



Shri Vile Parle Kelavani Mandal's
**MITHIBAI COLLEGE OF ARTS, CHAUHAN INSTITUTE OF SCIENCE &
AMRUTBEN JIVANLAL COLLEGE OF COMMERCE AND ECONOMICS
(AUTONOMOUS)**

*NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),
Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,
Best College (2016-17), University of Mumbai*

Affiliated to the
UNIVERSITY OF MUMBAI

Program: M.Sc

Course: ANALYTICAL CHEMISTRY

Semester-III

**Choice Based Credit System (CBCS) with effect from the
Academic year**

2018-19

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the M.Sc II.-Analytical, the learners should be enriched with knowledge and be able to-

- PSO1:** To have sound knowledge about the fundamentals and applications of various Analytical Instruments.
- PSO2:** To familiarize with the different branches of science like material Science, Nanoscience, Geology, Solid state Chemistry, Solid state Physics, etc which utilizes Analytical Chemistry to drive information.
- PSO3:** Deals with Qualitative and Quantitative Analysis.
- PSO4:** To develop better understanding of GMP and GLC.
- PSO5:** It also involves study of environmental pollution, Waste management, Green Chemistry, etc.
- PSO6:** To handle various Analytical Instruments, Interpretation of Spectra's, and trouble shooting.
- PSO7:** To study MSDS of various Chemicals.
- PSO8:** To study Stoichiometry and Chemometrics.

Preamble

The well-organized curriculum including basic as well as advanced concepts in the subject of Analytical Chemistry from first year to second year shall inspire the students for pursuing higher studies in chemistry, research and for becoming an entrepreneur. It also enable students to get employed in the various Research Institutes, Industries, Educational Institutes, Competitive exams and in the various departments of State and Central Government based on subject chemistry.

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Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	TEST	15 marks
Component 2 (CA-2)	ASSIGNMENT	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	Any Three out of Five	5	15
2	Any Three out of Five	5	15
3	Any Three out of Five	5	15
4	Any Three out of Five	5	15
5	Any Three out of Four	5	15
Total Marks			75

Signature

Signature

Signature

HOD

Approved by Vice –Principal

Approved by Principal

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Program: M.Sc. Analytical Chemistry				Semester: III	
Course: Analytical Chemistry				Course Code: PSAMACHA301	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives:					
<ol style="list-style-type: none"> 1. To orient learner about the importance of Analytical chemistry. 2. To orient learner about the principle, theory and working of Analytical Instruments. 3. To teach learner about the various applications of Analytical Instruments. 4. To teach learner about the basic concept and fundamental concepts of Analytical Chemistry. 					
Course Outcomes:					
After completion of the course, learners would be able to:					
CO1: To study and understand the concept of quality assurance.					
CO2: To study the importance of quality assurance in industry with reference to GMP and GLP.					
CO3: To study the fundamentals of preparative chromatography.					
CO4: To study various types of chromatography.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Quality in Analytical Chemistry-I				15L
2	Quality in Analytical Chemistry-II				15L
3	Chromatographic Technique-I				15L
4	Chromatography Technique-II				15L
	Total				60L
PRACTICALS					

Unit	Topics	No of Hours/ Credits
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Module 1	<p>Quality in Analytical Chemistry-I (15 L)</p> <p>1.1 The need for reliable results: Social and economic impact of wrong analysis, concept of quality, customer requirement, purpose of analysis 1.2 Principle of quality assurance, quality control: Quality management system, quality assurance and quality control, different standards and their main features, best practice 1.3 Sampling: Definition, types of samples, sampling plan, sample number and sample size, sub-sampling, sample handling and storage 1.4 Preparation for analysis: Method selection, sources of methods, factors to consider in choosing a method, performance criteria for methods used, reasons for incorrect analytical results, method validation.</p>	15/01
Module 2	<p>Quality in Analytical Chemistry-II</p> <p>2.1 Making measurements: (11 L) Good laboratory practice, calibration and measurement, achieving metrological traceability, quality control, environment, equipment and glassware, chemicals and consumables, maintenance and calibration of equipment 2.2 Data treatment: Essential statistics, control charts, measurement uncertainty 2.3 Documentation and its management 2.4 Managing quality 2.5 Signal to noise ratio: (4L) Signal to Noise ratio, sources of noise in instrumental analysis. Signal to Noise enhancement, hardware devices for noise reduction, software methods for Noise reduction.</p>	15/01
Module 3	<p>Chromatographic Techniques-I</p> <p>3.1 Ion exchange chromatography: (8L) Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchangers, chelating resins and their applications for separation of inorganic and organic compounds. 3.2 Ion chromatography: (7L) Principle, instrumentation with special reference to separation and suppressor columns, applications. 3.3 Exclusion chromatography: Theory, instrumentation and applications of gel permeation chromatography, retention behavior, inorganic molecular sieves, determination of molecular weight of polymer.</p>	15/01
Module 4	<p>Chromatographic Techniques-II</p> <p>4.1 Supercritical fluid Chromatography: (9L) Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis. 4.2 Affinity Chromatography: (3L) principle, instrumentation and applications 4.3 Optimum pressure lamellar chromatography (OPLC) (3L)</p>	15/01
Total:		60 L

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

**PRACTICAL I
(If applicable)**

PRACTICALS	
1	Determination of the pK value of an indicator.
2	Determination of copper and bismuth in mixture by photometric titration.
3	Estimation of strong acid, weak acid and salt in the given mixture conductometrically.
4	Analysis of mixture of carbonate and bicarbonate (present in ppm range) using pHmetry.
5	Determination of copper by extractive photometry using diethyldithiocarbamate.

Suggested Readings

Reference Books:

1. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997.
2. Quality assurance in analytical Chemistry, W Funk, V Dammann, G. Donnevert VCH Weinheim1995.
3. 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.
4. Lalit Singh and Vijay Sharma, Quality by Design (QbD) Approach in Pharmaceuticals: Status, Challenges and Next Steps, Drug Delivery Letters, 2015, 5, 2-8.
5. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997
6. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Saonders, College publication.
7. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
8. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
9. Analytical Chemistry, G. D. Christain, Wiley
10. Extraction Chromatography T. Braun, G. Ghersene, Elsevier Publications 1978.
11. Supercritical Fluid Extraction, Larry Taylor Wiley publishers N.Y. 1996
12. Ion exchange separation in analytical chemistry O Samuelson John Wiley 2nd Ed1963
13. Ion exchange chromatography Ed H.F Walton Howden, Hutchenson and Rossing 1976
14. Chromatographic and electrophoresis techniques I Smith MenemannInter science 19

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Jivanlal College of Commerce & Economics (AUTONOMOUS)

Program: M.Sc. Analytical Chemistry				Semester: III	
Course: Analytical Chemistry				Course Code: PSMACHA302	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives: To give insight of fundamental concepts of various Analytical instruments.					
Course Outcomes: After completion of the course, learners would be able to: CO1: Provides surface morphology and topography of materials. CO2: Helps in establishing the constitution of a molecule. CO3: Provides measurement of PD, EMF, etc. CO4: Helps in providing supplementary data which helps in establishing various properties of materials.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Surface Analytical Techniques				15L
2	Spectral Methods – II				15L
3	Electroanalytical Methods				15 L
4	Miscellaneous Techniques				15L
	Total				60 L
PRACTICALS					

Unit	Topics	No of Hours/ Credits
Module 1	Surface Analytical Techniques: 1.1 Preparation of the surface, difficulties involved in the surface analysis. (1L) 1.2 Principle, instrumentation and applications of the following: i. Secondary Ion mass spectroscopy. (4L) ii. Particle-Induced X-Ray Emission (5L)	15/01

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	iii. Low-Energy Ion Scattering and Rutherford Backscattering (5L)	
Module 2	Spectral Methods – II Principle, Instrumentation, and Applications of 2.1 Electron Spin Resonance Spectroscopy (ESR) (5L) 2.2 Mossbauer's Spectroscopy (5L) 2.3 Atomic Emission Spectroscopy- based on plasma and electrical discharge sources (5L)	15/01
Module 3	Electroanalytical Methods Advanced Electroanalytical Techniques: 3.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography (3L) 3.2 Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry. (3L) 3.3 Potential Step method- Chronoamperometry (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 ultra-microelectrodes in voltammetry (3L)	15/01
Module 4	Miscellaneous Techniques Principle, Instrumentation and Applications of: 4.1 Chemiluminescence techniques (5L) 4.2 Chiroptical Methods: ORD, CD (5L) 4.3 Spectroelectrochemistry (5L)	15/01
	Total	60 L

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**PRACTICAL I
(If applicable)**

1.	Estimation of drugs by non-aqueous titration: Pyridoxine hydrochloride,/ Sulphamethoxazole.	
2.	Determination of percentage purity of methylene blue indicator.	
3.	Estimation of fluoride in a tooth paste.	

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4.	Determination of silica by molybdenum blue method.	
5.	Estimation of cholesterol and Uric acid in the given sample of blood serum.	

Suggested Readings

Reference Books:

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

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Program: M.Sc. Analytical Chemistry				Semester: III	
Course: Analytical Chemistry				Course Code: PSMACHA303	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutori al (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives: To provide broad foundation in Analytical chemistry by providing insights in the different topics such as Body fluids and food Analysis.					
Course Outcomes: After completion of the course, learners would be able to: CO1: Analysis of various body fluids such as blood, saliva, urine, etc. CO2: To study antigen- antibody reaction with reference to immune system. CO3: To study analysis of food and food products with respect to various contaminants. CO4: Food analysis using advanced Analytical instruments and importance of packing.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Body Fluids				15L
2	Immunological Methods				15L
3	Food Analysis - I				15L
4	Food Analysis - II				15L
	Total				60 L
PRACTICALS					

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Unit	Topics	No of Hours/ Credits
Module 1	<p>Body Fluids</p> <p>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)</p> <p>1.2 Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals. (5L)</p> <p>1.3 Analytical techniques (including microbiological techniques) for vitamins. (5L)</p>	15/01
Module 2	<p>Immunological Methods</p> <p>2.1 General processes of immune response, antigen-antibody reactions, precipitation reactions, radio, enzyme and fluoro-immunoassays. (8L)</p> <p>2.2 Human Nutrition: Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids. (7L)</p>	15/01
Module 3	<p>3.1 Fuel value of food and importance of food nutrients (2L)</p> <p>3.2 Food Additives (5L) General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour.</p> <p>3.3 Food Contaminants (2L) Trace metals and pesticide residues, contaminants from industrial wastes (polychlorinated polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants.</p> <p>3.2 Food Additives (5L) General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour</p> <p>3.3 Food Contaminants (3L) Trace metals and pesticide residues, contaminants from industrial wastes (polychlorinated polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants.</p>	15/01
Module 4	<p>Food Analysis - II</p> <p>4.1 Food packaging (3L) Introduction, types of packing materials, properties and industrial requirements.</p> <p>4.2 Processing and Quality requirements of Milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat products. (5L)</p> <p>4.3 Analysis of Milk. (2L) Fat content, proteins, acidity, bacteriological quality and milk adulterants</p> <p>4.4 Analysis of Oils and Fats (2L) Acid value, sap value, iodine value. Determination of rancidity and antioxidants.</p> <p>4.5 Analysis of spices (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils. (3L)</p> <p>Total</p>	15/01
	60 L	

PRACTICALS	
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To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

PRACTICAL I
(If applicable)

1.	Total reducing sugars before and after inversion in honey using: (a) Cole's Ferricyanide (b) Lane - Eynon method.	
2.	Analysis of lactose in milk	
3.	Estimation of Caffeine in tea	
4.	Estimation of Vitamin C in lemon Juice/squash by Dichlorophenol-indophenol method.	
5.	Iodine value of oil / fat	
6.	Analysis of alcoholic beverages (Beer) for alcohol content by distillation followed by specific gravity method, acidity by titration, total residue by evaporation.	

Suggested Readings

Reference Books:

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: M.Sc. Analytical Chemistry				Semester: III	
Course: Analytical Chemistry				Course Code: PSMACHA304	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives: This paper deals with Pharmaceutical Analysis, Drugs, Forensic Science and Cosmetics Analysis using advanced Analytical instruments such as GC-MS, LC-MS, ICP-MS, etc.					
Course Outcomes: After completion of the course, learners would be able to: CO1: Involves Analysis and Standardisation of Pharmaceutical excipients. CO2: Deals with Analysis drug involving proximate analysis, In-vivo and In-vitro Analysis etc. CO3: Deals with study of bioequivalence and bioavailability studies. CO4: Involves study of identification and Analysis of raw materials and additives by Analytical instruments.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Pharmaceutical Analysis				15L
2	Drugs				15L
3	Forensic Science				15L
4	Cosmetics Analysis				15L
	Total				60 L
PRACTICALS					

Unit	Topics	No of Hours/ Credits
Module 1	Pharmaceutical Analysis 1.1 General idea regarding the Pharmaceutical Industry: (5L) definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries. 1.2 Sources of impurities in pharmaceutical products and raw materials. (4L)	15/01

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	<p>1.3 Standardization of finished products and their characteristics, official methods of quality control. (3L)</p> <p>1.4 Pharmaceutical Legislation: (3L) introduction to drug acts, drug rules(schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration.</p>	
Module 2	<p>Drugs</p> <p>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)</p> <p>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)</p>	15/01
Module 3	<p>Forensic Science</p> <p>3.1 Analytical Chemistry in Forensic Science: (2L) General idea.</p> <p>3.2 Forensic Analysis: (5L) Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification.</p> <p>3.3 Analytical Toxicology: (8L) Isolation, identification and determination of:</p> <p>3.3.1 Narcotics: Heroin, morphine and cocaine.</p> <p>3.3.2 Stimulants: Amphetamines and caffeine.</p> <p>3.3.3 Depressants: Benzodiazepines, Barbiturates and Mandrax.</p> <p>3.3.4 Hallucinogens: LSD and Cannabis.</p> <p>3.3.5 Metabolites of drugs in blood and urine of addicts.</p> <p>3.3.6 Viscera, stomach wash, vomit and postmortem blood for poisons like – cyanide, arsenic, mercury, insecticides and pesticides</p>	15/01
Module 4	<p>Cosmetics Analysis</p> <p>4.1 Cosmetics: (2L) Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis</p> <p>4.2 Deodorants and antiperspirants: (3L) Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea.</p> <p>4.3 Face powder: (3L) Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total).</p> <p>4.4 Hair tonic: (3L) 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers)</p>	15/01

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	4.5 Creams and Lotions: (2L) Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) 4.6 Lipsticks: (2L) General analysis with emphasis on Ash analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents.	
	Total	60 L
PRACTICALS		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

**PRACTICAL I
(If applicable)**

1.	To analyze Pyrolusite for: Fe by colorimetry and / or Mn by volumetry	
2.	To analyze Magnesium for Mg by complexometry.	
3.	Analysis of water sample: Total hardness and salinity.	
4.	Analysis of water sample: Acidity and sulphate (Benzidine method).	
5.	Analysis of Bauxite for Ti by colorimetry / Al by gravimetry / Fe (volumetric)	

Suggested Readings

Reference Books:

Reference Books:

Pharmaceutical and organic analysis

- 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 Charalambous, Academic press, 1978.
- 4) Harry's Cosmetology, 7th Ed, 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.

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- 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, Elsevier, 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, DrGayatri Prakash, S Chand and Company Ltd, New Delhi.
- 21) Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, JaypeeBrothersMedical 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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*NAAC Reaccredited 'A' grade, CGPA: 3.57 (February 2016),
Granted under RUSA, FIST-DST & -Star College Scheme of DBT, Government of India,
Best College (2016-17), University of Mumbai*

Affiliated to the
UNIVERSITY OF MUMBAI

Program: M.Sc

Course: ANALYTICAL CHEMISTRY

Semester-IV

**Choice Based Credit System (CBCS) with effect from the
Academic year**

2018-19

PROGRAMME SPECIFIC OUTCOMES (PSO'S)

On completion of the M.Sc.II- _____, the learners should be enriched with knowledge and be able to-

- PSO1:** To have sound knowledge about the fundamentals and applications of various Analytical Instruments.
- PSO2:** To familiarize with the different branches of science like material Science, Nanoscience, Geology, Solid state Chemistry, Solid state Physics, etc which utilizes Analytical Chemistry to drive information.
- PSO3:** Deals with Qualitative and Quantitative Analysis.
- PSO4:** To develop better understanding of GMP and GLC.
- PSO5:** It also involves study of environmental pollution, Waste management, Green Chemistry, etc.
- PSO6:** To handle various Analytical Instruments, Interpretation of Spectra's, and trouble shooting.
- PSO7:** To study MSDS of various Chemicals.
- PSO8:** To study Stoichiometry and Chemometrics.

Preamble

The well-organized curriculum including basic as well as advanced concepts in the subject of Analytical Chemistry from first year to second year shall inspire the students for pursuing higher studies in chemistry, research and for becoming an entrepreneur. It also enable students to get employed in the various Research Institutes, Industries, Educational Institutes, Competitive exams and in the various departments of State and Central Government based on subject chemistry.

Evaluation Pattern

The performance of the learner will be evaluated in two components. The first component will be a Continuous Assessment with a weightage of 25% of total marks per course. The second component will be a Semester end Examination with a weightage of 75% of the total marks per course. The allocation of marks for the Continuous Assessment and Semester end Examinations is as shown below:

a) Details of Continuous Assessment (CA)

25% of the total marks per course:

Continuous Assessment	Details	Marks
Component 1 (CA-1)	TEST	15 marks
Component 2 (CA-2)	ASSIGNMENT	10 marks

b) Details of Semester End Examination

75% of the total marks per course. Duration of examination will be two and half hours.

Question Number	Description	Marks	Total Marks
1	Any Three out of Five	5	15
2	Any Three out of Five	5	15
3	Any Three out of Five	5	15
4	Any Three out of Five	5	15
5	Any Three out of Four	5	15
Total Marks			75

Signature

Signature

Signature

HOD

Approved by Vice –Principal

Approved by Principal

**SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben
Jivanlal College of Commerce & Economics (AUTONOMOUS)**

Program: M.Sc. Analytical Chemistry				Semester: IV	
Course: Analytical Chemistry				Course Code: PSMACHA401	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives:					
<ol style="list-style-type: none"> 1. To orient learner about the different types of separation Science. 2. To orient learner about the fundamentals of Standardization of Herbal based products with respect to its formulation and extraction. 3. To acquaint learner about the basic concept and working of sensor. 4. To acquaint learner important bio-analytical techniques such as SDS-PAGE and electrophoresis. 					
Course Outcomes:					
After completion of the course, learners would be able to:					
CO1: It deals with fundamental of separation science.					
CO2: This topic involves Standardization of Herbal based products with respect to its formulation and extraction.					
CO3: It deals with study of various type of sensors and its application.					
CO4: It involves bio-analytical techniques like SDS-PAGE and electrophoresis. It also involves fundamental principle of nanoscience and its applications.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Separation Science				15L
2	Separation, Analysis and Standardization of Herbal based products.				15L
3	Chemical Sensors				15L
4	Advanced Techniques				15 L
	Total				60 L
PRACTICALS					

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Units	Topics	No of Hours/ Credits
Module 1	Separation Science 1.1 Membrane separation processes: operating principles and applications of microfiltration, ultra-filtration, reverse osmosis, dialysis and electro-dialysis. (8L) 1.2 Applications of Solvent extraction in Analytical Chemistryrecapitulation of solvent extraction, roles of solvent extraction in analytical chemistry, solvent extraction in sample preparation and pretreatment steps, solvent extraction as a means of analytical determination (7L)	15/01
Module 2	Separation, Analysis and Standardization of Herbal based products. 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, drying and processing of herbal raw material. (6L) 2.2 Extraction of herbal materials: Choice of solvent for extraction, methods used for extraction and principle involved in extraction. (3L) 2.3 Standardization of herbal formulation and herbal extracts: Standardization of herbal extract as per WHO cGMP guidelines, Physical, Chemical, Spectral and toxicological standardization, qualitative and quantitative estimations. (6L)	15/01
Module 3	Chemical Sensors: 3.1 General principles: Introduction of principles of chemical sensing; Signal transduction; Physiochemical and biological transducers; sensor types and technologies 3.2 Definition and Concepts: (3L) Terminology and working vocabulary; Main technical definitions: calibration, selectivity, sensitivity, reproducibility, detection limits, response time 3.3 Physico-chemical sensors and transducers: (3L) Thermal sensors; Electrochemical sensors (amperometric, potentiometric, conductometric); Semiconductor transducers (ISFET, ENFET); Optical transducer (absorption, fluorescence, bio/chemiluminescence, SPR); Piezoelectric and acoustic wave transducers; Limitations and problems to be addressed; An overview of performance and applications 3.4 Biochemical sensors: (9L) (a) Enzymes: Oligonucleotides and Nucleic acids; lipids (Langmuir-Blodgett bilayers, Phospholipids, Liposomes); Membrane receptors and transporters; Immunoreceptors; Limitations and Problems (b) Catalytic Biosensors: Mono-enzyme electrodes; bi-enzyme electrodes; enzyme sequence electrodes and enzyme competition electrodes (c) Affinity based biosensors: Inhibition-based biosensors; Cell-based biosensors; Biochips and biosensor arrays; Problems and limitations (d) Sensor Engineering: Methods sensor fabrication: self-assembled monolayers, screen printing, MEMS. Engineering concepts for mass production	15/01

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	(e) Applications: Environmental monitoring; Technological process control; food quality control; Clinical chemistry; Test-strips for glucose monitoring; Implantable sensors for long-term monitoring; Forensic science benefits; Problems and Limitations.	
Module 4	<p>Advanced Techniques</p> <p>4.1 Electrophoresis: introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephedax and thin layers),</p> <p>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)</p> <p>4.3 Advances in Nanotechnology</p> <p>4.3.1 Special nanomaterials: carbon nanotubes, quantum dots their preparations and applications</p> <p>4.3.2 Analytical techniques for characterization of nanomaterials (3L)</p> <p>4.4 Green Chemistry</p> <p>4.4.1 Principle and concept of green chemistry: sustainable development, atom economy, reducing toxicity</p> <p>4.4.2 Environmentally benign solvents, solvent free systems, supercritical fluids, ionic liquids as solvents and catalysts (4 L)</p> <p>Total</p>	15/01 60 L
PRACTICALS		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

**PRACTICAL I
(If applicable)**

PRACTICALS		
1.	Determination of pK value of H ₃ PO ₄ potentiometrically.	
2.	Estimation of Na ⁺ in dairy whitener by flame photometry	
3.	Spectrophotometric determination of pH of buffer solution.	
4.	Simultaneous determination of Ti ³⁺ and V ⁵⁺ spectrophotometrically by H ₂ O ₂ method.	
5.	To analyze Bronze for Zn by complexometric method	

Suggested Readings

Reference Books:

Reference Books:

1. Research Methodology: Methods & Techniques by C R Kothari, 2nd ed., Wishwa Publication, New Delhi
2. Research Methodology by D K Bhattacharyya, 1st ed., Excel Books, New Delhi, 2003.
3. How to Research by Loraine Blaxter, Christina Hughes and Molcolm Tight, Viva Books Pvt. Ltd., New Delhi
4. Chemical methods of separation, J A Dean, Van NostrandReinhold, 1969.
5. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
6. Extraction Chromatography, T. Braun, G. Ghersene, Elsevier Publications 1978.
7. Super critical fluid extraction, Larry Taylor Wiley publishers N.Y. 1996
8. Ion exchange separation in analytical chemistry, O Samuelson John Wiley 2nd ed 1963
9. Ion exchange chromatography, Ed H.F Walton Howden, Hutchenson and Rossing, 1976.
10. Chromatographic and electrophoresis techniques, I Smith Menemann Interscience 1960
11. Green chemistry and catalyst, R. A. Sheldon, Isabella Arends, Ulf Hanefeld Wiley VCH verlag GmBH& co.
12. Sustainable residential development: planning and design for green neighborhoods. Avi Friedman, McGraw Hill professional.

SVKM's Mithibai College of Arts, Chauhan Institute of Science & Amrutben
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Program: M.Sc. Analytical Chemistry				Semester: IV	
Course: Analytical Chemistry				Course Code: PSMACHA402	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives:					
1. To give insight of fundamental concepts and applications of NMR Spectroscopy. 2. To study vibrational and rotational changes in a molecule. While Auger Spectroscopy deals with surface morphology. 3. It involves study of physical and chemical changes as a function of temperature. 4. It involves study of hyphenated instruments and it applications.					
Course Outcomes:					
After completion of the course, learners would be able to:					
CO1: It deals identification of nature and type of hydrogen atoms present in a molecule.					
CO2: This involves Raman Spectroscopy, which deals with rotational and vibrational characteristic of molecule, while Auger Spectroscopy deals with surface analysis.					
CO3: This topic describes the effect of thermal energy on a given substances. It involves TG, DTA, DSC and EGA.					
CO4: This topic deals with Tandemization of instrument such as GC, HPLC, ICP, etc.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Spectral Methods III :NMR Spectroscopy				15L
2	Spectral methods IV				15L
3	I Radioanalytical and Thermal Methods				15L
4	Hyphenated Techniques				15L
	Total				60 L
PRACTICALS					

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Units	Topics	No of Hours/ Credits
Module 1	Spectral Methods III: NMR Spectroscopy 1.1 Introduction (1L) 1.2 Instrumental Design (6L) <ol style="list-style-type: none"> i. Magnet Systems ii. NMR Probes iii. RF Generation and Signal detection iv. Magnetic Field Gradients 1.3 Data Analysis and Interpretation <ol style="list-style-type: none"> i. Spectral Processing Manual data Interpretation: Application of NMR to other nuclei N^{15} , P^{31} and F^{19} spectroscopy (8L)	15/01
Module 2	Spectral methods IV Raman Spectroscopy (8L) 2.1 Principle 2.2 Instrumentation- Lasers, Detectors, Filters, Dispersion systems, components for transportation of light, sample chambers and measurement Probes, Noise in Raman spectroscopy and applications 2.3 Auger Electron spectroscopy (7L) Principle, Electron spectrometer design, compositional Depth profiling, Areas of application.	15/01
Module 3	Radioanalytical and Thermal Methods 3.1 Activation analysis- NAA, radiometric titrations and radio-release methods(5L) 3.2 Thermal analysis- (10L) Principle, Interfacing, instrumentation and Applications of <ol style="list-style-type: none"> i. Simultaneous Thermal Analysis- TG-DTA and TG-DSC Evolved gas analysis- TG-MS and TG-FTIR	15/01
Module 4	Hyphenated Techniques 4.1 Concept of hyphenation, need for hyphenation, possible hyphenations. (5 L) 4.2 Interfacing devices and applications of GC – MS, LC-MS ,ICP -MS, MS-MS (10L) Total	15/01 60 L
PRACTICALS		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

**PRACTICAL I
(If applicable)**

1.	Analysis of drugs by non-aqueous titration: Glycine, Sodium Benzoate	
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2.	Analysis of detergents: Active detergent matter, alkalinity and Oxygen releasing capacity	
3.	Determination of the purity of crystal violet	
4.	Estimation of Ca in Ca-pentathionate/calcium lactate tablets	
5.	Canned food: Limits test for tin/zinc.	

Suggested Readings

Reference Books:

Reference Books:

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 Holler Holt-Saunders 6th Edition, 1998.
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Ed.
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, 3rd Edition W. W. Wendlandt, John Wiley, N.Y. 1986.
7. Principles and Practices of X-ray spectrometric Analysis, 2nd Ed 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) 1st Edition 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 Meyer
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: M.Sc. Analytical Chemistry				Semester: IV	
Course: Analytical Chemistry				Course Code: PSMACHA403	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives: This topics deal with importance of waste management and study of various important purification processes which are carried out, so as to get functional materials.					
Course Outcomes: After completion of the course, learners would be able to: CO1: It deals with treatment of effluents using ETP process. CO2: It involves management and disposal of solid waste generated from industry, hospital, etc. CO3: It deals with various types of polymers and there applications. CO4: It involves study of important alloys, and various purification processes.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Effluent Treatment				15L
2	Solid Waste Management				15L
3	Plastics and Polymer				15L
4	Metallurgy				15L
	Total				60 L
PRACTICALS					

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Unit	Topics	No of Hours/ Credits
Module 1	<p>Effluent Treatment</p> <p>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 – Electrolysis, Electrodeposition and Ion Exchange etc. (3L) 1.6 Recycle and reuse of process and treated (effluent) water (2L)</p>	15/01
Module 2	<p>Solid Waste Management</p> <p>2.1 Solid waste management: (3L) objectives, concept of recycle, reuse and recovery 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 and E- Waste: (5L) Introduction, Toxicity, isolation, disposal and treatment.</p>	15/01
Module 3	<p>Plastics and Polymer</p> <p>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), separation and analysis of pigments, binders and thinners. (3L) 3.5 Role of Organo silicones in paints and their impact on environment. (3L)</p>	15/01
Module 4	<p>Metallurgy</p> <p>4.1 Ores and minerals: (3L) Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting) 4.2 Chemical analysis of ores for principal constituents: (4L) Galena, Pyrolusite, Bauxite, Hematite, Monazite 4.3 Alloys: (4L) Definition, analysis of Cupronickel, Magnesium, Steel and Stainless Steel, Bronze, Gun metal. 4.4 Techniques of purification: (4L) Zone refining, analysis of high purity materials like silicon, vacuum fusion and extraction techniques.</p> <p>Total</p>	15/01
	Total	60 L

PRACTICALS	
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To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

**PRACTICAL I
(If applicable)**

PRACTICALS		
1.	Analysis of Calcium, Iron and phosphorous in milk.	
2.	Determination of SAP value of oil.	
3.	Estimation of Aldehyde in lemon grass oil / Cinnamon oil .	
4.	Estimation of Glucose by Folin-Wu method	
5.	Analysis of water sample: Mn^{2+} by colorimetric method	

Suggested Readings

Reference Books:

1. Environmental Pollution Analysis, S. M. khopkar, New Age International publication, 2011.
2. Water and water pollution (hand book) Ed., Seonard'ICiacere, 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, SurendrakumarNorthen Book Center, 2009.
7. Handbook of chemical technology and pollution control 3rd Edn 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

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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.

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Program: M.Sc. Analytical Chemistry				Semester: IV	
Course: Analytical Chemistry				Course Code: PSMACHA404	
Teaching Scheme				Evaluation Scheme	
Lecture (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks - 25)	Semester End Examinations (SEE) (Marks- 75 in Question Paper)
4	4	NIL	4+2=6	25	75
Learning Objectives: 1. This topics provides understanding of various aspects of research, statistical analysis of data, chemometrics, interpretation etc.					
Course Outcomes: After completion of the course, learners would be able to: CO1: It deals with foundation of research and its pedagogy. CO2: This involves data analysis and. Chemometrics. CO3: This topic deals with scientific writing, paper presentation etc. CO4: It involves study of various chemicals and its MSDS employed in research.					
Outline of Syllabus: (per session plan)					
Module	Description				No of Hours
1	Research Methodology				15L
2	Data Analysis				15L
3	Methods of Scientific Research and Writing Scientific papers				15L
4	Chemical Safety & Ethical Handling of Chemicals				15L
	Total				60 L
PRACTICALS					

Unit	Topics	No of Hours/ Credits
Module 1	Research Methodology Print: Primary, Secondary and Tertiary sources. Journals: Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. Digital: Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups	15/01

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	and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus. Information Technology and Library Resources: The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	
Module 2	Data Analysis The Investigative Approach: Making and recording Measurements, SI units and their use, Scientific methods and design of experiments. Analysis and Presentation of Data: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.	15/01
Module 3	Methods of Scientific Research and Writing Scientific papers Reporting practical and project work, writing literature surveys and reviews, organizing a poster display, giving an oral presentation. Writing Scientific Papers: Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.	15/01
Module 4	Chemical Safety & Ethical Handling of Chemicals Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	15/01
	Total	60 L
PRACTICALS		

To develop scientific temper and interest by exposure through industrial visits and study/educational tours is recommended in each semester

**PRACTICAL I
(If applicable)**

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PRACTICALS		
1.	Project Evaluation	

Suggested Readings

Reference Books:

1. Research Methodology by N.C. Kothari