##### AC – -------------

##### Item No. ……..



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|  **S.Z.S.P. Mandal’s****Shri Pancham Khemraj Mahavidhyalay,****Sawantwadi416510****(Autonomous)****Affiliated to Mumbai university**  |
| **Sr.****No.** | **Heading** | **Particulars** |
| 1 | Title of the Course | **M.Sc. Analytical Chemistry** |
| 2 | Eligibility for Admission | M.Sc. Chemistry or equivalent qualification from other universities as may have been allowed by the relevant ordinances of this university |
| 3 | Passing Marks | 40% |
| 4 | Ordinances / Regulations (if any) |  |
| 5 | No. of Years / Semesters |  One / Two |
| 6 | Level |  PG  |
| 7 | Pattern |  Semester |
| 8 | Status |  Revised |
| 9 | To be implementedfrom Academic Year |  From Academic Year: 2024-2025 |

 Date: Signature:

 Chairman BoS in Chemistry Dean, Science and Technology

**University of Mumbai**

**Credit Distribution Structure for One Year**

 **(M.Sc. in Analytical Chemistry)**

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| **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** |  |  | ― | ― |   **CHEM**  **666** |   | PG Degree after 2-yr PG  |
| Quality in Analytical Chemistry -I**(CHEM 661)** | TH | 4 | Environmental Chemistry+Practical**CHEM 66511)****(OR)**Industrially Important Materials+Practical**(CHEM 66512)** |
| 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 |

 **S.Z.S.P. Mandal’s**

**Shri Pancham Khemraj Mahavidhyalay,**

**Sawantwadi416510**

**(Autonomous)**

**Affiliated to Mumbai university**

**Credit Distribution Structure for Two Years
(M.Sc. in Analytical Chemistry PROGRAM OUTLINE 2024-2025**

**Syllabus for Approval**

 **Proposed Draft Syllabus For M.Sc. Analytical Chemistry Semester I and II**

**Choice Based Credit System**

**Under New Education Policy (NEP) 2020**

**(To be implemented from the academic year, 2023-2024)**

 **PROGRAM OUTLINE 2023-2024**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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** | Environmental Chemistry+Practical | 02 + 02 |
| Elective 2 |  **CHEM 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 | **RPCHEM 671** | Research Project | 06 |

**S.Z.S.P. Mandal’s**

**Shri Pancham Khemraj Mahavidhyalay,**

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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 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.

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: III** |
| **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 learner will be able to** CLO1.validate sampling in chemical and pharmaceutical industriesCLO2.operate basic analytical techniques, develop problem solving skills and be  familiar with good laboratory practice.CLO3.optimize the variables that affect the analytical techniques used to solve a  specific problemCLO4.apply different type of chromatographic techniques to determine, identify and  characterize chemical compounds |

**Semester – III**

**Paper I**

**Quality in Analytical Chemistry -I**

**Course code: CHEM 661**

|  |  |  |  |
| --- | --- | --- | --- |
| **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 methods used, 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 ratioii) Determinations for blank samplesiii) Standard deviation of signalsiv) LOQ.(numericals expected) | **[5L]** |
|  | **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:* + 1. Types of packing column (pre-swollen ion

 exchanger, pre-packed ion exchanger,  Sephadex ion exchanger)* + 1. 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, 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 2nded1963
15. Ion exchange chromatography Ed H.F Walton Howden, Hutchenson and Rossing ,1976
16. Chromatographic and electrophoresis techniques I Smith Menemann Interscience,1960

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: III** |
|  **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 enhance the learner to obtain information and 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. |

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|  **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. |

**Paper II**

**Advanced Instrumental Techniques -I**

**(CHEM 662)**

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| --- | --- | --- | --- |
| **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:* + 1. Chemiluminesescence techniques
		2. Chirooptical Methods : ORD, CD
		3. Photoacoustic spectroscopy
		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

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: III** |
| **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 fluidsCO2.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  proteinsCLO3.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. |

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| **Course code- CHEM 663** | **Unit** | **Course/Unit Title-** **Bioanalytical 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

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| **PROGRAM(s):** **M.Sc.-II** | **SEMESTER: III** |
| **Course: Practical**  | **Course Code:**  **PRCHEM 644****Course Title:- Analytical Chemistry Practical** **(PRCHEM 664)** |
| **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:**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. |

**Analytical Chemistry Practical**

**Course Code: PRCHEM 664**

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| **Course code- PRCHEM 664** | **Chemistry Practical-I** | **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: 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 Calicium in Ca-pentothenate/Ca-lactate tablets.
 |  |
|  |  **Instrumental:** * + - 1. Determination of pKa value of an indicator spectrophotometrically.
			2. Determination of amount of sulphuric acid, acetic acid and copper sulphate by conductometric titration with NaOH.
			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 H2O2 method
 |  |

**Elective- I**

**Semester III**

**Course Title:- Environmental Chemistry**

**Course Code: CHEM 66511**

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: III** |
| **Course: Elective 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 ,their sourcesCO2. To determine the important constituents that determine the quality of the  environmental components (air ad soil)CO3.To learn the various concepts of environmental auditCO4.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. |

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| **Course Code: (CHEM 66511)** | **Unit**  | **Course Title:- Environmental Chemistry** **Elective- I** | **Credits 02/****30 Lectures** |
|  | **UNIT 1** | **ENVIRONMENTAL POLLUTION**  | **[15L]** |
| **1.1****1.2****1.3** | **AIR POLLUTION*** + 1. Sources, classification, pollutants and

 permissible limits.* + 1. Importance of automobile exhaust control and its limits
		2. Sampling and analysis of: Particulate matter,

 aerosols, ammonia, and organic vapors. * + 1. Carbon credit and global issues related to air

 pollution* + 1. Greenhouse gases and their substitutes

**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**1.2.5** Synthetic fertilizers and their long term effect on soil quality.  **OTHER TYPES OF ENVIRONMENTAL POLLUTION:****1.3.1** Noise Pollution : sources, effects, methods of measurements and control measures.  **1.3.2** Thermal Pollution: definition, source, impact, control measures. **1.3.3** Radioactive pollutants: source, exposure hazards, precautions in handling and safety,  long term effects.  | **[5L]****[5L]****[5L]** |
|  |
| **UNIT 2** | **WATER QUALITY STANDARDS, ENVIORNMENTAL LAWS AND AUDIT** | **[15L]** |
| **2.1****2.2****2.3** | **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. * + 1. Bore well water quality and analytical

 parameters. Quality of bottled mineral water * + 1. Process of purification of bore well water to

 bottled mineral water. * + 1. Regulatory requirements for packaged

 drinking water **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 (Prevention and Control of Pollution) Act, 1974 (Amendement 1988).**ENVIRONMENTAL AUDIT:**Concept of audit, Objectives, authorities, components, steps involved in environmental audit, evaluation methodology, benefits and certification | **[10L]****[5L]****[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)

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| **PROGRAM(s):** **M.Sc.-II** | **SEMESTER: III** |
| **Course: Elective Practical**  | **Course Code:**  **PRCHEM 66511****Course Title:- Environmental Chemistry Practical** **(PRCHEM 66511)** |
| **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:**CO1. To impart first-hand knowledge on practical methods for soil and water  analysisCO2. To equip learners with basic laboratory techniques of soil and water analysisCO3.To make them aware of different methods of analysis of soil and waterCO4.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 issuesCLO3. use the techniques and skills for doing analysis of soil and waste water 1. CLO4. undertake teaching, research and offer administrative and consultancy services
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| **Course code- PRCHEM 66511** | **Elective –I Practical****Environmental Chemistry Practical****(PRCHEM 66511)** | **Credits:02** |
| **Non – Instrumental:** 1. Determination of organic carbon in soil 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 method1. Determination of chromium in water sample by least

 square method 1. 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 Mn2+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].
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**Elective- II**

**Semester III**

**Course Title:- Industrially Important Materials**

**Course Code: CHEM 66512**

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: III** |
| **Course: Elective 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 learn the classification and biodegradation of insecticides and pesticides.CO2.To study of soaps and detergents with reference to chemical parametersCO3.To be acquainted with properties and processes of petrochemical productsCO4. 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 pathwaysCLO2. explain the chemical parameters of soaps and detergentsCLO3. describe the properties and processes of petrochemical productsCLO4.apply the knowledge gained about the certain industrially important  materials  |

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| **Course Code: CHEM 66512** |  | **Elective II** **Course Title:- Industrially Important Materials** | **Credits 02/****30 Lectures** |
|  | **UNIT I** | **Industrial Materials I** | **[15L]** |
| **1.1****1.2****1.3** | **Insecticides, Pesticides:** Classification of insecticides and pesticides. Biodegradation of insecticides and pesticides **Soaps and Detergents:** Classification and composition, qualitative analysis, quantitative analysis of detergents- alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents **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 impact on environment.  | **[5 L]****[5L]****[5L]** |
|  |
| **UNIT 2** | **Industrial Materials II** | **[15L]** |
| **2.1****2.2****2.3****2.4** | **Cement :** composition , classification , manufacturing process and properties of cement**Ceramics:**  properties and classification.**Glass**: composition of glass, types of glass, manufacturing process of glass  **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 fertilizeriii) Urea: Manufacturing process, action of urea as a fertilizer  | **[4L]****[2L]****[3L]****[6L]** |

**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>

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| **PROGRAM(s):** **M.Sc.-II** | **SEMESTER: III** |
| **Course: Elective Practical**  | **Course Code:**  **PRCHEM 66512****Course Title:- Industrially Important Materials** **Practical** **(PRCHEM 66512)** |
| **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:**1. CO 1: To be aware of various classical and instrumental methods of analysis for
2. commercial samples.
3. CO2: To get trained in handling various analytical instruments.
4. CO3: To get equipped with basic skills involved in sample pretreatment, detection of
5. analyte and reporting of results.
6. CO4: To be exposed to analysis of commercial samples for quality assessment.
7. **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. |

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| **Course Code: PRCHEM 66512** | **Elective II Practical****Course Title:- Industrially Important**  **Materials Practical** | **Credits****02** |
|  | **Non Instrumental** Assay of the following commercial samples as per IP 1. calcium carbonate
2. magnesium sulphate
3. glycerine
4. iodine
5. Analysis of calcium oxide in cement (white cement) complexometrically.
6. Determination of amount of acetic acid in ear drops titrimetrically.
7. 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 spectrophotometricaly.
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| **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. Provide opportunity to test their interest in a particular career before permanent commitments are made.CO2. develop skills in the application of theory to practical work situations. To develop skills and techniques directly applicable to their careers.1. To enable the student to be able to extract information from journals and digital resources. 2. Understanding tools to analyse the data, writing and presenting scientific papers. 3. Safe working procedure and ethical handling of chemicals. 4. Describe research, identification of research problems, and preparation of proposals. 5. Practice ethics in all the domains of research. 6. Analyze the results using mathematical and statistical tools |
| **Course Learning Outcomes:****At the end of the Course the learner will be able to**CLO1. Understand the Organizational Structure of a company. CLO2. Develop work habits and attitudes necessary for job success (technical competence, professional attitude, organization skills etc.) CLO3. Develop written communication and technical report writing skills. |

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: IV** |
| **Course: Paper-I** | **Course Code: CHEM667****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 productsCO3. Tolearn 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**

**Paper I**

**Quality in Analytical Chemistry -II**

**Course code: CHEM 667**

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| **Course code-****CHEM 667** | **Unit** | **Course/Unit Title:** **Quality in Analytical Chemistry -II** | **Credits 04/** **[60 L]** |
|  | **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****2.2** **2.3** | **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, drying and processing of herbal raw material.**Extraction of herbal materials:** Choice of solvent for extraction, methods used for extraction and principles involved in extraction.**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]****[3 L]****[6L]** |
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| **UNIT 3** | **Green Chemistry** |  **[15L]**  |
| **3.1****3.2****3.3****3.4** | **Principle and concepts of green chemistry**: sustainable development and green chemistry, atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity **Organic solvents:** environmentally benign solutions, solvent free systems, supercritical fluids (only introduction), ionic liquids as catalysts and solvents  **Emerging Green Technologies:** photochemical reactions (advantages and challenges), examples. Chemistry using microwaves, sonochemistry and electrochemical synthesis.  **Designing Greener Processes:** Inherently Safer Designs (ISD), Process intensification (PI) in-process monitoring.  |  **[4L]** **[4L]** **[4L]** **[3L]** |
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| **UNIT 4** | **Advanced Techniques** |  **[15L]**  |
| **4.1****4.2****4.3** | **Electrophoresis:** Introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephedax and thin layers) **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. **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).  | **[2L]****[8L]****[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

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: IV** |
| **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 spectroscopyCO2.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 spectroscopyCO4.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 analysisCO6.To understand the concept of hyphenated techniques in different analytical  instrumentsCO7.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 fieldsCLO2.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  in analysisCLO6.articulate the various hyphenated analytical instruments and its applications in  different fields |

**Paper II**

**Advanced Instrumental Techniques -II**

**(CHEM 668)**

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| **Course code- CHEM 668** | **Unit**  | **Course/Unit Title-** **Advanced Instrumental Techniques -II**  | **Credits: 04/60** **lectures** |
|  | **UNIT 1** | **Spectral Methods III** | **[15L]** |
| **1.1****1.2****1.3** |  **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.**Radio waves in imaging-** Principle, instrumentation, and applications of MRI.  Applications of NMR to other nuclei 13C, 31P and 19F spectroscopy | **[9L]****[3L]****[3L]** |
|  |
| **UNIT 2** | **Spectral Methods – IV** | **[15L]** |
| **2.1** **2.2** | **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. **Raman spectroscopy:** Theory, instrumentation, techniques : surface enhanced Raman spectroscopy (SERS) and resonance Raman spectroscopy. Applications of Raman spectroscopy.  | **[9L]****[6L]** |
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| **UNIT 3** | **Radiochemical And Thermal Methods** | **[15L]** |
| **3.1****3.2** | **Activation analysis*** + 1. Isotope dilution method: Introduction, principle. Types of isotopic dilution method: direct isotopic dilution method, inverse isotopic dilution method, double dilution method and applications.
		2. Radio-release method: Introduction, principle and

 applications * + 1. Radiometric titrations and Radioimmunoassay:

Principle, instrumentation and application**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 | **[8L]****[7L]** |
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| **UNIT 4** | **Hyphenated Techniques** | **[15L]** |
| **4.1****4.2** | Concept of hyphenation and need for hyphenation in analytical instrumentation.Interfacing devices and applications of 1. GC – MS
2. ICP –MS
3. GC - IR
4. Tandem Mass Spectrometry
5. LC – MS
6. HPLC-MS
7. CE-MS.
 | **[2L]****[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

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: IV** |
| **Course: Paper IV** | **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 managementCO3.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 lifeCLO3.classify the plastics and report the impact of plastics on environmentCLO4.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. |
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| **Course code- CHEM 669** | **UNIT** | **Course/Unit Title-****Selected topics in Analytical chemistry** | **Credits 04/****60 Lectures** |
|  | **UNIT 1** | **Effluent Treatment** | **[15L]** |
| **1.1.****1.2****1.3****1.4****1.5****1.6** | **Effluent treatment plant:** general construction and process flow charts.Treatment and disposal of Sewage.Effluent parameters for metallurgical industry. Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent. **Recovery of metals from effluent, modern methods –** Electrodialysis, Electrodeposition and Ion Exchange.Recycle and reuse process of effluent water . | **[3L]****[3L]****[2L]****[2L]****[3L]****[2L]** |
|  |
| **UNIT 2** | **Solid Waste Management** | **[15L]** |
| **2.1****2.2****2.3****2.4****2.5** |  Solid waste management: objectives, concept of recycle, reuse and recovery Methods of solid waste disposal.Treatment and disposal of sludge / dry cake Managing non-decomposable solid wastes Bio- medical waste : Introduction , Classification and methods of disposal  | **[3L]****[2L]****[3L]****[2L]****[5L]** |
|  |
| **UNIT 3** | **Plastics and Polymers** | **[15L]** |
| **3.1****3.2****3.3****3.4****3.5** | Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics. Metallic impurities in plastic and their determinationImpact of plastic on environment as pollutant.Paints and pigments: Types of paints pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners.Role of Organo-silicones in paints and their impact on environment | **[5L]****[2L]****[2L]****[3L]****[3L]** |
|  |
| **UNIT 4** |  **Metallurgy** | **[15L]** |
| **4.1****4.2****4.3****4.4** | **Ores and minerals:** Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting )**Chemical analysis of ores for principal constituents :** Galena,pyrolusite, bauxite, hematite, monazite **Alloys**: definition, analysis of Cupronickel, Magnelium, Steel and Stainless Steel, Bronze, Gun metal.**Techniques of purification:** Zone refining, analysis of high purity silicon materials | **[3L]****[4L]****[4L]** **[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).

**Elective- I**

**Semester IV**

**Course Code: (CHEM67011)**

 **Course Title:- Intellectual property right and cheminformatics Course Learning**

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: IV** |
|  **Course : Elective**  | **Course Code: CHEM67011****Course Title:- Intellectual property right 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 RightsCO2. To get the knowledge about the trade secrets ,IP infringement issues, and economic  value of Intellectual propertyCO3.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 issuesCLO3.apply the knowledge of cheminformatics in the areas of drug analysis, spectral  correlation and structural elucidation |

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| **Course code- CHEM67011** | **UNIT** | **Course/Unit Title-****Intellectual property rights and Cheminformatics** | **Credits 04/****60 Lectures** |
|  | **UNIT 1** | **Intellectual Property rights -I** | **[15 L]** |
| **1.1****1.2****1.3****1.4****1.5****1.6** | **Introduction to Intellectual Property:** Historical Perspective, Different types of IP, Importance of protecting IP.  **Patents:** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Software patents and their importance for India. **Industrial Designs**: Definition, How to obtain, features, International design registration. **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. **Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India. | **[2L]****[5L]****[2L]****[2L]****[2L]****[2L]** |
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| **UNIT 2** | **Intellectual Property rights -II** | **[15L]** |
| **2.1****2.2****2.3****2.4** | **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 assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.**Different International agreements:** **(a) World Trade Organization (WTO):** (i) General Agreement on Tariffs and 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, IPRand Plant Breeders Rights, IPR and Biodiversity. | **[2L]****[2L]****[2L]****[9L]** |
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| **UNIT 3** | **Cheminformatics - I** | **[15 L]** |
| **3.1****3.2****3.3** | **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  | **[5 L]****[5 L]****[5 L]** |
|  |
| **UNIT 4** | **Cheminformatics - II** | **[15 L]** |
| **4.1****4.2****4.3****4.4** | Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling ToxicityStructure – Spectra correlations, Prediction, NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis DesignIntroduction to drug design, Target identification and Validation, Lead Finding and Optimization, analysis ofHTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand based and Structure based Drug design, Application of Cheminformatics in Drug Design | **[5L]****[5L]****[3L]****[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.

**Elective- II**

**Semester IV**

**Course Code: CHEM67012**

**Course Title:- Pharmaceutical and Organic Analysis**

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| **PROGRAM(s): M.Sc.-II** | **SEMESTER: IV** |
|  **Course : Elective**  | **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 pharma-industry.CO3. To learn the various analytical processes in pharmaceutical industryCO4. 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 formsCLO2.realize the role of legislative body in pharma-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. |

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| **Course Code: CHEM 67012** | **Unit** | **Course Title:-** **Pharmaceutical and Organic Analysis****Elective- II** | **Credits:****04 /****60L** |
|  | **UNIT 1** | **Pharmaceutical Analysis**  | **[15L]** |
| **1.1****1.2****1.3** | 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.Sources of impurities in pharmaceutical products and raw materials. Standardization of finished products and their characteristics, official methods of quality control.  | **[7L]****[4L]****[4L]** |
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| **UNIT 2** | **Drugs** | **[15L]** |
| **2.1****2.2** | 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. Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies.Polymers in pharmaceuticals and novel drug delivery systems. | **[8L]****[7L]** |
|  |
| **UNIT 3** | **Forensic Science**  | **[15 L]** |
| **3.1****3.2****3.3** | Role of Analytical Chemistry in Forensic Science**Forensic Analysis:** Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification.**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.  | **[2L]****[5L]****[8L]** |
|  |
| **Unit 4** | **Cosmetic Analysis** | **[15 L]** |
| **4.1****4.2****4.3****4.4****4.5****4.6** | **Cosmetics:** Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis.**Deodorants and antiperspirants**: Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea.**Face powder:** Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total).**Hair tonic:** 2,5-diaminotoluene, potassium borates, sodium perborate,pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanentwavers)**Creams and Lotions:** Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy)**Lipsticks:** General analysis, determination of - nonvolatile matter, lakesand fillers, trichloroethylene-acetone soluble contents. | **[2L]****[3L]****[3L]****[3L]****[2L]****[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

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| **PROGRAM(s): M.Sc-II** | **SEMESTER: IV** |
| **Course: Research Projects**  | **Course Code: CHEM671** |
| **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** | **12** | **–** | **06** | **50** | **50** |
| **Course Objectives:** |
| **Course Learning Outcomes:****At the end of the Course,** |

## MODALITY OF ASSESSMENT

**THEORY EXAMINATION PATTERN:**

##  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** |

* 1. **External Examination- 50%- 50 Marks per paper in each Semester END THEORY EXAMINATION:**
		1. Duration - These examinations shall be of **two hours** duration.
		2. Theory question paper pattern
			1. There shall be 05 questions each of 10 marks on each unit.
			2. All questions shall be compulsory with internal choice within the questions.

## 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) |
| **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.