



# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## M.Sc. (Analytical Chemistry)

Choice Based Credit System (CBCS) (Batch 2021 -2023)

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY		PRACTICAL		
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
MISAN 301	DC	Analytical Biochemistry, Carbon Nano structures and Sensors	3	0	0	3	60	20	20	0	0

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit;

\*Teacher Assessment shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

### Course Objectives:

1. To give an in-depth account of general principles of Analytical Biochemistry with their specific applications of analytical techniques in the specific areas of Biochemistry
2. To recognize the principle and develop skills of isolation and purification of Biomolecules
3. To expose the students to a breadth of experimental techniques using modern instrumentation of Flow cytometry, MALDI and 2D NMR
4. Impart training in operating different instruments for structural elucidation of Biomolecules and practical knowledge about Biomedical sensor and Biosensors

**Course Outcomes:** After completion of this course the students are expected to demonstrate following knowledge, skills, and attitudes. The student can be able to demonstrate the following.

CO1. To understand the theory and mechanism of Electrophoresis and Electro separation

CO2. Recall the practical concepts of isolation of biomolecules with the help of Prep HPLC and Flash chromatography

CO3. Demonstrate and the Biological applications of Carbon clusters and Carbon nanotubes

CO4. Will gain the practical skills by handling the various analytical instruments further impart the structural elucidation knowledge of unknown molecules and Biomedical applications

### Syllabus:


#### Unit I General principle of Analytical Biochemistry:


Sampling of Biosystems, Introduction to Biomolecules (lipids, proteins, amino acids, Nucleic acids, enzymes, carbohydrates) specific Examples. Principle and application of electrophoresis: principle of electro separation, types of electrophoresis, Instrumental electrophoretic applications of both charged and uncharged species. Protein purification and sequencing methods. Mass spectrometric methods for quantification of biomolecules of high molecular weights.

#### UNIT II Isolation and purification of Biomolecules:

Isolation of biomolecules- role of Flash chromatography and Prep HPLC. Basic principles of centrifugation, types of centrifugation methods for biomolecules, Flow cytometry, principles, and applications. Characterization of Biomolecules- MALDI, 2D NMR and other techniques.

  
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### UNIT III Carbon Nanostructures:

Introduction of carbon molecules, carbon clusters, carbon nanotubes (CNT), Biological applications of carbon nanotubes. Synthesis of single walled carbon nanotubes (SWCNT), Structure and characterization, Chemical modification of carbon nanotubes and Doping.

### UNIT IV Role of Sensors in Analytical Biochemistry:


Theory, working principle of Sensors, Detailed description of Biosensors for glucose, DNA, and other biologically important molecules.

### UNIT V Biomedical Applications:

Role of Analytical Biochemistry in Drug Discovery research, Photo-Dynamic Therapy (PDT) in targeted drugs and drug delivery, Advances in manufacturing of Biomedical sensor and Biosensors, Quantum dot technology in cancer treatment, Nanoparticle as a drug carrier, Recent developments in the Biomedical applications.

### Textbooks:

1. Introduction to Nanotechnology by C.P. Poole, Jr & F. J. Owens, John Wiley and Sons (2009).
2. Nanobiotechnology by Subbiah Balagi, MJP Publishers, India (2010).
3. Understanding of Bioanalytical chemistry-principle and applications, Victor A Gault, Neville H McClenaghan, Wiley Blackwell, 2009.
4. Bioanalytical Chemistry, David J Holme, Hazel Peck, Prentice Hall, 3rd Edn., 2000.
5. Analytical Biochemistry, Andreas Manz, PetrasDittrich, NocollePamme, Dimitriv Iossifiedis, Imperial College Press, 2nd Edn., 2015.

  
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### Reference Books:

1. Instrumental Methods of Analysis: G. Chatwal and S. Anand, Himalaya Publishing House.
2. Bioanalytical chemistry, Susan R Mikkelsen and Eduard Corton, Wiley, 2004.

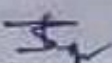
### List of Practical's: (If Practical Credit Shown in Syllabus)

#### Guidelines for Practical:

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MSAN 302	DC	Hyphenated and other Analytical techniques	3	0	0	3	60	20	20	0	0

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**Course Objectives:** The objective of Hyphenated and other Analytical techniques course is

1. To develop the understanding of different procedures involved in the hyphenated instruments and Thermal, Surface analytical methods of analysis.
2. To give basic knowledge of different instrumental techniques such as GC-MS, LC-MS, GC-FTIR and ICP-MS for the characterization of molecules
3. Enable students to learn experimental procedures and techniques of Radio chemical methods
4. Impart training in the analysis of unknown organic, inorganic samples and biomolecules

**Course Outcomes:** After completion of the course student can be able to demonstrate the following skills and attitudes

- CO1. Theoretical and practical understanding of different samples and methods of analysis
- CO2. To recognize the importance of GC-MS, GC-FTIR, LC-MS and ICP-MS techniques
- CO3. Student learns practical aspects of TG, DTA and DSC
- CO4. Impart training to evaluate the surface measurements with the help of XPES, SEM, Electron probe X-ray analysis and Auger Electron Spectroscopy (AES)

### Syllabus:


#### UNIT-I GC-MS and GC-FTIR:


GC-MS –Introduction, Instrumentation of GC-MS, and interface-Mass spectrometer (MS), Instrument operation, processing GC-MS data –Ion chromatogram, Library Searching-Quantitative measurement – sample preparation, selected ion monitoring-Application of GC-MS for Trace constituents, Drugs analysis, environmental analysis, and others. Gas Chromatography-Fourier Transform-Infrared (GC-FT-IR): Principle, Instrumentation, Applications.

#### UNIT-II LC-MS and Applications:

LC-MS –Introduction, Instrumentation –liquid chromatography- Mass spectrometer, Interface-Instrumental details processing LC-MS data –Ion chromatograms, Library Searching-Quantitative measurements, sample preparation, Selected ion monitoring-Application of LC-MS for Drugs analysis, Environmental samples, and others. Inductively Coupled Plasma-Mass Spectrometry (ICP-MS): Principle, Instrumentation, Applications.

  
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### UNIT-III Radio Chemical Methods:

Radioactive decay, Types of radiation, units and detection and measurements of radioactivity, activation analysis, isotope dilution method, tracer techniques, Radiometric titrations, Radio immuno assay.

### UNIT IV Thermal Methods of Analysis:

a) Thermogravimetry-Theory, Instrumentation, applications with special reference to Copper (II) sulphate  $[\text{CuSO}_4 \cdot 5\text{H}_2\text{O}]$ , Calcium oxalate  $[\text{CaC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}]$ . Applications of TG study of oxalates and chromates. b) Differential thermal analysis- Principle, Instrumentation, applications with special reference to the Clays, minerals & Coals (fuels). c) Differential Scanning Calorimetry- Principle, Instrumentation, applications to inorganic materials like chlorates and per chlorates, ammonium nitrate. Organic Compounds and Drugs.

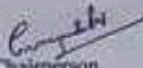
### UNIT V Surface analytical methods:


Introduction, types of surface measurements. Photon Probe Techniques: X-Ray Photoelectron spectroscopy - Principle, Instrumentation, applications. Electron Probe Techniques: Scanning electron microscopy (SEM) - Principle, Instrumentation, applications. Electron Probe X-ray analysis (EPXMA) - Principle, Instrumentation, applications. Auger electron spectroscopy (AES) - Principle, instrumentation, and applications.

### Textbooks:

1. Analytical Chemistry- J.G.Dick
2. Electroanalytical techniques - Kaur
3. Principles of Instrumental analysis, Skoog Holler and Neimann West, 6th edition.
4. Vogels textbook of Quantitative Inorganic Analysis. Bassett *et al.* Longman, ELBS 3rd edition.
5. W.Jeumings, Analytical gas chromatography, Academic Press, New York
6. Quantitative analysis VI Edition R.A. Day Jr & AL. Underwood Prentice- Hall India.
7. Analytical chemistry, Gary D. Christian, 6th edition John Wiley and sons. Inc, New York, 1994.
8. polarographic methods in analytical chemistry M.G. Arora
9. Instrumental methodology chemical analysis. Ewing.

  
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### Reference Books:


1. Introduction to Inductively coupled plasma emission spectroscopy, G.I Moore, Elsevier Science Publisher, New York, 1989.
2. Applications of ICP-MS, A.R. Date and A.L. Glay, London (Eds), Blakie, London
3. Instrumental techniques for Analytical chemistry, Ed. Frank Settle.
4. R.A Day A.C Underwood Qualitative analysis.
5. Wendlandt, Thermal Analysis, John Wiley Sons, New York.

### List of Practical's: (If Practical Credit Shown in Syllabus)

### Guidelines for Practical:

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MISAN 303	DC	Microanalytical techniques and Applications	3	0	0	3	60	20	20	0	0

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### Course Objectives:

1. To provide a broad foundation in Micro analytical techniques that stresses scientific reasoning and provide solution for an analytical problem
2. To provide the basic knowledge of Inorganic and Organic microanalysis and instrumentation
3. To learn the practical applications of kinetic micro analytical techniques with specific examples
4. Enable students to learn the industrial applications of micro analytical techniques with examples

**Course Outcomes:** The student can be able to deliver the following

- CO1. Recall the concepts of Macrocyclic, Supramolecular compounds and Microanalysis
- CO2. Apply and demonstrate the practical uses of Ring oven and Ring colorimetric techniques
- CO3. Practical utility and Industrial applications of Estimation of free fatty acid, Iodine value, and Saponification value of fats / oils, Estimation of blood cholesterol, DNA, and RNA
- CO4. Will gain the practical knowledge on the Determination of molecular weight and percentage purity of carboxylic acids. Students further learn Estimation of sugars and Unsaturation.


### Syllabus:

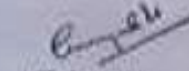
#### Unit I Microanalytical techniques:

Introduction, scope, and objectives of microanalytical technique, Difference between micro, trace and macro analysis. Microanalysis of real-world Samples: Molecular recognition and targeted analysis by using macrocyclic (crown ethers), macro bicyclic (cryptands), Supramolecular compounds (calixarenes) and polymeric materials

#### Unit II Biochemical Microanalysis:

Estimation of carbohydrates, amino acids and ascorbic acid in biological systems, Estimation of protein in egg albumin, Estimation of free fatty acid, Iodine value and saponification value of fats/oils, Estimation of blood cholesterol, DNA and RNA.

  
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**Unit III Inorganic microanalysis:**

Principle, Technique, qualitative and quantitative applications with special reference to Ring-oven technique and Ring colorimetric technique, Chemical microscopy

**Unit IV Organic Microanalysis:**

Determination of alkoxy, acetyl, acyl, hydroxyl, carbonyl, active hydrogen, nitroso, sulfonyl, amides and ester groups, Determination of molecular weight and percentage purity of carboxylic acid, Estimation of sugars, Estimation of unsaturation,

**Unit V Microanalysis by Kinetic Methods:**

Theoretical basis, Kinetic parameters, Kinetic methods of microanalysis- Tangent, fixed time and addition methods, Electrophoretic mediated microanalysis method. Recent development, commercial and industrial applications of Microanalysis methods.

**Textbooks:**

1. P.L. Kirk, Quantitative Ultra microanalysis, John Wiley.
2. G.D. Christian, Analytical Chemistry, John Wiley & Sons, New York (2001).
3. S.M. Khopkar, Analytical Chemistry of Macrocyclic and Supramolecular Compounds, Narosa Publishing House, New Delhi (2002).
4. Jag Mohan, Organic Analytical Chemistry - Theory and Practice, Narosa Publishing House, New Delhi (2003).

  
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### Reference Books:

1. Physical Methods in Chemistry, R.S. Drago, Saunders College
2. C.L. Wilson and D.L. Wilson, Comprehensive Analytical Chemistry", Vol. I (A) and I(B), Elsevier.
3. Instrumental Analysis, D. A. Skoog, F.J.Holler and S.R. Crouch, Thomson Brooks/Cole, Cengage Learning, UK

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MSAN 304 (A)	DE	Analytical quality management and IP rights	3	0	0	3	60	20	20	0	0

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**Course Objectives:**


1. To provide knowledge of Analytical quality management and IP rights with ISO certification
2. Student will learn about the Quality assurance, Quality control and Quality accreditation
3. Apply knowledge about documentation, storing, archiving records and types of sampling
4. To develop the understanding of property rights, patent, copy rights and management system

**Course Outcomes:** After completion of this course the students are expected to demonstrate following knowledge, skills, and attitudes. The student can be able to demonstrate the following.  
CO1. To aware of internal standardization, calibration, sampling, and maintenance of various instruments and students will learn the industrial applications of sampling techniques  
CO2. To learn the practical importance of Quality control charts, literature methods and analytical method development, ICH guidelines for method validation, sensitivity, and limit of detection  
CO3. Apply and demonstrate the uses of Documentation, quality manual. Students will gain the practical applications of report writing, and filing quality assurance documentation  
CO4. Acquire the practical knowledge of laboratory accreditation, features of ISO 9001 to 9004, and forms of IPR, IP laws in India. Student will learn IPR licensing, technology transfers.

**Syllabus:**

**Unit I Principles & Terminology in Quality Assurance:**

Standard-Primary standard; standard solution, calibration standard, check standard, Blank; reagent blank, method blank, calibration blank, instrumental blank, process blank, field blank, equipment blank. Calibration: Internal standardization, external standardization, addition method, control sample, dry weight, Duplicate. Sampling: Basics of Sampling, Purpose of sampling, homogeneous and heterogeneous samples, The Sampling Plan, Legal and Statutory requirements, Types of Sampling, Sample Numbers and Sample size, Sub-sampling, and its procedures.

  
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### Unit II Quality Assurance and Quality control I:


Quality control charts, the X-quality control chart, R-quality control chart and its interpretation, spiked sample control charts, use of blind samples in quality control, use of proficiency evaluations in quality control, Analysis of standard reference materials, Analysis of duplicates. Analytical Methods: Characteristics of an analysis, Choosing the methods – standard methods, official methods, literature methods analytical method development, Comparison of analytical methods, writing analytical methods, modification of analytical methods, Validation of new methods-ICH guidelines for method validation-sensitivity, specificity, selectivity, accuracy, precision, robustness, ruggedness, limit of detection and limit of quantitation, ruggedness testing of methods.


### Unit III Quality Assurance –II:


Documentation for quality assurance. Documentation, Quality Manual, Supporting Documentation, Record Management, Records, Generating Records, Record Identification, Document and Record Control, Reporting Results, Copying Records, Storing and Archiving Records. General Reagents and volumetric reagents, sample labelling, sample log-in/register, sample analysis, reporting, recording and personal training. Instrument calibration and maintenance. Analytical report. Personal, training, records-professional, personnel, technician personnel. Filing quality assurance documentation.


### Unit IV Quality Accreditation:

Need for laboratory accreditation. International aspects of laboratory accreditation and in India, Criteria for laboratory accreditation, Benefits of laboratory accreditation, The Management System, The Benefits of a Management System, Types of Management Standards for Laboratories, Standards Available for Laboratories, Features of ISO 9001:2008, Features of ISO/IEC 17025:2005, Features of ISO 15189:2003. Significance of ISO 9001, 9002, 9003, 9004, Requirements, ISO/IEC 17025 Requirements, ISO 9001 Requirements, Quality manual, and other Documentation.

  
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### Unit V Intellectual Property Rights:

Definition, scope, and different forms of IPR, IP laws in India. International Regime of I.P.R. Procedural Aspects of Intellectual Property Rights. Patents, definition, types, contents of patent, Inventions-patentable and non-patentable, claims and types of claims, requirements for patenting, restrictions, and the power of patents. Copy rights, Trademarks and Geo Graphical Indications of goods. Plant varieties and farmer's rights, IPR Licensing and technology transfers


### Text & Reference books:


1. Principles of instrumental Analysis - Sixth edition-skoog, Hooler, Nieman
2. Analytical chemistry - Gary D.Christian, Sixth edition, John Wiley and sons. Inc, New York 1994.
3. Quality Assurance in Analytical Chemistry, B.W.Wenclawaik, Springer, India, 2004.
4. What everyone should know about patents by N.Subbaram - Pharma Book Syndicate 5.
6. Principles of Analytical chemistry - M.Valcarcel.
7. R.A Day A.C Underwood Qualitative analysis
8. Handbook of Quality Assurance for the analytical chemistry laboratory, James Dux, Van Nostrand Reinhold, New York, 1986.
9. Training Manuals on ISO 9000 PQM, Giridhar, Raj Publishing House, 2001
10. How to Practice GLP, PP Sharma, vandana Publications, 2000, New Delhi.
11. Applying ISO-9000 Quality Management systems, International Trade Centre publishing, UNCTAD/WTO, Geneva, Switzerland, Indian Edition Printed by D.L.Shah Trust


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MSAN 304 (B)	DE	Separation techniques and Applications	3	0	0	3	60	20	20	0	0

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit;

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### Course Objectives:

1. To provide a clear, incisive treatment of different separation techniques and applications
2. To provide the practical knowledge of functionalization, Size exclusion chromatography, and ion-exchange chromatography
3. To develop the practical understanding of Liquid-Liquid partition chromatography
4. Impart training in the supercritical fluid chromatography, reverse osmosis, and electro dialysis

**Course Outcomes:** The student will be able to deliver the following

- CO1. Theoretical and practical understanding of different types of extraction (batch, continuous and counter current) and applications
- CO2. Enable to gain the practical knowledge of packing of column, selection of solvent and loading of sample in MPLC, Flash chromatography and other types of chromatography
- CO3. To learn the practical applications of Capillary electrophoresis, GF chromatography
- CO4. Impart practical experiments in the separation of gases, water purification, Affinity chromatography, Electro membrane processing and Flotation techniques

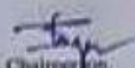
### Syllabus:


#### Unit I Solvent extraction:


Principle, processes and applications of solvent extraction, Distribution law and Partition coefficient. Different types of Solvent extraction systems-Batch extraction, Continuous extraction, Counter current extraction, solvent extraction systems, applications in metallurgy, general applications in analysis and pre-concentration, special extraction systems like crown ethers, Super fluid, and surfactant extraction-examples. Organic reagents as extraction agents - acetylacetone, thionyl trifluoro acetone, tri-n-octyl phosphine oxide.


#### Unit II Liquid-Liquid partition chromatography:

Principle supports, partitioning liquids, eluents, reverse phase chromatography, apparatus, and applications. Flash Chromatography Packing of column, selection of solvent, loading of sample. Dry column flash chromatography - Packing of column, selection of solvent, loading of sample medium pressure liquid chromatography (MPLC) - Apparatus, packing of column, selection of solvent, loading of sample.

  
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# Shri Vaishnav Vidyapeeth Vishwavidyalaya

## M.Sc. (Analytical Chemistry)

Choice Based Credit System (CBCS) (Batch 2021 -2023)

COURSE CODE	CATEGORY	COURSE NAME	L	T	P	CREDITS	TEACHING & EVALUATION SCHEME				
							THEORY			PRACTICAL	
							END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*
MSAN 304 (B)	DE	Separation techniques and Applications	3	0	0	3	60	20	20	0	0

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit;

\*Teacher Assessment shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

### Unit III Size exclusion chromatography:

Principles of gel – filtration Chromatography. Instrumentation, retention behaviour, resolution, selection of gel type, applications, structure of zeolite crystals, applications. Ion exclusion – principle and applications. Capillary electrophoresis: principle, details of the instrument, Applications to Inorganic and Organic compounds.

### Unit IV Ion -exchange chromatography:


Ion-exchange resins, structure of resins. Ion exchange equilibria, selectivity, ion exchange chromatography with reference to anions and cations, applications separation of rare earth metal ions, Amino acid analysis, purification of water for laboratory and industrial use, deionized water. Inorganic molecular sieves: structure of Zeolites, crystals, types of sieves, application in the separation of gases including hydrocarbons, ion exclusion- principles and applications, Counter current chromatography- principles and application, Affinity chromatography- principles and applications.


### Unit V Other methods of separation:

Supercritical Fluid Chromatography (SFC)- Instrumentation of SFC, stationary and mobile phases used in SFC, Detectors, Advantages of SFC. Technique, and applications of SFC. Membrane separations: Reverse osmosis for water purification, electro dialysis, electro membrane processing, liquid membranes. Flotation techniques: Froth flotation, Ion flotation, Molecular sieves, clathrates.


### Textbooks:

1. Separation methods by M.N. Sastri, Himalaya Publishing Company, Mumbai.
2. Principles of Instrumental Analysis – Skoog, Holler, Nieman.
3. R.P.W. Scott, Techniques and practice of chromatography, Marcel Dekker Inc., New York.
4. Analytical Chromatography by Gurdeep R Chatwal
5. Analytical chemistry by Gary D. Christian
6. Vogel Textbook of Quantitative inorganic Analysis.
7. Chemical separation methods, John A Dean, Von Nostrand Reinhold, New York.

  
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### Reference books:

1. Separation methods - J.A Dem
2. H.M. Mc Nair and J.M. Miller, Basic Gas Chromatography, John Wiley, New York.
3. J. MohdJani, M. Leary, A. Subic and M. Gibson, Materials & Design, 2014, 56, 1078-1113.
4. J. M. G Cowie, Polymers: Physics and Chemistry of Modern Materials, Blackie, London, 1992.
5. E. Helfman, Chromatography, Van Nostrand, Reinhold, New York.
6. Encyclopedia of Industrial Chemical Analysis, Foster Dee Snell et al, Inter-science Publishers, 1967.

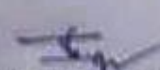
List of Practical's: (If Practical Credit Shown in Syllabus)

### Guidelines for Practical:

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MSAN 304 (C)	DE	Environmental and Industry material analysis	3	0	0	3	60	20	20	0	0

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit.

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### Course Objectives:

1. The purpose of the course is to make the students to understand different analysis of oils, fats, dyes, paint, and industry material analysis
2. To provide theoretical and practical knowledge of the assessments of water and air quality
3. To develop the practical understanding of flash point of volatile constituents, separation of pigments and estimation of binders
4. Applying practical aspects of analysis of Fertilizers- determination of moisture, Total nitrogen, and analysis of active ingredients of detergents, CMC, and total phosphates

**Course Outcomes:** After completion of the course student demonstrate the following

- CO1. To become aware of cloud point, Polanski value, elaiden test and saponification number
- CO2. To study the composition and analysis of paints, dyes, and estimation of total lead in paints
- CO3. Practical understanding of water pollutants, water quality standards, DO, BOD, and COD
- CO4. Design experiments on sampling of air, and chemical analysis of CO, SO<sub>2</sub>, H<sub>2</sub>S, and NO

### Syllabus:

#### Unit I Analysis of oils, fats, and soaps:

Introduction to natural fats and oils, Softening point, Titre point, cloud point, Polanski value, Elaiden test, Saponification number, Iodine number and Acid number. Introduction to soaps, analysis of soap (saponifiable and unsaponifiable), estimation of free alkali in soap.

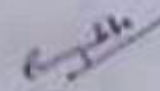
#### Unit II Analysis of Dyes and Paint:

Type of dyes and their analysis, Composition, and analysis of paints - determination of volatile and non-volatile constituents, flash points, separation of pigments, estimation of binders and thinners, total lead, lead chromate.

#### Unit III Analysis of Fertilizers and detergents:

Analysis of fertilizers: Ammoniacal fertilizers, phosphate fertilizers: determination of moisture, total N, NH<sub>4</sub>, P, Si, lime. (b) Classification of detergents: Analysis of active ingredients from detergents, estimation of CMC, chlorides, and total phosphates.

  
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### Unit IV Assessment of Water Quality:

Sources of water, sampling procedure of water and wastewater, classification of water for different uses, types of water pollutants and water quality standards for drinking water. Analytical methods for the determination of the following ions in water: Anions:  $\text{CO}_3^{2-}$ ,  $\text{HCO}_3^-$ ,  $\text{F}^-$ ,  $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ , Cations:  $\text{Fe}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{Cr}^{3+}$ . Determination of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

### Unit V Assessment of Air quality and soil:

Composition of pure air, classification of air pollutants, sources of air pollutants, sampling of air, standards for ambient air quality. Chemical analysis for the following: Carbon monoxide (CO), Sulphur dioxide ( $\text{SO}_2$ ), Hydrogen Sulphide ( $\text{H}_2\text{S}$ ), Nitric oxide (NO). Analysis of soils: Sampling, determination of moisture, total N, P, Si,  $\text{CaCO}_3$ , organic carbon and alkali metal ions.

### Textbooks:

1. Air pollution - M.N.Rao, H.V.N.Rao, Tata McGrawHill publishing company, 1998
2. Environmental Chemistry, Anil Kumar De, Wiley Eastern Ltd, 2003.
3. Environmental Analysis, S.M. Khopkar (IIT, Bombay), 1991.
4. Text book of Metallurgical Analysis, B.C.Agarwal and S.P.Jain, Khanna publishers, 2003
5. Standard Methods of Chemical Analysis, 6th edition, N. Howell Furman, D. Van Nostard Company Inc, Princeton, 1962.

### Reference books:

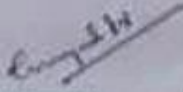
1. Technical Methods of Analysis-Griffin, McGraw Hill Book, 1927
2. Vogel's textbook of quantitative chemical analysis - Jeffery J Bassett, J. Mendham, R. C. Denney, 5th edition, ELBS, 1991.


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