. To understand the copyright laws and related subject matters in research.
4. To understand the basic concepts of chemoinformatics.
5. To design and develop solutions to analyze pharmaceutical problems using computers.

Course outcomes:

1. Correlate the knowledge of IPR with its utilization in designing strategy for chemical product development for various purposes.
2. Acquire comprehensive knowledge on Patents including filing of patents.
3. Gain ability to bridge the gap between chemistry and data science, creating innovative solutions and driving advancements in pharma and chemical industries.
4. The learnings can help the budding researchers in accelerating drug discovery by efficiently screening large compound libraries and predicting molecular properties of novel compounds.

Elective-I

Course Code: CHEM 67011

INTELLECTUAL PROPERTY RIGHTS AND CHEMOINFORMATICS

Unit-I **[15L]**

Introduction to Intellectual Property:

Histroical Perspective, Different types of IP, Importance of protecting IP.

Patents:

Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.

Industrial Designs:

Definition, How to obtain, features, International design registration.

Layout design of integrated circuits:

Circuit boards, Integrated Chips Importance for electronic industry.

Copyrights:

Introduction, How to obtain, Differences from Patents.

Trade Marks:

Introduction, How to obtain, Different types of marks-Collective marks, certification marks, service marks, Trade names, etc.

Unit-II **[15L]**

Geographical Indications:

Definition, rules for registration, prevention of illegeal exploitation, importance to India.

Trade Secrets:

Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.

IP Infringement issue and enforcement:

Role of Judiciary, Role of law enforcement agencies-Police, Customs, etc.

Economic Value of Intellectual Property:

Intangible assests and their valuation, Intellectual Property in the Indian Context- Various Laws in India Licensing an technology transfer.

Different International agreements:

(a) World Trade Organization (WTO):

(i) General Agreement on Tariffs & Trade (GATT) , TradeRelated Intellectual Property Rights (TRIPS) agreement.
(ii) General Agreement on Trade related Services (GATS)Madrid Protocol.
(iii) Berne Convention
(iv) Budapest Treaty

(b) Paris Convention

WIPO and **TRIPS, IPR** and Plant Breders Rights, IPR and Biodiversity

Unit-III **[15L]**

Introduction to Cheminformatics:

History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular Modeling and Structure elucidation.

Representation of molecules and chemical reactions:

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching chemical structures:

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit-IV [15L]

Applications: Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure-Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure-Spectra correlations, Prediction of NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, Analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-Based and Structure Based Drug Design, Application of Cheminformatics in Drug Design.

Reference books:

1. Andrew R. Leach & Valerie, J. Gillet (2007) *An introduction to Cheminformatcs*. Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) Cheminformatics: a text-book. Wiley-VCH.
3. Gupta, S.P. *QSAR and Molecular Modeling*, Springer-Anamaya Pub.: New Delhi.

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Elective -II	Course Code: CHEM 67012 Course Title:-Special Topics in Analytical Chemistry-I			
Teaching Scheme				Evaluation Scheme
Lectures (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	–	04	50	50

Learning Objectives:

1. Introduce the students to classification and analysis of samples by radio chemical and thermal methods.
2. To learn about green chemistry and its necessity, the principles and concepts of green chemistry, wastes and its treatment, catalysis and green chemistry and safer solvents used.
3. Students will learn sampling and qualitative and quantitative analysis of cosmatic, soap and detergents samples using conventional and analytical techniques like Uv, IR spectrophotometry.
4. Students shall learn about sources and extraction of herbal materials, standardization of herbal formulation and herbal extracts by separation techniques.

Course outcomes:-

1. Students get thorough knowledge regarding isotopes activation and dilution methods, X-ray and gamma radiography, and thermal analysis by physical, chemical and Spectroscopic: mass spectrometry and infrared methods.
2. Students will be able to apply the principles of green chemistry to chemical-related problems and waste treatment and reduction, use of catalyst and hazardous solvents in greener way in industries.
3. The students will learn to apply analytical procedures and instrumental techniques for analysis of constituents in cosmatics, soaps and detergents.
4. The learners get acquainted with the extraction of herbal medicinal products from their

sources, qualitative and quantitative analysis of herbal products using GC, HPLC etc as per WHO and GMP guidelines.

Elective-II

Course Code: CHEM 67012

SPECIAL TOPICS IN ANALYTICAL CHEMISTRY-I

Unit-I **[15L]**

1.1 **Radiochemical methods:**

Isotope dilution method and activation analysis, radiometric and radio release methods.

Auto, X-ray and gamma radiography.

1.2 **Thermal Methods:**

Simultaneous thermal analysis, Evolved gas analysis: Definition, Instrumentation, Classification of methods (Physical, Chemical and Spectroscopic: mass spectrometry and infrared), Applications.

Unit-IIGREEN CHEMISTRY **[15L]**

2.1 **Principles and Concepts of Green Chemistr**y:

Sustainable development and green chemistry, Atom economy, examples of atom economic and atom un-economic reactions

2.2 **Waste:**

Production, Problems and Prevention; Sources of waste from chemical industry, on-site waste treatment (Physical treatment and Chemical treatment), design for degradation.

2.3 **Catalysis and Green Chemistry:**

Comparison of catalyst types, Heterogeneous catalysts (zeolites and the bulk chemical industry, catalysts in fine chemicals and pharmaceutical industries, catalytic converters), homogeneous catalysts (transition metal catalysts with phosphene ligands, greener Lewis acids, asymmetric catalysis), phase transfer catalysis, Biocatalysis, Photocatalysis

2.4 **Organic solvents:**

Environmentally benign solutions: solvent free systems, supercritical fluids, ionic liquids as catalysts and solvents.

Unit-IIICOSMETIC, SOAP & DETERGENT ANALYSIS **[15L]**

3.1 **Cosmetic Analysis:**

Introduction to cosmetics

Hair tonic: 2,5-diaminotoluene, potassium bromate, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers).

Creams and lotions: types of emulsions, chloroform soluble material, glycerol, pH emulsion, ash analysis, non-volatile matter by IR spectroscopy.

3.2 **Soap and Detergents analysis:**

Analysis of soaps and detergents: General scheme of analysis, sampling, alcohol soluble materials, moisture and volatile matter, active ingredient and

equivalent combined SO_3^{3-}.

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

Tests for synthetic detergents: Unsulfonated or unsulfated matter, ester SO3, Combined alcohols, total combined SO3, 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-IVANALYSIS OF HERBAL BASED PRODUCTS **[15L]**

4.1 AYUSH - Introduction

4.2 Herbs as a raw material:

Definition of herb, herbal medicine, herbal medicinal products, herbal drug preparation.

Sources of herbs

Selection, identification and authentication of herbal materials, drying and processing of herbal raw material.

4.3 Extraction of herbal materials:

Choice of solvent for extraction

Methods used for extraction and principles involved in extraction.

4.4 Standardization of herbal formulation and herbal extracts:

Standardization of herbal extract as per WHO cGMP guidelines.

Physical, chemical, spectral and toxicological standardization, qualitative and quantitative estimations. Determination of metals

4.5 Various chromatographic techniques for the separation, identification, purification and estimation.

Reference books:

1. Nuclear and Radiochemistry, 3rd Edition, G. Friedlander, J. W. Kennedy, E. S. Macias and J. M. Miller, Wiley, New York, 1981.
2. Nuclear and radiochemistry, K. H. Lieser, 2nd Edition, Weinheim, Germany, Wiley VCH, 2001.
3. Radiochemistry and Nuclear Methods of Analysis, W. D. Ehmann and D. E. Vance, Wiley, New York 1981.
4. Thermal Methods of Analysis, P. J. haines, Blacke, London, 1995.
5. Thermal Analysis, 3rd Edition, W. W. Wendlandt, Wiley, New York, 1985
6. Paul T. Anastas, John C. Werner, Green chemistry: Theory and Practice, Oxford University Press, 1998.
7. Mike Lancaster, Green Chemistry: An Introductory Text, RSC Paperbacks. Chemistry of Natural Products, V. K. Ahluwalia, L. S. Kumar, S. Kumar, Ane Books, India, (2006).
8. High-Performance Thin Layer Chromatography (HPTLC), M. Shrivastav, Springer-Verlag Berlin Heidelberg, New York, (2011).
9. Traditional and Folk Herbal Medicine, Vol. 1, Dr. V. K. Gupta, Daya Publishing House, (2012).

10. A Selection of Prime Ayurvedic Plant drugs-Ancient Modern Concordance, S. Dev, Anamaya Publishers, New Delhi, (2006). F.J. Welcher, Standard methods of chemical analysis, volume 3, part-B, (Soap and Detergents).

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Elective -III	**Course Code: CHEM 67013** **Course Title:-Special Topics in Analytical Chemistry-II**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 50)**	**Semester End Examination (Marks- 50)**
04	**–**	**04**	**50**	**50**

Learning Objectives:

1. Students learn the fundamental material properties of organic electronic materials, particularly the electronic and optical processes in these materials. Understand the principles of semiconductor physics and semiconductor device physicsand applications of organic electronic materials in various electronic and optoelectronic devices.
2. The course aims to acquaint the students with the advanced aspects of electrochemistry so that they are able to understand the mechanism and processes of photoelectrochemistry, Bioelectrochemistry and electrochemical sensors.
3. The students acquire knowledge on energy storage technologies, basics of electrochemistry in batteries and supercapacitors, need of energy storage and different types of energy storage devices like battery and supercapacitors and its applications.
4. Students get knowledge about studying surface chemistry and adsorption of gases, especially on solid surfaces. Langmuir, BET isotherms, film characterization and thermodyanamics of adsorption.

Course outcomes:-
The students will be able to-

5. Have the basic knowledge for studying the electronic and photonic processes involved in molecular solids, as well as some basics on organic materials and organic electronic

deviceslike OLEDs and Photovoltaics.

6. Learn about interaction of light with electrochemical systems for surface characterization, semiconductor, phototelectrocatalysis and bioanalysis studies.
7. Students acquire fundamental knowledge of energy storage technologiesviz. batteries and supercapacitors work, and novel developments in energy storage technology research. Understand how storage technologies solve real-world problems at domestic, city and grid scales.
8. Students will learn about phenomenon of adsorption of various analytes on solid surface, various adsorption isotherms like Langmuir etc, electrical aspects of surface chemistry and its measurement by BET technique.

Elective-III

Course Code: CHEM 67013

SPECIAL TOPICS IN ANALYTICAL CHEMISTRY-II

Unit-I Organic Electronic/Semiconductor Materials **[15L]**

1.1 Introduction to organic electronicmaterials and their basic properties viz. band vs hopping transport; Fermi level; small molecules and polymers; polarons; excitons; band gap; cyclic voltammetry; UPS; conductivity measurements, charge carrier mobility determination;; charge transport and energy structure oforganic electronics; case-studies on specific organic semiconductor materials used in current research(polyacetylene, MEH-PPV, P3HT, PEDOT, PANI, acenes, copper phthalocyanine; PTCDA and perylene bisimides; triarylamines; oligothiophenes);optical properties (energy levels, color changes, light emission and absorption);organic electronic circuit components (conductors, resistors, capacitors, diodes,transistors); electrochemistry of organic electronic materials, and applications ofredox properties; organicelectronics like organic light emitting diodes (OLEDs) and photovoltaics (measurement techniques, solar cells); an overview ofcurrent applications and commercialization (cost, implementation, environmentalconsideration).

Unit-II Advanced Topics in Electrochemistry **[15L]**

2.1 Photoelectrochemistry: introduction, band bending at the semiconductor/solution interface, photoexcitation of electrons by absorption of light, surface effects in photoelectrochemistry, photoelectrocatalysis, the photoelectrochemical splitting of water, the photoelectrochemical reduction of CO_2. Bioelectrochemistry : bioelectrodics, membrane potentials, electrochemical communication in biological organisms,

enzymes as electrodes, electron transfer in p450 enzymes, electrochemical sensors, electrochemical biosensors, gas sensors, solid state devices and sensor arrays.

Unit-III Energy Storage and Conversion Devices **[15L]**

3.1 Charge storage mechanism, lead-acid batteries, metal ion batteries, metal sulfur batteries, metal air batteries, supercapacitors, pesudocapacitors, fuel cells, advanced Li-ion and beyond Li-ion battery systems (multivalent battery systems), redox-flow batteries, solid state thin film batteries, solid state micro supercapacitors.

Unit-IV Surface Chemistry **[15L]**

4.1 Adsorption of gases and vapors on solids, the Langmuir adsorption isotherm, kinetic and statistical derivation of Langmuir adsorption isotherm, adsorption entropies, lateral interactions, the BET and related isotherms, derivation of the BET equation, properties of the BET equation, Langmuir Blodgett films, structure and characterization, mixed LB films, studies of the LB deposition process, thermodynamics of adsorption chemisorption and catalysis, chemisorption, the molecular view, chemisorption isotherms, kinetics of chemisorption, the chemisorption bond. Electrical aspects of surface chemistry, electrical double layer, Stern treatment of the electrical double layer, free energy of a diffuse double layer, repulsion between two plane double layers, zeta potential, electrophoresis, electro osmosis, streaming potential sedimentation potential electro capillarity, thermodynamics of electro capillary effects.

Reference Books:

1. Functional Organic Materials by T. J. J. Müller and U. H. F. Bunz, Wiley-VCH, 2007
2. Introduction to Organic Electronic and Optoelectronic Materials and Devices by Sam-Shajing Sun, Larry R. Dalton, CRC Press, 2008
3. Organic Electronics Materials and Devices by S. Ogawa, Springer, 2015
4. Electronic Processes in Organic Semiconductors: An Introduction by A. Kohler and H. Bassler, Wiley-VCH, 2015
5. Organic Optoelectronics by Wenping Hu, John Wiley and Sons, 2013.
6. A.J.Bard and L.R. Faulkner, Electrochemical methods –Fundamentals and Applications, 2nd Ed., John Wiley and Sons, 2001.
7. C.Hamann, A. Hamnett and W. Vielstich, Electrochemistry, Wiley, 2007.
8. R.J. Gale, Spectroelectrochemistry, Wiley 2010.
9. C. Breitkopfand K.Swider-Lyons, (Eds.) Springer Handbook of Electrochemical Energy, Springer, 2017.

10. J. Newman, E. Karen Thomas-Alyea, Electrochemical Systems. 3rd Ed.,Wiley-Interscience, 2004.
11. O' Hayre, Ryan, Suk-Won Cha, et al. Fuel Cell Fundamentals. 2nd Ed., Wiley, 2009.
12. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Applications. 2nd Ed.,Wiley, 2001.
13. A.W. Adamson and A. P. Gast, Physical Chemistry of Surfaces, 6th Ed., John Wiley & sons 1997.
14. P.C. Hiemenz, Principles of colloids and surface chemistry,2ndEd.,Marcel DekkerInc., 1986.

PROGRAM(s): M.Sc.-II	SEMESTER: IV			
Course: Research Project	**Course Code: CHEM 671** **Course Title:-Research Project**			
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 75)**	**Semester End Examination (Marks- 75)**
	–	**06**		

Learning Objectives:

1. To understand and discuss the new research topics in the field of chemistry.
2. To understand the importance, relevance, and procedure to gather back ground literature information from various scientific database.
3. To display, organize and represent correlation between different types of data.
4. To summarize and provide a concise summary of research projects carried out.
5. Demonstrate a capacity to communicate research results clearly and comprehensively.

Course outcomes: -

1. Students will define a research question, design objectives and appropriate hypothesis for their project.
2. Students will find and evaluate relevant literature and back ground information related to their project.
3. Students will learn and use the techniques needed to do their experiments.
4. Students will learn and follow appropriate protocols for documenting their research as well to analyse the experimental data.
5. Students will be able to use logic and evidence to draw conclusions and future scope of the research work done.

Course Code: CHEM 671

Paper-Research Project

CHEM 671: Research Project

SEMESTER IV

Course: Research Project

Guidelines:

1. Students are to work on research project individually and should be the continuity of the research project selected in the semester.
2. Research Project is of 6 credits which equals to project working hours of 180.
3. The title of the research project should be descriptive, appropriate and concise as possible.
4. A detailed description of Chemicals, equipment, experimental procedures should be mentioned in the project report.
5. The project report should be well-structured, should present an accurate and complete account of the research performed with data, discussion and conclusions.
6. The publications of earlier work should be cited.
7. Record of attendance and continuous performance of the student is monitored by the mentor.
8. At the end of the semester, the student has to present the project report in a bound form for external evaluation.
9. Participation in national and international conferences and other project competitions is encouraged.

Evaluation of Research Project Semester - IV

A) CONTINUOUS ASSESSMENT - 50%

Sr. No.	Evaluation Type	Marks
1	Attendance (DPR* to be maintained)	**20**
2	Experimental/Interpretation	**35**
3	Conclusion/ output	**20**
	Total	**75**

DPR:Daily Progress Report

B) SEMESTER ENDEXAMINATION - 50%

Sr. No	Evaluation Type	Marks
1	Presentation	**20**
2	Dissertation	**30**
3	Viva	**25**
	Total	**75**

Theory Examination Pattern:

A. Internal Assessment- 50%- 50 Marks per paper

Sr.No.	Evaluation Type	Marks
1	Written Objective/Short Answer Examination	25
2	Assignment/ Case study/ field visit report/ presentation/ project	25
	Total	50

External Examination- 50%-

Paper Pattern:

Question	Options	Marks
Q.1	2 out of 4	10
Q.2	2 out of 4	10
Q.3	2 out of 4	10
Q.4	2 out of 4	10
Q.5	4 out of 8	10
	TOTAL	**50**

Semester End Practical Examination:

Particulars	Continuous assessment (CA)	Semester end external examination
Laboratory work	15	15
Viva	05	05
Journal	**05**	**05**
Total	**25**	**25**

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Letter Grades and Grade Points

Semester GPA/ Program CGPA/Semester	% Marks	Letter Grade Result
9.00-10.00	90.0-100.0	O (Outstanding)
8.00≤9.00	80.0≤90.0	A+ (Excellent)
7.00≤8.00	70.0≤80.0	A (Very Good)
6.00≤7.00	60.0≤70.0	B+ (Good)
5.50≤6.00	55.0≤60.0	B (Above Average)
5.00≤5.50	50.0≤55.0	C (Average)
4.00≤5.00	40.0≤50.0	P (Pass)
Below 4.00		F (Fail)
Ab (Absent)		Absent

Sign of HOD

Prof. Shivram S. Garje
Head of Department,
Department of Chemistry,
University of Mumbai

Sign of Dean,

Prof. Shivram S. Garje
Dean, Science and Technology
University of Mumbai

Team for Creation of Syllabus

Name	College Name	Sign
Dr. Manjusha Karve	Department of Chemistry, University of Mumbai	
Dr. Rajesh M. Kamble	Department of Chemistry, University of Mumbai	
Dr. Bhushan B. Popatkar	Department of Chemistry, University of Mumbai	
Dr. Kalpana Jain-Patankar	Department of Chemistry, Royal College of Arts, Science & Commerce Mira road	

Sign of HOD

Prof. Shivram S. Garje
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Dean, Science and Technology
University of Mumbai

Appendix B

Justification for M.Sc. (Analytical Chemistry)

1.	The necessity for starting the course:	M.Sc. (Analytical Chemistry) course is necessary for those who seek to deepen their knowledge, specialize in a particular area, and pursue advanced careers in research, industry, academia, or other chemistry-related fields. It offers numerous opportunities for personal and professional growth, enabling you to make a positive impact on the world through scientific exploration and discovery.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	The course has already commenced from the academic year from 1967 and in the academic year 2022-23 it is restructured under NEP 2020
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?	This course is not self-financed. Currently, twelve permanent faculty members are working in the department out of 26 sanctioned faculty positions.
5.	To give details regarding the duration of the Course and is it possible to compress the course?	The duration of the program is two years (4 semesters). It is not possible to compress the course. Under NEP 2020 students have option of exit at the end of first year with PG Diploma in Analytical Chemistry.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	The intake capacity of the program is 20. Number of admissions for the academic year 2022-23 is 20.
7.	Opportunities of Employability / Employment available after undertaking these courses:	M.Sc. (Analytical Chemistry) students have a wide range of employment opportunities across various sectors. The skills and knowledge acquired during their master's program make them well-equipped for diverse roles. Some of the common areas where M.Sc.(Analytical Chemistry) students can find employment include;Research and Development (R&D), Pharmaceutical Industry, Chemical Manufacturing, Environmental and Analytical Chemistry, Quality Assurance and Control, Materials Science and Nanotechnology, Teaching and

		Academia, Healthcare and Clinical Research etc.The key to employability for M.Sc. (Analytical Chemistry) students are to build a strong resume through internships, research projects, and networking. Additionally, staying updated with the latest advancements in the field and continuously improving their skills can enhance their competitiveness in the job market.

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