University of Mumbai

No. AAMS_UGS/ICC/2024-25/144

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 Studies in Chemistry** at its meeting held on 02nd September, 2024 and subsequently passed by the Board of Deans at its meeting held on 3rd September, 2024 **vide** item No. 6.17 (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** is introduced 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).

(Dr. Prasad Karande)
REGISTRAR

MUMBAI – 400 032
21st September, 2024

To

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

BOD 6.17(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. 6.17 (N)

As Per NEP 2020

University of Mumbai

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

Syllabus for
Semester III & IV

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

(with effect from the Academic year 2024-2025)

UNIVERSITY OF MUMBAI

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: SP-25B	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	From the Academic Year 2024-25

Sign of the BOS Coordinator
Dr. Sunil Patil
BOS in Chemistry
Director, Students' Welfare,
University of Mumbai

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 to act as a catalyst 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 Organic 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 Organic 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.

R: SP-25B

MSc (Analytical Chemistry) NEP Syllabus - Semester 3 & Semester 4

Year	Level	Sem	Major				RM	OJT /FP	RP	Cum. Cr.	Degree
			Mandatory			**Elective**					
			3*4+ 2=14			**4**			**4**	**22**	
II	**6.5**	**Sem III**	Quality in Analytical Chemistry -I **(CHEM 661)**	TH	4	Environmental Chemistry + **(CHEM 66511)** Practical **(PRCHEM66511)** **(OR)** Industrially Important Materials **(CHEM 66512)** + Practical **(PRCHEM66512)**	—	—	**CHEM 666**		PG Degree after 2-yr PG
			Advanced Instrumental Techniques -I **(CHEM 662)**	TH	4						
			Bioanalytical Chemistry and Food Analysis **(CHEM 663)**	TH	4						
			Analytical Chemistry Practical **(PR CHEM 664)**	PR	2						
		Sem IV	**3*4=12**			**4**			**6**	**22**	
			Quality in Analytical Chemistry - II **(CHEM 667)**	TH	4	Intellectual Property Rights & Cheminformatics **(CHEM 67011)** **(OR)** Pharmaceutical and Organic Analysis **(CHEM 67012)**	—	—	**CHEM 671**		
			Advanced Instrumental Techniques -II **(CHEM 668)**	TH	4						
			Selected Topics in Analytical Chemistry **(CHEM 669)**	TH	4						

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

UNIVERSITY OF MUMBAI
Syllabus for Approval

Proposed Draft Syllabus for M.Sc. Chemistry
Semester III and IV

Choice Based Credit System
Under New Education Policy (NEP) 2020
(To be implemented from the academic year, 2024-2025)
PROGRAM OUTLINE 2024-2025

YEAR	COURSE	COURSE CODE	COURSE TITLE	CREDITS
M.Sc. Sem-III	Mandatory Course-I	**CHEM 661**	Quality in Analytical Chemistry -I	04
	Mandatory Course-II	**CHEM 662**	Advanced Instrumental Techniques -I	04
	Mandatory Course-III	**CHEM 663**	Bioanalytical Chemistry and Food Analysis	04
	Mandatory Course Practical	**PRCHEM 664**	Analytical Chemistry Practical	02
	Elective 1	**CHEM 66511** + **PRCHEM 66511**	Environmental Chemistry + Practical	02 + 02
	Elective 2	**CHEM 66512** + **PRCHEM 66512**	Industrially Important Materials + Practical	02 + 02
	Research Project -RP	**CHEM 666**	Research Project	04
M.Sc. Sem-IV	Mandatory Course-I	**CHEM 667**	Quality in Analytical Chemistry -II	04
	Mandatory Course-II	**CHEM 668**	Advanced Instrumental Techniques -II	04
	Mandatory Course-III	**CHEM 669**	Selected Topics in Analytical Chemistry	04
	Elective 1	**CHEM 67011**	Intellectual Property Rights & Cheminformatics	04
	Elective 2	**CHEM 67012**	Pharmaceutical and Organic Analysis	04
	Research Project -RP	**CHEM 671**	Research Project	06

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, scrutinize 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 analyzed 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.

Semester – III

PROGRAM(s): M.Sc.-II				SEMESTER: III	
Theory: Mandatory Course Paper -I				Course Code: CHEM661 Course Title: - Quality in Analytical Chemistry - I	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks- 50)
04	NA	–	04	50	50

Course Objectives:

CO1.To understand the sampling techniques

CO2.To identify the quality systems to chemical analysis.

CO3.To understand important parameters to validate analytical methods from experimental data

CO4.To learn the principles and procedures of separation techniques in chemical analysis.

Course learning Outcomes:

At the end of the course the learner will be able to

CLO1. validate sampling in chemical and pharmaceutical industries

CLO2. operate basic analytical techniques, develop problem solving skills and be familiar with good laboratory practice.

CLO3. optimize the variables that affect the choice of analytical techniques in chemical analysis

CLO4. apply different type of chromatographic techniques to determine, identify and characterize chemical compounds

Semester – III

Mandatory Course Paper -I

Quality in Analytical Chemistry -I

COURSE CODE: CHEM 661 **CREDIT : 4**

Course code- CHEM 661	Unit	Course/Unit Title: Quality in Analytical Chemistry -I	Credits 04 / 60 Lectures
	UNIT 1	**Sampling and Method validation**	**[15L]**
	1.1	**Sampling** : **1.1.1** Definition, types of sample, sampling plan, quality of sample, subsampling, sampling of raw materials, intermediates and finished products. **1.1.2** Sample preparations – dissolution technology and decomposition, storage of samples. **1.1.3** Pre-treatment of samples: soil, food and cosmetics.	**[8L]**
	1.2	**1.2.1** Selection of the Method: sources of methods, factors to consider when selecting a method, performance criteria for choice of analytical method, reasons for incorrect analytical results. **1.2.2** Method validation, and quality by design (PAT – Process Analytical technology – QBD (quality by design)	**[7L]**
	UNIT 2	**Parameters for method validation**	**[15L]**
	2.1	**Measurement of uncertainty:** Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results	**[4L]**
	2.2	**Signal to noise:** Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction, software methods for noise reduction.	**[6L]**
	2.3	**Calculation of LOD based on the numerical value of** i) S/N ratio ii) Determinations for blank samples iii) Standard deviation of signals iv) LOQ.	**[5L]**

		(numericals expected)	
	UNIT 3	**Chromatographic Techniques -I**	**[15L]**
	3.1	**Ion-exchange chromatography:** Ion exchange equilibria, breakthrough capacity	**[2L]**
	3.2	Ion exchange separation by column chromatography: **3.2.1** Types of packing column (pre-swollen ion exchanger, pre-packed ion exchanger, Sephadex ion exchanger) **3.2.2** Sample preparation and elution - sample concentration, sample composition, sample volume, sample viscosity, elution. **3.2.3** Applications of ion exchange chromatography	**[6L]**
	3.3	**Ion-pair chromatography:** Principle, instrumentation with special reference to separation and suppressor columns, applications	**[2L]**
	3.4	**Exclusion chromatography :** Theory, instrumentation and applications of gel permeation chromatography, retention behavior, inorganic molecular sieves and determination of molecular weight of polymer	**[5L]**
	UNIT 4	**Chromatographic Techniques -II**	**[15L]**
	4.1	**4.1.1** Supercritical fluid Chromatography: Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, **4.1.2** Instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis.	**[8L]**
	4.2	Affinity Chromatography: principle, instrumentation and applications	**[4L]**
	4.3	Optimum pressure liquid chromatography (OPLC)	**[3L]**

List of books and references:

1. Quality Assurance and Quality Control in Analytical Chemical Laboratory A Practical Approach, Piotr Konieczka, Jacek Namiesnik, 2009 by Taylor and Francis Group LLC.
2. Ion Exchange Chromatography Principles and Methods, Amersham Biosciences
3. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997
4. Quality assurance in analytical Chemistry, W Funk, V Dammann, G. Donnevert VCH Weinheim1995.

5. Amit S. Patil *et. al.*,Quality by Design (QbD) : A new concept for development of Quality pharmaceuticals, International Journal of Pharmaceutical Quality Assurance; 4(2); 13-19.
6. Lalit Singh and Vijay Sharma, Quality by Design (QbD) Approach in Pharmaceuticals: Status, Challenges and Next Steps, Drug Delivery Letters, 2015, 2-8
7. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997
8. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Saonders, College publication.
9. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
10. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
11. Analytical Chemistry, G. D. Christain, Wiley
12. Extraction Chromatography T. Braun, G. Ghersene, Elsevier Publications 1978.
13. Supercritical Fluid Extraction, Larry Taylor Wiley publishers N.Y. 1996
14. Ion exchange separation in analytical chemistry O Samuelson John Wiley 2nd ed1963
15. Ion exchange chromatography Ed H.F Walton Howden, Hutchenson and Rossing ,1976
16. Chromatographic and electrophoresis techniques I Smith Menemann Interscience,1960

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

Course objectives:

CO1. To understand the theoretical basis of advanced instrumental techniques.

CO2. To understand how to apply these techniques in analysis.

CO3. To increase the learner's interest in the technical aspects of analytical instruments.

CO4.To comprehend the different types of electroanalytical techniques for analysis of samples and their unique applications.

Course learning Outcomes:

At the end of the course learner will be able to apply the

CLO1. theoretical principles ,instrumentation and applications of surface analytical techniques.

CLO2. basic instrumentation of ESR, Mossbauer's Spectroscopy and Atomic Emission spectroscopy.

CLO3. principle, working ,instrumentation and applications of different Electroanalytical methods.

CLO4. principle, instrumentation and applications of various sophisticated analytical instruments.

Semester – III

Mandatory Course Paper -II

Advanced Instrumental Techniques -I

COURSE CODE : CHEM 662 **CREDIT : 4**

Course code- CHEM 662	Unit	Course/Unit Title- Advanced Instrumental Techniques -I	Credits: 04/ 60 lectures
	UNIT 1	**Spectral Methods I**	**[15L]**
	1.1	Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis.	**[1L]**
	1.2	Principle, instrumentation and applications of the following: **1.2.1** Secondary Ion mass spectroscopy. **1.2.2** Particle-Induced X-Ray Emission **1.2.3** Low-Energy Ion Scattering and Rutherford Backscattering	 **[4L]** **[5L]** **[5L]**
	UNIT 2	**Spectral Methods – II**	**[15L]**
	2.1	Principle, Instrumentation, and Applications of **2.1.1** Electron Spin Resonance Spectroscopy (ESR) **2.1.2** Mossbauer's Spectroscopy **2.1.3** Atomic Emission Spectroscopy- based on plasma and electrical discharge sources	 **[5L]** **[5L]** **[5L]**
	UNIT 3	**Electroanalytical Methods –Basic principles, Instrumentation and applications**	**[15L]**
	3.1	Advanced Electroanalytical Techniques**:-** Normal and Differential Pulse Polarography , Current Sampled (TAST) Polarography,	**[3L]**
	3.2	Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry.	**[3L]**
	3.3	Potential Step method- Chronoamperomertry	**[2L]**
	3.4	Controlled potential technique- Chronopotentiometry	**[2L]**
	3.5	Stripping Voltammetry- anodic, cathodic, and adsorption	**[2L]**

	3.6	Chemically and electrolytically modified electrodes and ultramicroelectrodes in voltammetry	**[3L]**
	UNIT 4	**Miscellaneous Techniques**	**[15L]**
	4.1	Principle, Instrumentation and Applications of: **4.1.1** Chemiluminescence techniques **4.1.2** Chirooptical Methods : ORD, CD **4.1.3** Photoacoustic spectroscopy **4.1.4** Spectroelectrochemistry	**[3L]** **[5L]** **[3L]** **[4L]**

List of books and references:

1. Analytical Chemistry, G. D. Christian, 4thEd. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann,5th Edition (1998)
4. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F.A. Settle Jr 6th Ed CBS (1986)
5. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987)
6. Electrochemical Methods, A. J. Bard and L.R. Faulkner, John Wiley, New York,(1980)
7. Electroanalytical Chemistry, J.J . Lingane, 2nd Ed Interscience, New York (1958)
8. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker,New York, 1980.
9. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (Aseries of volumes)
10. Techniques and mechanism of electrochemistry, P. A. Christian and A. Hamnett, Blachie Academic and Professional (1994)
11. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of Volumes)
12. Treatise on Analytical Chemistry, Eds. I. M. Kolthoff and Others, Interscience Pub.(A series of volumes).
13. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, (A series of volumes)
14. Polarographic Methods in Analytical Chemistry, M. G. Arora, Anmol Publications Pvt Ltd
15. Surface Analysis –The Principal Techniques, 2ndEdition Edited by John C. Vickerman and Ian S. Gilmore 2009 John Wiley & Sons, Ltd. ISBN: 978-0-470-01763-0
16. NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry *R. V. Parish*.Ellis Horwood, Chichester

PROGRAM(s): M.Sc.-II			SEMESTER: III	
Theory: Mandatory Course Paper –III			Course Code: CHEM 663 Course Title:- Bioanalytical Chemistry and Food Analysis	
Teaching Scheme			Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	NA	04	50	50

Course Objectives:

CO1.To understand the composition and detection of various body fluids
CO2.To get familiar with the characteristics of various food components.
CO3.To know about the various techniques in estimation of vitamins
CO4.To understand immunoassay and food analysis using different experimental techniques

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1. explain the nutritional value of vitamins and minerals
CLO2. explain the method of determination of enzymes, carbohydrates and proteins
CLO3. explain the procedure for analyzing the food samples and to identify the presence of adulterants, contaminants, and pesticide residues.
CLO4. assess the safety and quality of food products based on their analytical results.
CLO5. evaluate the impact of processing on food components and make judgments regarding the suitability of food additives in various products.

Semester – III

Mandatory Course Paper –III

Bio-analytical Chemistry and Food Analysis

COUSE CODE :CHEM 663 **CREDIT : 4**

Course code- CHEM 663	Unit	Course/Unit Title- Bio-analytical Chemistry and Food Analysis	Credits 04/ 60 Lectures
	UNIT 1	**Composition of body fluids and its detection**	**[15L]**
	1.1	Composition of body fluids and detection of abnormal levels of glucose, creatinine, uric acid in blood, protein, ketone bodies and bilirubin in urine leading to diagnosis of diseases.	**[5L]**
	1.2	Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals.	**[5L]**
	1.3	Analytical techniques (including microbiological techniques) for vitamins.	**[5L]**
	Unit 2	**Immunological Methods:**	**[15L]**
	2.1	General processes of immune response, antigen-antibody reactions, precipitation reactions, radio, enzyme and fluoro-immuno assays.	**[8L]**
	2.2	Human Nutrition: Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids.	**[7L]**
	Unit 3	**Food Analysis - I**	**[15L]**
	3.1	Fuel value of food and importance of food nutrients	**[2L]**
	3.2	**3.2.1** Food Additives – General idea about food processing and preservation. Food preservation through irradiation, chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners and enzymes. **3.2.2** Analysis of food products for flavouring agents and colour.	**[5L]**

	3.3	Food Contaminants– Trace metals and pesticide residues, contaminants from industrial wastes (polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants.	**[8L]**
	Unit 4	**Food Analysis - II**	**[15L]**
	4.1	Food packaging – Introduction, types of packing materials properties and industrial requirements.	**[2L]**
	4.2	Processing and quality requirements of milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat products.	**[6L]**
	4.3	Analysis of Milk – Fat content, proteins, acidity, bacteriological quality and milk adulterants.	**[2L]**
	4.4	Analysis of Oils and Fats – acid value, sap value, iodine value. Determination of rancidity and antioxidants.	**[2L]**
	4.5	Analysis of spices (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils	**[3L]**

List of books and References:

1. General, organic and biological chemistry, H. Stephen Stoker, Cengage Learning.
2. Advance dairy chemistry, vol 3, P. F. Fox, P. L. H. McSweeney Springer.
3. Physiological fluid dynamics vol 3, Nanjanagud Venkatanarayanasastry Chandrasekhara Swamy Narosa Pub. House, 1992
4. Molecular Biological and Immunological Techniques and Applications for food,edited by Bert Popping, Carmen Diaz-Amigo, Katrin Hoenicke, John Wiley & sons.
5. Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan,Springer.
6. Principles of package development, Gribbin et al
7. Modern packaging Encyclopedia and planning guide, Macgra Wreyco.
8. Food Analysis, Edited by S. Suzanne Nielsen, Springer
9. Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
10. Bioanalytical Chemistry, S. R. Mikkelesen and E. Corton, John Wiley and sons 2004
11. Analysis of food and beverages, George Charalanbous, Accademic press 1978

PROGRAM(s): M.Sc.-II				SEMESTER: III	
Mandatory Course Practical				Course Code: PRCHEM 644 Course Title:- Analytical Chemistry Practical	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 25)	Semester End Examination (Marks- 25)
NA	04	NA	02	25	25

Course Objectives:

CO1. To understand basic principles and theoretical background of non-instrumental and instrumental methods for the analysis of different samples.

CO2.To equip learners with basic laboratory skills and handling of instrumental techniques.

CO3.To train learners with sample preparation techniques for a variety of samples.

CO4. To make learners do various calculations and generate correct results after the analysis.

Course Learning Outcomes:

After the completion of the course, learners will be able to

CLO1. select the appropriate method of analysis of the given sample.

CLO2. prepare a representative sample of a given bulk sample for analysis.

CLO3. use a proper method with required tools and techniques for analyzing a given sample.

CLO4. systematically perform the calculations and get the required results after the analysis.

Semester – III

Mandatory Course

Analytical Chemistry Practical

Course Code: PRCHEM 664 **Credit :2**

Course code- PRCHEM 664	Analytical Chemistry Practical	Credits: 02
	Non Instrumental 1. Determination of calcium by complexometric titration with EDTA in the sample of milk powder 2. Determination of SAP value for a given oil sample 3. Determination of iodine value for a given oil sample 4. Honey sample: Determination of total reducing sugars before and after inversion by Cole's Ferricyanide method. 5. Estimation of benzoic acid and salicylic acid in Whitfield ointment. 6. Estimation of Fe in iron tablets using titrimetric method. 7. Estimation of calcium in Ca-pentothenate/Ca-lactate tablet.	
	Instrumental: 1. Determination of pKa value of an indicator spectrophotometrically. 2. Determination of amount of sulphuric acid, acetic acid and copper sulphate in a mixture by conductometric titration with sodium hydroxide. 3. Determination of percentage purity of the given sample of methylene blue / Malachite green 4. Spectrophotometric determination of pH of a buffer solution. 5. Determination of aniline and ethanolamine in a mixture of two in acetonitrile by potentiometric titration. 6. Simultaneous determination of Ti(III) and V(V) spectrophotometrically by H_2O_2 method	

PROGRAM(s): M.Sc.-II			SEMESTER: III	
Theory: Elective Course I			Course Code: CHEM 66511 Course Title:- Environmental Chemistry	
Teaching Scheme			Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 25)	Semester End Examination (Marks- 25)
02	NA	02	25	25

Course Objectives:

CO1. To understand different type of environmental pollution and their sources

CO2. To determine the important constituents that determine the quality of the environmental components (air and soil)

CO3.To learn the various concepts of environmental audit

CO4.To get acquainted with different environmental laws w.r.t air and water pollution.

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1. apply the knowledge gained to minimize pollution and improve the quality of the environment.

CLO2. assess the pollution level in environment.

CLO3. contribute in conducting environmental audit.

CLO4. apply different environmental laws as per situation.

Semester – III

Elective Course – I

Course Title:- Environmental Chemistry

Course Code: CHEM 66511 **Credit: 2**

Course Code: (CHEM 66511)	Unit	Elective- I Course/Unit Title:- Environmental Chemistry	Credits 02/ 30 Lectures
	UNIT 1	**ENVIRONMENTAL POLLUTION**	**[15L]**
	1.1	**AIR POLLUTION** **1.1.1** Sources, classification, pollutants and permissible limits. **1.1.2** Importance of automobile exhaust control and its limits **1.1.3** Sampling and analysis of: Particulate matter, aerosols, ammonia, and organic vapors. **1.1.4** Carbon credit and global issues related to air pollution **1.1.5** Greenhouse gases and their substitutes	**[5L]**
	1.2	**SOIL POLLUTION AND SOIL ANALYSIS:** **1.2.1** Sources of soil pollution and their control **1.2.2** Sampling of soil **1.2.3** Determination of water holding capacity ,total nitrogen, ammonia and nitrates. **1.2.4** Fertility of soil and effect of pollution on quality of soil **1.2.5** Synthetic fertilizers and their long term effect on soil quality.	**[5L]**
	1.3	**OTHER TYPES OF ENVIRONMENTAL POLLUTION:** **1.3.1** Noise Pollution : sources, effects, methods of measurements and control measures. **1.3.2** Thermal Pollution: definition, sources, impact, control measures. **1.3.3** Radioactive pollutants: source, exposure hazards, precautions in handling and safety,	**[5L]**

		long term effects.	
	UNIT 2	**WATER QUALITY STANDARDS, ENVIORNMENTAL LAWS AND AUDIT**	**[15L]**
	2.1	**WATER QUALITY STANDARDS** **2.1.1** Quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs, quality of potable water from natural sources. **2.1.2** Bore well water quality and analytical parameters. Quality of bottled mineral water **2.1.3** Process of purification of bore well water to bottled mineral water. **2.1.4** Regulatory requirements for packaged drinking water	**[5L]**
	2.2	**ENVIRONMENTAL LAWS:** **2.2.1** Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC. **2.2.2** Water Act (Prevention and Control of Pollution) Act, 1974 (Amendement 1988).	**[5L]**
	2.3	**ENVIRONMENTAL AUDIT:** Concept of audit, objectives, authorities, components, steps involved in environmental audit, evaluation methodology, benefits and certification	**[5L]**

List of Books and References:

1. Environmental Chemistry, A. K. De, 2nd ED. Wiley (1989).
2. Environmental Pollution Analysis, S. M. Khopkar, John Wiely (1993).
3. Air Pollution Sampling And Analysis, Sharad Gokhale, IIT Guwahati, May 2009.
4. Environmental Pollution Analysis, S. M. Khopkar, New Age International publication (2011).
5. Water And Water Pollution (hand book) Ed., Seonard'l Ciacere, Vol I to IV, Marcel Dekker inc. N.York(1972)
6. Water pollution, Arvind kumar, APH publishing (2004)
7. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.
8. Guidelines for drinking-water quality, Third edition, (incorporating first and second addenda). WHO report.
9. Soil pollution, S.G. Misra and Dinesh Mani, APH Publishing Corporation, (2009).
10. Soil Pollution: origin, monitoring and remediation, Abrahim Mirsal, Springer (2010).
11. Noise Pollution, Donald F Anthrop, Lexington Books, (1973)

12. Noise Effects Handbook: A Desk Reference to Health and Welfare Effects of Noise (1981) Available at NCL laboratories e- Library.
13. Chemistry, Emission Control, Radioactive Pollution and Indoor Air Quality Edited by Nicolas Mazzeo, InTech Publications (2011).
14. Environmental Protection Against Radioactive Pollution: N. Birsen, Kairat K. Kadyrzhanov, Springer publication , (2003).
15. Environmental law in India, Mohammad Naseem, Wolters Kluwer.
16. Environmental Protection, Law And Policy In *India* Kailash Thakur google books (1997)

PROGRAM(s): M.Sc.-II				SEMESTER: III	
Elective Course I Practical				Course Code: PRCHEM 66511 Course Title:- Environmental Chemistry Practical	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA)	Semester End Examination
NA	04	NA	02	(Marks- 25)	(Marks- 25)

Course Objectives:

CO1. To impart first-hand knowledge on practical methods for soil and water analysis

CO2. To equip learners with basic laboratory techniques of soil and water analysis

CO3.To make them aware of different methods of analysis of soil and water

CO4.To train learners for the calculation of analyte concentration in the environmental sample

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1. decide the suitable analytical method for the analysis of the soil and water sample

CLO2. apply the knowledge to solve environmental issues

CLO3. use the techniques and skills for doing analysis of soil and waste water

CLO4. undertake teaching, research and offer administrative and consultancy services

Semester – III

Elective Course I Practical
Course Title:- Environmental Chemistry Practical
Course Code: PRCHEM 66511 **Credit: 2**

Course code- PRCHEM 66511	Elective Course I Practical Environmental Chemistry Practical (PRCHEM 66511)	Credits: 02
	Non – Instrumental: 1. Determination of organic carbon in soil by Walkley-Black method. 2. To determine the alkalinity of a given water sample 3. To determine the salinity of a given water sample 4. To determine the amount of sulphate in the given water sample by the benzidine sulphate method 5. Determination of chromium in water sample by least square method 6. Estimation of extractable calcium in soil sample complexometrically	
	Instrumental: 1. Determination of potassium in soil sample flame photometrically by standard addition method 2. Determination of sodium in water sample flame photometrically by calibration curve method. 3. To determine the amount of Mn^{2+} in the given water sample spectrophotometriclly. 4. Determination of lead in the water sample spectrophotometrically. 5. Determination of available nitrogen in the soil or estimation of ammonia in Water by Kjeldahl distillation assembly [Demo experiment].	

PROGRAM(s): M.Sc.-II			SEMESTER: III	
Theory : Elective Course II			Course Code: CHEM 66512 Course Title:- Industrially Important Materials	
Teaching Scheme			Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 25)	Semester End Examination (Marks- 25)
02	NA	02	25	25

Course Objectives:

CO1.To understand the classification and biodegradation of insecticides and pesticides.
CO2.To study about soaps and detergents with reference to their chemical parameters
CO3.To be acquainted with properties and processes of petrochemical products
CO4. To understand the composition, manufacturing process, properties of certain industrially important materials

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1.classify the types of insecticides and pesticides along with their biodegradation pathways
CLO2. explain the chemical parameters of soaps and detergents
CLO3. describe the properties and processes of petrochemical products
CLO4.apply the knowledge gained about the certain industrially important materials

Semester III
Elective Course II
Course Title:- Industrially Important Materials

Course Code: CHEM 66512 **Credit :2**

Course Code: CHEM 66512		Elective Course II Course/Unit Title:- Industrially Important Materials	Credits 02/ 30 Lectures
	UNIT I	**Industrial Materials I**	**[15L]**
	1.1	**Insecticides, Pesticides:** Classification of insecticides and pesticides. Biodegradation of insecticides and pesticides	**[5 L]**
	1.2	**Soaps and Detergents:** Classification and composition, qualitative analysis, quantitative analysis of detergents- alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents	**[5L]**
	1.3	**Petrochemical products:** Crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and its impact on environment.	**[5L]**
	UNIT 2	**Industrial Materials II**	**[15L]**
	2.1	**Cement :** composition , classification , manufacturing process and properties of cement	**[4L]**
	2.2	**Ceramics:** properties and classification.	**[2L]**
	2.3	**Glass**: composition of glass, types of glass, manufacturing process of glass	**[3L]**
	2.4	**Fertilizer**: 2.4.1 Definition, classification of fertilizer and sources of fertilizer. 2.4.2 Types of nitrogenous fertilizers: i) Ammonium nitrate (manufacturing process- Stengel process). ii) Ammonium Sulphate : Manufacturing process, action of ammonium sulphate as a fertilizer iii) Urea: Manufacturing process, action of urea as a fertilizer	**[6L]**

List of books and references

1. Green chemistry An Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002)
2. Pesticide Analysis Ed K. G. Das, Dekker (1981)
3. Analytical, Agricultural Chemistry S. L Chpra J.S Kanwar Kalyani publication
4. Soil and plant Analysis C.S Piper , Hans Publication
5. https://in.docworkspace.com/d/sIIuA8L9Y9ODWsgY
6. https://in.docworkspace.com/d/sIAKA8L9Y4OLWsgY
7. https://in.docworkspace.com/d/sICuA8L9Yx4zhsgY
8. https://in.docworkspace.com/d/sIC6A8L9Y76HhsgY

PROGRAM(s): M.Sc.-II				SEMESTER: III	
Elective Course II Practical				**Course Code: PRCHEM 66512** **Course Title:-** **Industrially Important Materials Practical**	
Teaching Scheme				**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks- 25)**	**Semester End Examination (Marks- 25)**
NA	**04**	**NA**	**02**		

Course Objectives:

CO 1: To be aware of various classical and instrumental methods of analysis for commercial samples.

CO2: To get trained in handling various analytical instruments.

CO3: To get equipped with basic skills involved in sample pretreatment, detection of analyte and reporting of results.

CO4: To be exposed to analysis of commercial samples for quality assessment.

Course Learning Outcomes:

At the end of the course learner will be able to

CLO 1: decide the appropriate method and plan the steps for the analysis of commercial samples.

CLO2: operate analytical instruments confidently for the purpose of analysis.

CLO3: apply the skills acquired to estimate commercial samples with highest degree of accuracy.

CLO4: calculate and express the results in a meaningful manner from the perspective of quality assessment.

Semester III
Elective Course II Practical
Course Title:- Industrially Important Materials

Course Code: PRCHEM 66512 **Credit :2**

Course Code: PRCHEM 66512	Elective Course II Practical Course Title:- Industrially Important Materials Practical	Credits 02
	Non Instrumental 1. Assay of the following commercial samples as per IP i. calcium carbonate ii. magnesium sulphate iii. glycerine iv. iodine 2. Analysis of calcium oxide in cement (white cement) complexometrically. 3. Determination of amount of acetic acid in ear drops titrimetrically. 4. Preparation of cold cream and vanishing cream [Demo Experiment]	
	Instrumental: 1. Estimation of aspirin content in the tablet by conductometric titration. 2. Determination of phosphate ion in detergent sample spectrophotometrically. 3. Estimation of iron in tablet spectrophotometrically by using 1,10-phenanthroline . 4. Determination of paracetamol in tablet spectrophotometrically.	

PROGRAM(s): M.Sc-II				SEMESTER: III	
Course: Research Project				Course Code: CHEM 666	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-50)	Semester End Examination (Marks- 50)
NA	08	–	04	50	50

Course Objectives:

CO1. To create awareness about the significance of research
CO2. To identify a research problem
CO3. To enable the learner to extract information from journals / digital resources and understand how to make a systematic research plan
CO4. To develop skills in the application of theory to experimental work situations.

Course Learning Outcomes:

At the end of the Course the learner will be able to

CLO1. select the research topics of interest and create a systematic research plan for a chosen research project
CLO2. develop skills in qualitative and quantitative analysis
CLO3. demonstrate the ability to choose analytical methods appropriate to research topic
CLO4. demonstrate good practices in research

Guidelines:

1. Students are to work on research project individually
2. Research Project is of 4 credits which equals to project working hours of 120.
3. Novelty in research should be the focus when selecting a research topic.
4. The topic of research chosen by the student has to be of their interest, taking in account of its usefulness, social relevance and contribution to the field of chemistry
5. Record of attendance and continuous performance of the student is monitored by the mentor.
6. At the end of the semester, the student has to present the project report in a bound form for external evaluation
7. Participation in national and international conferences and other project competitions is encouraged.
8. Literature survey for the research project is suggested to be from journals of reputed publications and UGC – CARE journals.

Semester – IV

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

Course Objectives:

CO1. To understand various methods of separation used in pre-treatment of samples.
CO2. To know about different methods of preparation and quality aspect of herbal based products
CO3. To learn about the principles, recent development and applications of green chemistry.
CO4. To get well versed with various techniques of electrophoresis.
CO5**.** To gain knowledge about nanotechnology as an emerging field.

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1. comprehend the role of solvent extraction and membrane techniques in sample pre-treatment.
CLO2. explain the terms, elaborate the methods of preparation and quality assessment with regards to herbal based products.
CLO3.illustrate the principles and applications of green chemistry from industry perspective.
CLO4.explain and compare different methods of electrophoresis.
CLO5.describe the preparation and analysis of nano-scale materials.

Semester – IV

Mandatory Course Paper I

Quality in Analytical Chemistry -II

COURSE CODE: CHEM 667 **CREDIT :4**

Course code- CHEM 667	Unit	Course/Unit Title: Quality in Analytical Chemistry -II	Credits 04/ [60 Lectures]
	UNIT 1	**Separation Science**	**[15L]**
	1.1	**Membrane separation processes:** operating principles and applications of microfiltration, ultra-filtration, reverse osmosis, dialysis and electro-dialysis	**[8L]**
	1.2	**Solvent Extraction:** Role of solvent extraction in analytical chemistry, solvent extraction in sample preparation and pre-treatment steps, applications of solvent extraction in industry	**[7L]**
	UNIT 2	**Separation, Analysis and Standardization of Herbal based products.**	**[15L]**
	2.1	**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 materials.	**[6L]**
	2.2	**Extraction of herbal materials:** Choice of solvent for extraction, methods used for extraction and principles involved in extraction.	**[3 L]**
	2.3	**2.3.1 Standardization of herbal formulation and herbal extracts:** Standardization of herbal extract as per WHO and GMP guidelines, Physical, Chemical, Spectral and toxicological standardization, qualitative and quantitative estimations. **2.3.2** Markers for Herbal Medicine (DNA marker and Chemical marker)	**[6L]**
	UNIT 3	**Green Chemistry**	**[15L]**

	3.1	**Principle and concepts of Green chemistry**: sustainable development and green chemistry, atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity	**[4L]**
	3.2	**Organic solvents:** environmentally benign solutions, solvent free systems, supercritical fluids (only introduction), ionic liquids as catalysts and solvents	**[4L]**
	3.3	**Emerging Green Technologies:** photochemical reactions (advantages and challenges), examples. Chemistry using microwaves, sonochemistry and electrochemical synthesis.	**[4L]**
	3.4	**Designing Greener Processes:** Inherently Safer Designs (ISD), Process intensification (PI) in-process monitoring.	**[3L]**
	UNIT 4	**Advanced Techniques**	**[15L]**
	4.1	**Electrophoresis:** Introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephedax and thin layers)	**[2L]**
	4.2	**Techniques of Electrophoresis:** Low and high voltage, SDS-PAGE, continuous electrophoresis, capillary electrophoresis, zone, gel, isoelectric focusing, isotaechophoresis and miceller electro kinetic capillary chromatography-instrumentation, detection and applications.	**[8L]**
	4.3	**Introduction to Nanotechnology:** Analytical techniques in nanotechnology, consequences of the nanoscale, (nanoparticles morphology, electronic structure, optical properties) one dimensional nano materials (nanofilms, nanolayers), two dimensional nanomaterials (nanotubes, nanowires), three dimensional nanomaterials (nanoparticles and quantum dots).	**[5L]**

List of books and references:

1. Fingerprinting analysis and Quality Control Methods of Herbal Medicines, Ravindra Kumar Pandey, Shiv Shankar Shukla, Amber Vyas, Vishal Jain, Shailendra Saraf, CRC Press, Taylor and Francis Group, Boca Raton London New York.
2. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
3. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
4. Extraction Chromatography, T. Braun, G. Ghersene, Elsevier Publications 1978.
5. Super critical fluid extraction, Larry Taylor Wiley publishers N.Y. 1996
6. Ion exchange separation in analytical chemistry, O Samuelson John Wiley 2nd ed 1963
7. Ion exchange chromatography, Ed H.F Walton Howden, Hutchenson and Rossing 1976
8. Chromatographic and el ectrophoresis techniques, I Smith Menemann Interscience 1960
9. Green chemistry and catalyst, R. A. Sheldon, Isabella Arends, Ulf Hanefeld Wiley VCH verlag GmBH & co.
10. Sustainable residential development: planning and design for green neighborhoods. Avi Friedman, McGraw Hill professional

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

Course Objectives:

CO1. To understand the basic principles, instrumentation of FT-NMR, COSY, TOCSY and HETCOR spectroscopy

CO2.To know the importance of MRI and applications of NMR to other nuclei

CO3.To describe the basic principles, instrumentation and applications of SERS and Resonance Raman spectroscopy

CO4.To discuss the principle, types and applications of isotopic dilution method, radio-release method, radiometric titration and radioimmunoassay

CO5.To explain the principle, interfacing, instrumentation, and applications of thermal methods in analysis

CO6.To understand the concept of hyphenated techniques in different analytical instruments

CO7.To comprehend the role of interfacing devises and applications of hyphenated analytical instruments

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1. relate FT-NMR, COSY, TOCSY and HETCOR spectroscopy and its applications in various fields

CLO2.discover the importance of MRI and NMR to other nuclei

CLO3.interpret the applications of SERS and resonance Raman spectroscopy

CLO4.correlate the applications of isotopic dilution method, radio-release method, radiometric titration and radioimmunoassay

CLO5.apply the principle, interfacing, instrumentation, and applications of thermal methods

CLO6.articulate the various hyphenated analytical instruments and its applications in different fields

Semester – IV

Mandatory Course Paper II

Advanced Instrumental Techniques -II

COURSE CODE:CHEM 668 **CREDIT:4**

Course code- CHEM 668	Unit	Course/Unit Title- Advanced Instrumental Techniques -II	Credits: 04/ 60 lectures
	UNIT 1	**Spectral Methods III**	**[15L]**
	1.1	**NMR Spectroscopy -**Theory and Instrumentation of **1.1.1** FT-NMR, **1.1.2** 2D -NMR, FID signal generation techniques in 2D- NMR **1.1.3** Homo nuclear correlation spectroscopy (COSY) **1.1.4** Total correlation spectroscopy (TOCSY) **1.1.5** Heteronuclear correlation (HETCOR) spectroscopy.	**[9L]**
	1.2	**Radio waves in imaging-** Principle, instrumentation, and applications of MRI.	**[3L]**
	1.3	Applications of NMR to other nuclei ^{13}C, ^{31}P and ^{19}F spectroscopy	**[3L]**
	UNIT 2	**Spectral Methods – IV**	**[15L]**
	2.1	**Mass spectroscopy:** correlation of mass spectra with molecular structure- interpretation of mass spectra, analytical information derived from mass spectra- molecular identification, metastable peaks, fragmentation reactions.	**[9L]**
	2.2	**Raman spectroscopy:** Theory, instrumentation, techniques of surface enhanced Raman spectroscopy (SERS) and resonance Raman spectroscopy. Applications of Raman spectroscopy.	**[6L]**
	UNIT 3	**Radiochemical And Thermal Methods**	**[15L]**
	3.1	**Activation analysis** **3.1.1** Isotope dilution method: Introduction, principle. Types of isotopic dilution method: direct isotopic dilution method, inverse isotopic dilution method,	**[8L]**

		double dilution method and applications. **3.1.2** Radio-release method: Introduction, principle and applications **3.1.3** Radiometric titrations and Radioimmunoassay: Principle, instrumentation and applications	
	3.2	**Thermal analysis** Principle, interfacing, instrumentation, and applications of: **3.2.1**Simultaneous Thermal analysis –TG-DTA and TG-DSC **3.2.2** Evolved gas analysis- TG-MS and TG-FTIR	**[7L]**
	UNIT 4	**Hyphenated Techniques**	**[15L]**
	4.1	Concept of hyphenation and need for hyphenation in analytical instrumentation.	**[2L]**
	4.2	Interfacing devices and applications of i) GC – MS ii) ICP –MS iii) GC - IR iv) Tandem Mass Spectrometry v) LC – MS vi) HPLC-MS vii) CE-MS.	**[13L]**

List of books and references:

1. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J HollerHolt- Saunders 6 th Edition (1998)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5thEd.
4. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A.
5. Thermal methods of Analysis, P. J. Haines, Blackie Academic & Professional, London(1995)
6. Thermal Analysis, 3rdEdition W. W. Wendlandt, John Wiley, N.Y. (1986)
7. Principles and Practices of X-ray spectrometric Analysis, 2ndEd E. P. Bertain, Plenum Press,NY, (1975)
8. Nuclear Analytical Chemistry, D. Bane, B. Forkman, B. Persson, Chartwell - Bratt Ltd(1984)

9. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, A series of volumes
10. A Complete Introduction to Modern NMR Spectroscopy 1St Edition by Roger S.Macomber
11. Spectrometric Identification of Organic Compounds Hardcover – by Robert M.Silverstein Wiley
12. Tandem Techniques (Separation Science Series) 1stEdition by Raymond P. W. Scott John Wiley & Sons Ltd, 1997
13. Encyclopedia of Analytical Science, Editors-in-Chief: Paul Worsfold, Alan Townshend,and Colin Poole ISBN: 978-0-12-369397-6
14. Encyclopedia of Analytical Chemistry: Applications, Theory, and Instrumentation. Meyers Robert A Meyers
15. Introduction to Thermal Analysis Techniques and Applications Edited by Michael E. Brown
16. Principles and Applications of Thermal Analysis Edited by Paul Gabbott
17. https://chem.libretexts.org/Courses/Sophia_College_for_Women/Thermal_Methods_of_Analysis_(Shetty)

PROGRAM(s): M.Sc.-II			SEMESTER: IV	
Theory: Mandatory Course Paper III			**Course Code: CHEM 669** **Course Title:-** **Selected topics in Analytical chemistry**	
Teaching Scheme			**Evaluation Scheme**	
Lectures (Hours per week)	**Practical (Hours per week)**	**Credit**	**Continuous Assessment (CA)** **(Marks- 50)**	**Semester End Examination** **(Marks- 50)**
04	**NA**	**04**	**50**	**50**

Course Objectives:

CO1.To have knowledge of effluent treatments , recovery of metals from effluents, recycling and reuse of effluent water.

CO2.To get knowledge of solid waste management

CO3.To study different types of plastics and analysis of plastics.

CO4.To gain a comprehensive understanding of paints and pigments, including their types, analysis methods, and environmental impact.

CO5.To understand the different types of metallurgical process and applications.

Course Learning Outcomes:

At the end of the course learner will be able to

CLO1.apply the concepts of different types of effluent treatment.

CLO2.explain the process of waste management in day-to-day life

CLO3.classify the plastics and report the impact of plastics on environment

CLO4.analyze and apply the appropriate methods of analysis for paints and pigments.

CLO5.apply the knowledge of metallurgy in analysis of mineral, alloys and environmental management.

Semester – IV

Mandatory Course Paper III

Selected topics in Analytical chemistry

COURSE CODE:CHEM 669 **CREDIT:4**

Course code- CHEM 669	UNIT	Course/Unit Title- Selected topics in Analytical chemistry	Credits 04/ 60 Lectures
	UNIT 1	**Effluent Treatment**	**[15L]**
	1.1.	**Effluent treatment plant:** general construction and process flow charts.	**[3L]**
	1.2	Treatment and disposal of sewage.	**[3L]**
	1.3	Effluent parameters for metallurgical industry.	**[2L]**
	1.4	Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent.	**[2L]**
	1.5	**Recovery of metals from effluent, modern methods –** Electrodialysis, Electrodeposition and Ion Exchange.	**[3L]**
	1.6	Recycle and reuse process of effluent water.	**[2L]**
	UNIT 2	**Solid Waste Management**	**[15L]**
	2.1	Solid waste management: objectives, concept of recycle, reuse and recovery	**[3L]**
	2.2	Methods of solid waste disposal.	**[2L]**
	2.3	Treatment and disposal of sludge / dry cake	**[3L]**
	2.4	Managing non-decomposable solid wastes	**[2L]**
	2.5	Bio- medical waste : Introduction , classification and methods of disposal	**[5L]**
	UNIT 3	**Plastics and Polymers**	**[15L]**
	3.1	Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics.	**[5L]**
	3.2	Metallic impurities in plastic and their determination	**[2L]**
	3.3	Impact of plastic on environment as pollutant.	**[2L]**
	3.4	Paints and pigments: Types of paints pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination),	**[3L]**

	3.5	separation and analysis of pigments, binders and thinners. Role of organo-silicones in paints and their impact on environment	[3L]
	UNIT 4	**Metallurgy**	**[15L]**
	4.1	**Ores and minerals:** Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting)	**[3L]**
	4.2	**Chemical analysis of ores for principal constituents :** Galena,pyrolusite, bauxite, hematite, monazite	**[4L]**
	4.3	**Alloys**: definition, analysis of cupronickel, magnelium, steel and stainless steel, bronze, gun metal.	**[4L]**
	4.4	**Techniques of purification:** Zone refining, analysis of high purity silicon materials	**[4L]**

List of Books and References:

1. Environmental Pollution Analysis, S. M. khopkar, New Age International publication(2011)
2. Water and water pollution (hand book) Ed., Seonard'l Ciacere, Vol I to IV, Marcel Dekker inc. N.Y.(1972)
3. Water pollution, Arvind kumar, APH publishing (2004)
4. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.
5. Solid waste management, K Sasikumar and Sanoop Gopi Krishna PHI publication (2009)
6. Solid waste management, Surendrakumar Northen Book Center (2009)
7. Handbook of chemical technology and pollution control 3rdEdn Martin Hocking AP Publication (2005).
8. Fundamental Concepts of Environmental Chemistry, Second Edition G. S. Sodhi , Alpha Science, 2005
9. Chemical analysis of metals ; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering
10. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines, 1979.
11. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).
12. Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology & Engineering (1960)

PROGRAM(s): M.Sc.-II				SEMESTER: IV	
Theory: Elective Course I				Course Code: CHEM67011 Course Title:- Intellectual property rights and Cheminformatics	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	NA	–	04	50	50

Course Objectives:

CO1. To understand the concept of Intellectual Property Rights

CO2. To get the knowledge about the trade secrets ,IP infringement issues, and economic value of Intellectual property

CO3.To understand chemoinformatics with respect to structure, drug designing and application.

Course Learning Outcomes:

After completion of this course the learner will able to

CLO1.develop awareness about Intellectual Property Rights.

CLO2.discover the value of Intellectual property rights, different types of international agreements and infringement issues

CLO3.apply the knowledge of cheminformatics in the areas of drug designing, spectral correlation and structural elucidation

Semester IV

Elective Course – I
Course Title: Intellectual property rights and Cheminformatics

COURSE CODE: CHEM67011 **CREDIT :4**

Course code- CHEM 67011	UNIT	Course/Unit Title- Intellectual property rights and cheminformatics	Credits 04/ 60 Lectures
	UNIT 1	**Intellectual Property rights -I**	**[15 L]**
	1.1	**Introduction to Intellectual Property:** Historical perspective, different types of IP, Importance of protecting IP.	**[2L]**
	1.2	**Patents:** Historical perspective, basic and associated right, WIPO, PCT system, traditional knowledge, Software patents and their importance for India.	**[5L]**
	1.3	**Industrial Designs**: Definition, procedure to obtain, features, International design registration.	**[2L]**
	1.4	**Copyrights:** Introduction, procedure to obtain, differences from patents.	**[2L]**
	1.5	**Trade Marks:** Introduction, procedure to obtain, different types of marks – Collective marks, certification marks, service marks, trade names etc.	**[2L]**
	1.6	**Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India.	**[2L]**
	UNIT 2	**Intellectual Property rights -II**	**[15L]**
	2.1	**Trade Secrets:** Introduction and historical perspectives, scope of protection, risks involved and legal aspects of Trade Secret Protection.	**[2L]**
	2.2	**IP Infringement issue and enforcement:** Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.	**[2L]**

	2.3	**Economic Value of Intellectual Property:** Intangible assets and their valuation, Intellectual Property in the Indian context – Various laws in India Licensing and Technology transfer.	**[2L]**
	2.4	**Different International agreements:** **(a) World Trade Organization (WTO):** (i) General Agreement on Tariffs and Trade (GATT), Trade Related 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 Breeders Rights, IPR and Biodiversity.	**[9L]**
	UNIT 3	**Cheminformatics - I**	**[15 L]**
	3.1	**Introduction to cheminformatics:** History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation	**[5 L]**
	3.2	**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.	**[5 L]**
	3.3	**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	**[5 L]**
	UNIT 4	**Cheminformatics - II**	**[15 L]**
	4.1	Prediction of properties of compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity	**[5L]**

	4.2	Structure – Spectra correlations, prediction, NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design	**[5L]**
	4.3	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,	**[3L]**
	4.4	Application of Cheminformatics in drug design	**[2L]**

REFERENCES:

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

PROGRAM(s): M.Sc.-II				SEMESTER: IV	
Theory: Elective Course II				Course Code: CHEM67012 Course Title:- Pharmaceutical and Organic Analysis	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 50)	Semester End Examination (Marks- 50)
04	NA	–	04	50	50

Course Objectives

CO1. To get a general idea about pharmaceutical industry, different pharmaceutical formulations and various dosage forms.
CO2. To understand the role of legislative body in pharmaceutical industry.
CO3. To learn the various analytical processes in pharmaceutical industry
CO4. To be acquainted with the role of analytical chemistry in forensic science
CO5. To gain knowledge about the different cosmetics, composition and their analysis

Course learning Outcomes:

After completion of this course the learner will able to

CLO1.deal with different pharmaceutical formulations and dosage forms
CLO2.realize the role of legislative body in pharmaceutical industry.
CLO3.apply the knowledge of analytical processes in drug analysis.
CLO4.appreciate the role of analytical chemistry in forensic science.
CLO5.gain knowledge of the various aspects of cosmetic industry.

Semester IV

Elective Course - II
Course Title:- Pharmaceutical and Organic Analysis

COURSE CODE: CHEM67012 **CREDIT:4**

Course Code: CHEM 67012	Unit	Course Title:- Pharmaceutical and Organic Analysis Elective- II	Credits: 04 / 60 lectures
	UNIT 1	**Pharmaceutical Analysis**	**[15L]**
	1.1	General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries.	**[7L]**
	1.2	Sources of impurities in pharmaceutical products and raw materials.	**[4L]**
	1.3	Standardization of finished products and their characteristics, official methods of quality control.	**[4L]**
	UNIT 2	**Drugs**	**[15L]**
	2.1	Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests.	**[8L]**
	2.2	Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies. Polymers in pharmaceuticals and novel drug delivery systems.	**[7L]**
	UNIT 3	**Forensic Science**	**[15 L]**
	3.1	Role of Analytical Chemistry in Forensic Science	**[2L]**
	3.2	**Forensic Analysis:** Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification.	**[5L]**

	3.3	**Analytical Toxicology: Isolation, identification and determination of:** **3.3.1** Narcotics: Heroin, morphine and cocaine. **3.3.2** Stimulants: Amphetamines and caffeine. **3.3.3** Depressants: Benzodiazepines, Barbiturates and Mandrax. **3.3.4** Hallucinogens: LSD and Cannabis. **3.3.5** Metabolites of drugs in blood and urine of addicts. **3.3.6** Viscera, stomach wash,vomit and post-mortem blood for poisons like – cyanide, arsenic, mercury, insecticides and pesticides.	**[8L]**
	Unit 4	**Cosmetic Analysis**	**[15 L]**
	4.1	**Cosmetics:** Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis.	**[2L]**
	4.2	**Deodorants and antiperspirants**: Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea.	**[3L]**
	4.3	**Face powder:** Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total).	**[3L]**
	4.4	**Hair tonic:** 2,5-diaminotoluene, potassium borates, sodium perborate,pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers)	**[3L]**
	4.5	**Creams and Lotions:** Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy)	**[2L]**
	4.6	**Lipsticks:** General analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents.	**[2L]**

List of books and references

1. Analytical Biochemistry, David J Holmes and Hazel Peck, Longman, 1983.
2. Bioanalytical Chemistry, Susan R Mikkelesen and Eduardo Cotton, John Wiley and Sons, 2004.
3. Analysis of food and beverages, George Charalanbous, Academic press, 1978.

4. Harry's Cosmetology, 7thEd, Longman Scientific Co.
5. Formulation and Function of Cosmetics, Joseph Stefan Jellinek, Wiley Interscience, 1971.
6. Cosmetic Technology, Edward Sagarin, Interscience Publishers, 1957.
7. Modern Cosmetics, Edgar George Thommsen, Francis Chilson, Drug and Cosmetic Industry, 1947.
8. Encyclopedia of Industrial Chemical Analysis, Foster Dee Snell et al, Interscience Publishers, 1967.
9. Government of India Publications of Food, Drug and Cosmetic Act and Rules.
10. The Handbook of Drug Laws, M L Mehra, University Book Agency, Ahmedabad, 1997.
11. Chemical Analysis of Drugs, Takeru Higuchi, Interscience Publishers, 1995.
12. Text book of Pharmaceutical Analysis, Kenneth Antonio Connors, Wiley, 2001.
13. Food Processing and Preservation, B Sivasankar, Prentice - Hall of India Private Limited, 2007.
14. Food Additives, R M Pandey and S K Upadhyay, INTECH, Open Science/Open Minds.
15. Food Science, B Srilakshmi, New Age International (P) Ltd. Publishers, 2003.
16. Food Contaminants: Sources and Surveillance, Edited by C Creaser, R Purchase, Elseiver, 1991.
17. The Chemical Analysis of Food and Food Products, Morris B Jacobs.
18. FSSAI (Food Safety and Standards Authority of India) Manuals of Methods of Analysis of Foods (Oils and Fats, Milk and Milk Products, Food Additives), Ministry of Health and Family Welfare, Government of India.
19. Fundamentals of Urine and Body Fluid Analysis, Nancy A Brunzel, Elsevier health Sciences, 2013.
20. Lab Manual on Blood analysis and Medical Diagnostics, Dr Gayatri Prakash, S Chand and Company Ltd, New Delhi.
21. Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, Jaypee Brothers Medical Publishers (P) Ltd, 2012.
22. Indian Pharmacopeia, Volume I and II.
23. Forensic Chemistry, Suzanne Bell, Pearson Prentice Hall Publication, 2006
24. Forensic Chemistry, David E Newton, Infobase Publishing, 2007.
25. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995.
26. AOAC Volume I and II

PROGRAM(s): M.Sc-II				SEMESTER: IV	
Course: Research Project				Course Code: CHEM 671	
Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks-75)	Semester End Examination (Marks- 75)
NA	12	–	06	75	75

Course Objectives:

CO1. To become aware of safe working procedure and ethical handling of chemicals.
CO2.To understand the use of mathematical and statistical tools to analyse the data, writing and presenting scientific papers
CO3. To practice ethics in research.
CO4. To learn to work independently and as part of a team

Course Learning Outcomes:

At the end of the Course the learner will be able to

CO1.acquire new knowledge and understanding in a particular field of research.
CO2. have the ability to design or perform the new method or techniques developed during research.
CO3.interpret and present a report on the research performed.
CO4. enhance the ability to use technology.
CO5. have insights, ideas in identifying resource selection and collaborate interdepartmental / interfaculty research activities.

Guidelines:

1. Students are to work on research project individually and it should be the continuity of the research project selected in the semester 3.
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.

MODALITIES OF ASSESSMENT

I) THEORY EXAMINATION FOR MANDATORY COURSES - SEMESTER III AND SEMESTER IV AND ELECTIVE COURSE - SEMESTER IV

A) CONTINUOUS ASSESSMENT- 50% - 50 Marks per paper

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

B) SEMESTER END THEORY EXAMINATION- 50% (50 Marks per paper)

1. **Duration** - These examinations shall be of **TWO HOURS** duration.

2. **Theory question paper pattern**

   i) There shall be 04 questions each of 10 marks on each unit and one mix question for 10 marks.

   ii) All questions shall be compulsory with internal choice within the question

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1	2 out of 4	10	Unit I
Q.2	2 out of 4	10	Unit II
Q.3	2 out of 4	10	Unit III
Q.4	2 out of 4	10	Unit IV
Q.5	5 out of 8	10	Units (I+II+III+IV) *Two questions from each unit*
TOTAL		**50**	

MODALITIES OF ASSESSMENT

II) THEORY EXAMINATION FOR ELECTIVE COURSE - SEMESTER III

A) CONTINUOUS ASSESSMENT- 50% - 25 Marks per paper

Sr.No	Evaluation Type	Marks
1	Written Objective/Short Answer Examination	**15**
2	Assignment/ industrial visit report / presentation	**10**
	Total	**25**

B) SEMESTER END THEORY EXAMINATION- 50% (25 Marks per paper)

1.Duration - These examinations shall be of **ONE HOUR** duration.

2.Theory question paper pattern

i) There shall be 02 questions each of 10 marks on each unit and one mix question for 10 marks.

ii) All questions shall be compulsory with internal choice within the question

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1	2 out of 4	8	Unit I
Q.2	2 out of 4	8	Unit II
Q.**3**	3 out of 6	9	Units (I+II) *Three questions from each unit*
TOTAL		**25**	

MODALITIES OF ASSESSMENT

PRACTICAL EXAMINATION
FOR
SEMESTER III

A) CONTINUOUS ASSESSMENT OF PRACTICALS - 50% (25marks)

Particulars	Continuous Assessment (CA)
Assessment during practicals (Interaction / Performance) Skill, accuracy, precision of measurement, Record of observation, calculations, graph, result and conclusion. Timely submission of journal	**20**
Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	**05**
Total	**25**

B) SEMESTER END PRACTICAL EXAMINATION - 50%(25marks)

Duration –One Practical session shall consist **Four hours.**

Particulars	Semester end Practical examination
Laboratory work	**15**
Viva	**05**
Journal	**05**
Total	**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

MODALITIES OF ASSESSMENT FOR RESEARCH PROJECT
SEMESTER III

Course: Research Project **Course Code: CHEM 666**

A) CONTINUOUS ASSESSMENT- 50% (50 marks)

Sr.No	Evaluation Type	Marks
1	Selection of the project	10
2	Literature survey	15
3	Scheme /Outline of project	10
4	Methodology	15
	Total	**50**

B) SEMESTER END EXAMINATION - 50% (50 marks)

Sr.No	Evaluation Type	Marks
1	Report	20
2	Presentation	30
	Total	**50**

MODALITIES OF ASSESSMENT FOR RESEARCH PROJECT
SEMESTER IV

Course: Research Project **Course Code: CHEM671**

A) CONTINUOUS ASSESSMENT - 50% (75 marks)

Sr.No	Evaluation Type	Marks
1	Experimental work	30
2	Characterization & Interpretation	25
3	Conclusion	20
	Total	**75**

B) SEMESTER END EXAMINATION - 50% (75 marks)

Sr.No	Evaluation Type	Marks
1	Report	25
2	Presentation	50
	Total	**75**

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 - 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sign of the BOS Coordinator
Dr. Sunil Patil
BOS in Chemistry
Director, Students' Welfare, University of Mumbai

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