

M. Sc. II (Analytical Chemistry)

Syllabus

(As per NEP 2020 Recommendations)

20th March, 2024

Progressive Education Society's
Modern College of Arts, Science and Commerce (Autonomous),
Shivajinagar, Pune -05

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For

M.Sc. (Analytical Chemistry)

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2023-24)

Semester 1 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP111	Major Paper 1 (Theory)	Fundamentals of Physical Chemistry I	4	4	50	50	100
	23ScCheP112	Major Paper 2 (Theory)	Molecular Symmetry and Main group Chemistry	4	4	50	50	100
	23ScCheP113	Major Paper 3 (Practical)	Lab Course on 23ScCheP111 & 23ScCheP112	4	4	50	50	100
	23ScCheP114	Major Paper 4 (Theory)	Basic Organic Chemistry	2	2	25	25	50
Major Electives (4)	23ScCheP121	Major Elective (T+P)	Organic Reactions (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP122	Major Elective (T+P)	Analytical Methods (T + P)	6	4	50	50	100
RM (4)	23ScCheP131	RM Paper 1	RM Core Paper	2	4	50	50	100
	23ScCheP131	RM Paper 2	Department Specific Paper	2				
OJT(4)		—	—	—	—	—	—	—
Total				26	22	275	275	550

Semester 2 (First Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP211	Major Paper 1 (Theory)	Molecular Spectroscopy and Nuclear Chemistry	4	4	50	50	100
	23ScCheP212	Major Paper 2 (Theory)	Coordination and Bioinorganic Chemistry	4	4	50	50	100
	23ScCheP213	Major Paper 3 (Practical)	Lab Course on 23ScCheP211 & 23ScCheP212	4	4	50	50	100
	23ScCheP214	Major Paper 4 (Theory)	Organic Spectroscopy	2	2	25	25	50
Major Electives (4)	23ScCheP221	Major Elective (T+P)	Synthetic Organic Chemistry (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP222	Major Elective (T+P)	Analytical Chemistry (T + P)	6	4	50	50	100
RM (4)	-	-	-	-	-	-	-	-
	-	-	-	-				
OJT(4)	23ScCheP241	OJT	On Job Training	8	4	50	50	100
Total				30	22	275	275	550

Semester 3 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP311	Major Paper 1 (Theory)	Advanced Electrochemical Analytical Methods	4	4	50	50	100
	23ScCheP312	Major Paper 2 (Theory)	Sophisticated Analytical Techniques	4	4	50	50	100
	23ScCheP313	Major Paper 3 (Practical)	Lab Course on Analytical Chemistry I	4	4	50	50	100
	23ScCheP314	Major Paper 4 (Theory)	Photochemistry, Free radicals and Pericyclic Reactions	2	2	25	25	50
Major Electives (4)	23ScCheP321	Major Elective (T+P)	Pharmaceutical Analysis (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP322	Major Elective (T+P)	Geochemical & Alloy analysis (T + P)	6	4	50	50	100
RP (4)	23ScCheP351	RP	Research Project	8	4	50	50	100
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

Semester 4 (Second Year)

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP411	Major Paper 1 (Theory)	Analytical Spectroscopy	4	4	50	50	100
	23ScCheP412	Major Paper 2 (Theory)	Catalyst Characterization Techniques	4	4	50	50	100
	23ScCheP413	Major Paper 3 (Practical)	Lab Course on Analytical Chemistry II	4	4	50	50	100
Major Electives (4)	23ScCheP421	Major Elective (T+P)	Toxicology & Food Analysis (T + P)	6	4	50	50	100
Major Electives (4)	23ScCheP422	Major Elective (T+P)	Safety in Chemical Laboratory (T + P)	6	4	50	50	100
RP (4)	23ScCheP451	RP	Research Project	12	6	75	75	150
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

OE : Open Elective

AEC: Ability Enhancement Course

VEC: value Education Courses

CC : Co-Curricular Courses

IKS : Indian Knowledge System

OJT : On Job Training

FP : Field Project

VSC : Vocational Skill Courses

CEP : Community Engagement Project

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M.Sc. II (Analytical Chemistry) Syllabus

Semester III

Sr No	Subject Code	Old Name	New Name
1	23ScCheP311	Advanced Electrochemical Analytical Methods	Advanced Analytical Electrochemical Methods
2	23ScCheP312	Sophisticated Analytical Techniques	Introduction to Advanced Sophisticated Analytical Techniques

Semester IV

Sr No	Subject Code	Old Name	New Name
1	23ScCheP412	Catalyst Characterization Techniques	Industrial Chemicals, Characterization of Functional Polymers and Solid Catalyst
2	23ScCheP421	Toxicology & Food Analysis (T + P)	Analytical Toxicology & Food Analysis (T + P)

M.Sc. II (Analytical Chemistry) Syllabus

Semester III

23ScCheP311: Advanced Analytical Electrochemical Methods (4 Credits, 60 L)

Chapter No.	Section I: Electrochemical Methods of Analysis (2 Credits, 30L)	
1	Voltammetry and Polarographic methods A) Polarography principles Instrumentation, Types of microelectrode such as Dropping mercury electrode, Static drop mercury electrode, rotating disc and ring disc electrode, Cell for polarography, Reference and counter electrode and circuit diagram, Polarogram and polarographic currents charging or capacitive current, Role of supporting electrolyte, Factors affecting on polarographic wave, Ilkovic Equation, Advantages and disadvantages of DME, polarographic maxima and Maxima suppressors, Interference due to dissolved oxygen, Applications such as qualitative and quantitative analysis by calibration curve and standard addition methods, Numerical problems. B) Hydrodynamic voltammetry Principle, Applications, Voltametric detectors in chromatography, Flow injection analysis, Voltametric oxygen sensors. C) Pulse Polarography Different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, Stripping method, voltammetry with ultra-micro electrode, Applications of differential pulse polarography and Square wave polarography. D) Cyclic voltammetry Principle of cyclic Voltammetry, Cyclic voltammogram of $K_3[Fe(CN)_6]$, parathion, riboflavin etc. Criteria of reversibility of electrochemical reactions, Quasi reversible and irreversible processes.	16 L
2	Amperometry	05 L

	Principle, Instrumentation, Applications, amperometric titrations, chronoamperometry, Chrono-potentiometry	
3	Coulometry Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, Electrolysis at constant working electrode potential, Coulometric methods of analysis Faraday's laws of electrolysis, Instrumentations-Constant current and constant voltage instruments, Potentiostatic coulometry-Instrumentation and applications, Coulometric titrations (Amperostatic coulometry - Apparatus and applications, advantages and limitations) Numerical problems	09 L
	Section II: Current Analytical Methods of Analysis in Industries (2 Credits, 30 L)	
4	Radiochemical Methods of Analysis A)Activation analysis: Neutron activation analysis, principle, technique, steps involved in neutron activation analysis, Radiochemical and instrumental methods of analysis, important applications of NAA. B)Isotope dilution analysis: Principle, types of isotope dilution analysis, typical applications of isotope dilution analysis. C) Radiometric titration: Principle, techniques based on complex formation and precipitation, radiometric titration curves for estimation of ions from their mixture.	14 L
6	Thermal methods of analysis Principle, different methods of thermal analysis, A) Thermogravimetric method of analysis Instrumentation, Thermogravimetric analysis, Factors affecting thermogram, Applications TGA for quantitative analysis (TG analysis of CaC_2O_4 , H_2O , $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, dolomite ore, AgNO_3 , nylon 6, nylon 6,6etc.) and problems based TGA), Brief introduction of TGA-IR.	14 L

	B) Differential Thermal Analysis (DTA) Instrumentation, General Principles, Differential thermogram, DT and TG curve together, Applications (DT analysis of mixture of polymers, DT analysis of $\text{CaC}_2\text{O}_4\cdot\text{H}_2\text{O}$, DT analysis of sulfur, DT analysis of $\text{CuSO}_4\cdot 5\text{H}_2\text{O}$, TG and DT curve for $\text{Mn}(\text{PH}_2\text{O}_2)_2\cdot\text{H}_2\text{O}$. C) Differential Scanning Calorimetry (DSC) Principle, Instrumentation, and Applications, (DSC curve of polyethylene terephthalate), DSC curve for isothermal crystallization of polyethylene, DSC of phenacetin), Evolved gas analysis.	
7	Thermometric titrations	02 L

Reference:

- 1) Introduction to instrumental analysis by R. D. Broun, McGraw Hill (1987)
- 2) Instrumental methods of chemical analysis by H. Willard, L. Merrit, J.A. Dean and F.A. settle. Sixth edition CBS (1986)
- 3) Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992) and Principles of Instrumental Analysis Skoog, West, Niemann.
- 4) Vogel Textbook of quantitative analysis 6th Ed.
- 5) J. chemical education, 60,302 to 308 (1983)
- 6) Thermal analysis by W.W. Wendlandt, John Wiley, (1986)
- 7) Cyclic Voltammetry and frontiers of electrochemistry by N. Noel and K. I. Vasu IBH, New Delhi (1990)
- 8) Source book of Atomic energy by Glasstone.
- 9) Principle of Activation Analysis- P. Kruger, John Wiley and sons, (1971).
- 10) Instrumental methods of chemical analysis by H. Kaur

**23ScCheP312: Introduction to Advanced Sophisticated Analytical Techniques
(4 Credits, 60L)**

Chapter No.	Section I: Advanced Analytical Techniques (2 Credits, 30 L)	
1	Polarimetry Introduction, Principle, Types of Polarimetry, Instrumentation, Plane polarized light, Theory of optical activity, Applications, Numerical Problems.	05 L
2	Circular Dichroism (CD) Introduction, Principle, Plane and circularly polarized light, Circular Dichroism Spectroscopy, Instrumentation, Examples, Applications, Advantages , Limitation.	05 L
3	Optical Rotatory Dispersion (ORD) Introduction, Fundamental principle of ORD, Theory, Instrumentation, Hyphenated techniques, Cotton effect and curves, Types of cotton curve, Specific applications of ORD, Octant rule, Difference between ORD and CD, Conclusion.	05 L
4	Advanced Chromatographic Techniques High Performance Thin Layer Chromatography (HPTLC), Gas Chromatography (GC), High Performance Liquid Chromatography, Ultra Performance Liquid Chromatography (UPLC), Inductively Coupled Plasma (ICP), Fourier Transform Infrared (FTIR)	08 L
5	Hyphenated Techniques Principles, Instrumentation, Applications, ICP-AES, ICP-MS, GC-MS, GC-IR, HRMS/MS, LCMS, with case study	07 L
	Section II : Atomic Spectroscopy Techniques (2 Credits, 30 L)	

6	X- ray Methods of Analysis & Electronic Spectroscopy technique Principle, Theory- X-ray spectral lines, X-ray tube, X-ray Emission-instrumentation and chemical analysis , X-ray absorption - instrumentation and chemical analysis, X-ray fluorescence - instrumentation and chemical analysis ,X-ray diffraction - instrumentation and chemical analysis , X-ray photoelectron spectroscopy-instrumentation and chemical analysis , Auger electron microscopy, Ultraviolet photoelectron spectroscopy, Numerical problems	11 L
7	An Introduction to Analysis of Textural and Microscopic properties Limitations of the Human Eye, The X-ray Microscope, The Transmission Electron Microscope, The Scanning Electron Microscope, Scanning Transmission Electron Microscope, Analytical Electron Microscopy, Scanning-Probe Microscopes, SEM and TEM Analysis, SEM and TEM applications, SAED (Selected Area Electron Diffraction) pattern, EDX (Energy Dispersive X-Ray) Analysis – Elemental mapping, Colour mapping.	14 L
8	Photoacoustic Spectroscopy Introduction, Principle, Theory, Instrumentation, Applications.	05 L

References

- 1) Introduction to Instrumental Analysis by R. D. Broun, McGraw Hill (1987)
- 2) Instrumental methods of chemical analysis by H. Willard, L.Merritt, J.A. Dean and F.A. settle. Sixth edition CBS (1986)
- 3) Fundamentals of Analytical Chemistry, 6th edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing.
- 4) Principles of Instrumental Analysis, Skkog, Holler, Nieman, (Sixth Ed.)
- 5) Vogel's Textbook of Quantitative Analysis 6th Ed.
- 6) Modern analytical techniques in pharmaceutical and bioanalysis By Dr. Istvan Bak (Book Available Online).

- 7) Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (free e book available on internet).
- 8) Extraction technique in analytical science, John R. Dean, Wiley (2009).
- 9) Organic Spectroscopy by William Kemp 3rd edition.
- 10) Application of Circular Dichroism, International journal of molecular science ISSN 1422-0067.
- 11) Instrumental methods of chemical analysis by B.K.Sharma.
- 12) Encyclopedia of Materials Characterization by Richard Brundle, Charles K Evans, Jr., and Shaun Wilson.
- 13) Principles and techniques of biochemistry and molecular biology, 7th edition, by Keith Wilson and John Walker.

23ScCheP313: Lab Course on Analytical Chemistry I (4 Credits)

Chapter No.	Name of the Experiment
	PHYSICAL PRACTICALS
1	Conductometry- 1. Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their K_a value by conductivity measurement method. 2. Determination of commercial vinegar by conductometry titration. 3. Determination of Critical Micellar Concentration (C.M.C) of a surface active agent by Conductometrically. 4. Determination of concentration of sulfuric acid, acetic acid and copper sulfate by conductometric titration with sodium hydroxide. 5. Determination of Boric acid by conductometry.
2	Potentiometry- 1. Determination of strength of phosphoric acid by Potentiometric titration.
3	Flame Photometry- 1. Determination of Na from water sample by flame photometry. Calibration curve method or by standard addition method. 2. Determination of Na and K from water sample by flame photometry binary method/internal standard method.
4	Turbidimetry- 1. Determination of Cl^- by turbidimetric method using turbidimetric titration 2. Determination of Cl^- by turbidimetric method using calibration curve method.
5	Spectrophotometer- 1. Spectrophotometric determination of pK value of an indicator.

	2. Determination of phosphorus in given unknown solution by Spectrophotometry.
6	Polarimetry- 1. Determination of purity of Sugar sample by optical rotation by polarimetry. 2. Determination of purity of Glucose sample by optical rotation by polarimetry
7	Radioactivity- 1. To determine the characteristics of a Geiger-muller counter. 2. To determine Absorption coefficient and half thickness of aluminum (Al) Absorber for gamma radiation source using G.M. counter.
8	Polarography- 1. Determination of Cu and Zn 2. Amperometric titration of Pb(II) with potassium dichromate solution. 3. Identification and Determination of Cd^{2+}
9	Data Analysis- 1. Statistical Evaluation of given experimental Data.
	INORGANIC PRACTICALS
1	Analysis of Bronze with respect to Copper and tin
2	Estimation of Copper by Spectrophotometrically from alloy sample (Brass / Bronze)
3	Analysis of Bauxite Ore for Aluminium, Iron and Silica
4	Analysis of Dolomite Ore for Calcium, Magnesium and Silica
5	Analysis of Zinc-Chrome pigment for Chromium and Zinc
6	Determination of alcohol from given sample by Spectrophotometrically
7	Estimation of Iron from sydent Spectrophotometric method
8	Determine amount of magnesium from given Talcum Powder

9	Thermogravimetric Analysis (TGA) 1) CaCO_3 2) $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ 3) AgNO_3 4) $\text{Mn}(\text{PH}_2\text{O}_2)_2 \cdot \text{H}_2\text{O}$ 5) Polymer 6) Dolomite ore for CaCO_3 and MgCO_3 content
10	Determination of Chemical Oxygen Demand from waste water.
11	Determination of Ni(II) or Co(II) by using alpha nitroso beta naphthol from steel sample or from given sample by spectrophotometry
11	Estimation of any two metal ions by Atomic Absorption spectroscopy from soil or any given sample
12	Determination of Zn (II) by Photo Fluorimetry
13	Analysis of Commercial Hypochlorite or peroxide solution by iodometric titration
14	Lanthanide separation using column chromatography.

References:

- 1) Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)

23ScCheP314: Photochemistry, Free radical and Pericyclic Reactions (2 Credits, 30L)

Chapter No.	Photochemistry, Free radical and Pericyclic reactions (2 Credits, 30 L)	
1	Pericyclic Reactions Recapitulation of molecular orbitals, their symmetry properties, Woodward- Hoffmann's conservation of orbital symmetry property rule and its application to the ground state and excited state electrocyclic reactions, Cycloaddition, Cheletropic, Sigmatropic reactions etc. Fukui's HOMO and LUMO orbitals and its application to the ground state and excited state electrocyclic reactions. Synthesis of Endiandric acid and Citral (through pericyclic reactions and BASF synthesis).	15 L
2	Photochemistry Principles of photochemistry, Orbital symmetry considerations, Excited states and their properties, experimental setup of photochemical reactions; Photochemical reactions of olefins, carbonyl, aromatic substrates and their application in organic synthesis. Reaction viz Isomerisation, Paterno-Buchi, Barton, Norrish type I and II etc. Photochemical aromatic substitution reaction, Reactions with singlet oxygen.	10 L
3	Free radicals in organic synthesis Formation, stability and detection of long and short lived radicals, homolysis and free radical displacement, addition and rearrangement of free radicals, Baldwin's rule of ring closure, radical cyclizations and their applications in synthesis	5 L

References

- 1) Advanced Organic Chemistry, Part A- F.A Carey and R.J Sundberg 5th edition.
- 2) Excited states in Organic Chemistry- J.A Barltrop and J.D Coyle, John Wiley & Sons

- 3) Radical in Organic Synthesis B. Giese, Pergamon press (1986)
- 4) Organic Photochemistry : A Visual approach, Jan Kopecky, VCH publishers
- 5) Organic Photochemistry, O Kaan
- 6) Norman R.O.C Organic Chemistry.
- 7) Conservation of orbital symmetry, R. B. Woodward and R Hoffmann; Verlag Chemie, weinheim (1970)
- 8) Orbital Symmetry : A problem solving approach- R. E. Lehr and A.P. Marchand;Academic (1972)
- 9) Organic reactions and orbital symmetry, 2nd Ed. T. L. Gilchrist and R. C. Storr; Cambridge, University Press.
- 10) Modern Heterocyclic Chemistry, L. A. Paquette (Benjamin).

23ScCheP321: Pharmaceutical analysis (Theory) (2 Credits, 30 L)

Chapter No.	Pharmaceutical Analysis (2 Credits, 30 L)	
1	Development of new drug Definitions of Drug and Generic Drugs, Development of New Drugs, Preclinical pharmacology (Animal Studies) , Acute, Subacute and Chronic Toxicity Studies (Toxicity Profile), Therapeutic Index (Safety and Efficacy Evaluation), Absorption Distribution and Assimilation Studies (Pharmacokinetics), Clinical Pharmacology (Human Studies) , Clinical Trials Phase I, Phase II, Phase III, Phase IV Trials, Stability Studies and Self Life Fixation.	06 L
2	Biological Tests & Assay Introduction to biological assay, Biological assay of Heparin sodium, Determination of Amylase activity, Determination of Proteolytic Activity, Test for Insulin in solution, Test for Undue Toxicity	05 L
3	Microbiological Tests and Assays Microbiological test for Antibiotics, Standard preparation and units of Activity, Test organisms and Inoculums, apparatus – Cylinder plate assay and Turbidimetric Assay receptacles, Methods a) Cylinder plate or Cup-plate method – a) Two level factorial Assay b) Turbidimetric or Tube Assay Method, Test for Sterility	07 L
4	Physical Test, Determinations, Limit tests and Sterilization Disintegration Test for Tablets and Capsules, Dissolution Test for Tablets and capsules, Moisture / water content by Karl-Fischer titration, Limit tests for Arsenic, Heavy metals, Iron, Lead, Sulfate, Chloride, methods for sterilization, steam sterilization, dry heat sterilization, sterilization by filtration, gas sterilization, sterilization by ionizing radiation, sterilization by heating with Bactericides.	07 L
5	Dosage forms and Chemical Analysis	05 L

	Brief introduction to different dosage forms, Tablets – Different types of tablets, Additives used in tablet Manufacture, Capsules - Types of capsules, Assays as per IP - Aspirin, Adrenaline, Paracetamol, Isoniazid, Niacinamide.	
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Reference

- 1) Indian Pharmacopoeia Volume I and II.
- 2) Practical Pharmaceutical chemistry A. H. Beckett & J. B. Stenlake third edition volume 1.
- 3) Remington's Pharmaceutical sciences.
- 4) Ansel's Pharmaceutical Analysis.

23ScCheP321: Pharmaceutical analysis (Practical) (2 Credits, 60 L)

Sr. No.	Name of the Experiment
1	Assay of local anesthetic (Lignocaine) by non aqueous titration method.
2	Determination of iron from pharmaceutical preparation by titration with ceric ammonium sulfate.
3	Estimation of glucose from Glucon-D by titration with Fehling solution.
4	Estimation of Vitamin-C by using 2, 6- Dichlorophenol Indophenol method.
5	Preparation, purification and assay of aspirin.
6	Analysis of paracetamol as per IP with respect to identification and assay by titrimetry.
7	Estimation of reducing sugar by dinitrosalicylic acid (DNSA) method by spectrophotometry
8	Estimation of 'Fe' from a given syrup sample by spectrophotometric thiocyanate method.
9	Analysis of ibuprofen as per IP with respect to identification and estimation of percent purity.
10	Estimation of creatinine and cholesterol from a given sample by kit method.
11	Estimation of glucose from given sample by glucose oxidase method and Estimation of urea by kit method by spectrophotometry
12	Estimation of tryptophan by spectrophotometry
13	Estimation of ethanol content of sample by pycnometer.
14	Estimation of Sulfur by Messenger's method.
15	Estimation of protein by Lowry's method.
16	Preparation of Methyl Salicylate (Wintergreen Oil) and assay its purity.
17	Synthesis of nanoparticles and its characterization.
18	Determination of Iron from pharmaceutical preparation by titration with ceric ammonium sulfate.

19	Estimation of Phenolic compounds (Salicylic acid, Salbutamol Sulphate, Phenol) by Folin Ciocalteu reagent
20	Limit test of heavy metals and iron to pharmaceutical preparation

Reference

- 1) Indian Pharmacopoeia Volume I, II and III.

23ScCheP322: Geochemical and Alloy analysis (Theory) (2 Credits, 30L)

Chapter No.	Geochemical & alloy Analysis (2 Credits, 30 L)	
1	Methods for alloy and geochemical analysis Dolomite (For Silicate, Mg and Ca content), Ilmenite (for Silicate, Ti and Fe content), Monazite (for rare earth metals), Hematite and Magnetite (silicate and Fe content), Pyrolusite (for silicate and Mn content) and Bauxite (for Al and Silicate content). (Analytical methods as per Indian Standards)	10 L
2	Analysis of Alloys Stainless Steel (for Fe, Cr, Ni, Co, Cu, Mn, W, Si, V, Mo, Ti, Pb and Zr) Bronze and Gunmetal (Cu, Sn), Brass (Cu, Zn, Sn, Pb), Solder (Pb and Sn), Nichrome (Fe, Ni, Cr), analysis of nickel Silver (Sn, Pb, Cu, Fe, Ni and Zn) and Aluminium based alloys (Al, Mg, etc.). (Analytical methods as per Indian Standards)	10 L
3	Analysis of Soil i) Sampling, ii) Carbonate, Organic carbon, and organic matter, iii) Total nitrogen, ammonia and nitrates, iv) Total determination of major soil constituents by fusion analysis, v) silica and total combined oxides of Iron, Aluminium, and Titanium, vi) Determination Ca, Mg, Na, K, phosphate, boron, Co, Cu, Zn, vii) Exchangeable cations viii) Cation exchange capacity, ix) chemical analysis as a measure of soil fertility. (Analytical methods as per Indian Standards)	10 L

References

- 1) Standard Methods of Chemical Analysis by F. J. Welcher Part A and Part B Sixth Edition
- 2) Quantitative Inorganic Analysis including Elementary Instrumental Analysis, By A. I. Vogel

23ScCheP322: Geochemical and Alloy analysis (Practical) (2 Credits)

Chapter No	Geochemical & alloy Analysis (Practical) (2 Credits)
1	Alloy analysis 1) Magnalium 2) Nichrome
2	Analysis of industrial material 1. Plaster of Paris 2. Talcum powder 3. Pigment (Ti) 4. End group analysis of polymer (acid number /hydroxyl values/ Iodine value)
3	Spectrophotometer 1.Determination of p-nitrophenol from the given mixture 2. Estimation of Cu and Fe 3. Removal of toxic dyes /metals.
4	Analysis of silica and iron from Ilmenite ore.
5	Analysis of cupronickel alloy.
6	Synthesis and characterization of Tris (ethylenediamine) Ni(II) thiosulphate.
7	Synthesis and characterization of CuO nanoparticles
8	Photocatalytic activity of CuO nanoparticles

References:

- 2) Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)

Semester IV

23ScChep411: Analytical Spectroscopy (4 Credits, 60L)

Chapter No.	Section I: Atomic spectroscopic analysis (2 Credits, 30 L)	
1	Atomic Spectroscopy Introduction, Elementary Theory, Sources, Burners, Atomic emission spectra, Atomic absorption spectra, Effect of temperature on emission, absorption and fluorescence, Electrothermal atomizers, Instrumentation for AFS, Radiation sources atomic absorption methods, Instrumentation for AAS, Interferences, Background correction methods: Deuterium arc background correction, Zeeman background correction, The Smith-Hieftje system, Standard addition and internal standard method of analysis, Comparison of atomic absorption and emission methods, Inductively coupled plasma and direct current plasma emission spectroscopy, Cold vapour technique, Determination of these micronutrients from soils, plants and fruits, Applications of AAS, AES and ICPAES, analysis of micronutrients like Mo, B, Cu, Zn essential towards the healthy growth of crops and fruits, Determination of these micronutrients from soils, plants and fruits.	12 L
2	Atomic Mass Spectroscopy Principle, Instrumentation, Ionization methods- Electron bombardment ionization, Arc and spark ionization, Photo-ionization, Thermal ionization, Chemical ionization, Field ionization and field desorption, Laser-induced ionization, Photoelectric ionization, Mass analyzers- Magnetic, Double focusing, Time of flight, Quadrupolar, Ion cyclotron resonance analyzer, Correlation of mass spectra with molecular structure and molecular weight, Using library, Isotopic Abundances, Fragmentation patterns, Quantitative analysis, Applications and Problems. Fourier transform mass spectrometry	09 L
3	Laser Based techniques	09L

	Atomic Fluorescence Spectroscopy (AFS), Introduction, Apparatus for AFS, EMR source for AFS, LASERS, Cells for AFS, Plasmas, Wavelength selection for AFS, Detectors for AFS, Theory of AFS, Analysis with AFS, Interference with AFS, Resonance Ionization Spectroscopy, Laser-enhanced ionization spectroscopy, Principle, Types of transition tunable laser, Classification of medium pumping and controlling mechanism, Instrumentation, Detecting of various gasses, liquid and solids.	
	Section II: Molecular Spectroscopic Techniques (2 Credits, 30L)	
4	Chemiluminescence Introduction, Principle, Types, Measurement of chemiluminescence, Instrumentation, Quantitative chemiluminescence, Gas phase chemiluminescence's analysis, Chemiluminescence titrations, Electro-chemiluminescence.	09 L
5	Fluorescence and phosphorescence Introduction, Fluorescence, Photo luminescent theory, Electron transitions during photoluminescence, Factors affecting photoluminescence, Luminescent apparatus, Optical extractive sources, Wavelength selectors, Detectors and readout devices, Photo luminescent spectra, Photo luminescent analysis, Analysis of non-photoluminating compounds, Determinations of mixtures, Specific examples of analysis using photoluminescence, Numerical Problems	09 L
6	Ultraviolet-Visible Spectroscopy of Polyatomic Species Introduction, Electron Transitions, Chromophores, Instrumentation, Qualitative analysis, Quantitative analysis, Wavelength choice, Solvents, Determination of Non-absorbing substances, Mixture of absorbing species, Derivative Spectrophotometry, Expanded-Scale Spectrophotometry, Difference Spectrophotometry, Titrations, Ligand-Metal Ratio, Equilibrium Constants, Kinetic Measurements, Numerical problems.	12 L

References

- 1) Introduction to instrumental analysis by R. D. Braun, MC. Graw Hill- International edition.

- 2) Analytical spectroscopy by Kamlesh Bansal- First edition.
- 3) Instrumental methods of chemical analysis by Willard, Dean and Merittee- Sixth edition.
- 4) Analytical chemistry principles by John H. Kenedey- Second edition, Saunders college publishing.
- 5) Spectroscopic identification of organic compounds Fifth Ed., Silvestrine, Bassler, Morrill, John Wiley and sons.
- 6) Analytical Chemistry, Ed. by Kellner, Mermet, otto, Valcarcel, Widmer, Second Ed. Wiley – VCH.
- 7) Vogel's Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.
- 8) Electron microscopy in the study of material, P. J Grundy and G. A Jones, Edward Arnold.

23ScCheP412: Industrial Chemicals, Characterization of Functional Polymers and Solid Catalyst (4 Credits, 60L)

Chapter No.	Section I: Fertilizer, Paint, Pigment and Functional Polymers (2 Credits, 30L)	
1	Analysis of fertilizers: Sampling and sample preparation, Nitrogen: Total nitrogen by kjeldahl, method for nitrate - Total nitrogen by reduced iron method, Phosphorous: Total phosphorous available and non available, Total phosphorus by alkalimetric ammonium molybdophosphate method, Water soluble phosphorus citrate insoluble phosphorus. Potassium : Potassium by titrimetric tetraphenylborate method, Flame photometric method, Numericals based on % of N,P and K.	07 L
2	Analysis of Paint and Pigment: Introduction, test on the total coating, Separation of pigment binder and thinner of solvent type coating. Separation of pigment binder and Thinner of latex paints. Identification of the binder. Identification of polymer resins and oils. Identification of plasticizer, Identification and Analysis of pigments. Identification of inorganic pigments. Analysis of white and tinted pigments, outline of general procedure, HCL insoluble, Titanium dioxide, total lead, Acid soluble calcium, antimony oxide, total sulfate, total carbonate.	07 L
3	Introduction to polymers: Brief history to polymers. How polymers are made. Classification of polymers. Types of polymerization reactions.	02 L
4	Analysis and testing of polymers: Chemicals analysis of polymers, X-ray diffraction analysis, Thermal analysis : TGA, DTA, Physical testing of polymers Mechanical Properties: Fatigue testing; Impact testing, Tear resistance, Hardness, Abrasion resistance, Thermal Properties: Softening temperature, Flammability. Optical Properties: Transmittance, Color, Gloss, Haze and transparency. Electrical Properties: Dielectric constant and loss factor, Resistivity, Dielectric strength. Determination of functional groups of polymers. Solubility test	08 L

5	Measurement of molecular weight and size: End group analysis, colligative properties measurements, solution viscosity, Derivations for number average molecular weight (M_n), Weight average molecular weight (M_w), Molecular weights and degree of polymerisation, molecular size, Numericals based on number average molecular weight, weight average molecular weight, functionality, polydispersity index (PDI) etc.	06 L
	Section II: Solid Characterization Techniques (2 Credits, 30L)	
6	Solid State UV-VIS Spectroscopy Introduction, DRS- UV Spectroscopy	04 L
7	Solid State IR Spectroscopy Introduction, DRS- IR Spectroscopy, Py-IR spectral studies, Qualitative acidity measurement Lewis and Brønsted acidity calculations, Applications	06 L
8	Solid State NMR Spectroscopy Basic principles, Structural and chemical information from solid state NMR line shapes, ^{29}Si NMR examples, ^{31}P NMR examples	04 L
9	BET Analysis Adsorption of gases: Chemisorption, Physisorption, Behavior of physisorption isotherms, BET equation and theory, Instrumentation (Schematic), Applications in the measurement of Pore volume, Pore size analysis, Total surface area	06 L
10	Temperature Programmed studies Temperature Programmed Desorption, Temperature Programmed Reduction, Temperature Programmed Oxidation	05 L
11	Powder XRD Studies Basic principles, SAXRD (Small Angle X-Ray diffraction pattern) and WAXRD (Wide Angle X-Ray diffraction pattern), XPS studies and catalyst characterization.	05 L

References

- 1) Solid State Chemistry and its Applications by Anthony West, 2nd edition, John Wiley & Sons, Ltd, 2014
- 2) Solid State Chemistry by Lesley Smart and Elaine Moore, 3rd edition, Taylor and Francis Group, 2005
- 3) Encyclopedia of Materials Characterization by Richard Brundle, Charles K Evans, Jr., and Shaun Wilson, Butterworth-Heinemann of Reed Publishing (USA), 1992.

23ScCheP413: Lab Course on Analytical Chemistry II (4 Credits)

Experiment No.	Name of the Experiment
	PHYSICAL PRACTICALS
1	Potentiometry- 1. Differential Potentiometric titration. 2. Determination of pK values of maleic acid/ malonic acid by Potentiometric titration with sodium hydroxide using glass electrode 3. Determination of commercial vinegar by Potentiometric titration
2	Flame photometry- 1. Determination of K from water sample by flame photometry. Calibration curve method or by standard addition method. 2. Determination of calcium from dairy whitener by Flame photometry.
3	Turbidimetry- 1. Determination of SO_4^{2-} by turbidimetric method using turbidimetric titration. 2. Determination of SO_4^{2-} by turbidimetric method using calibration curve method.
4	Spectrophotometer- 1. Determination of the amount of each copper and bismuth or copper and Iron (III) from the given mixture by spectrophotometric titration using standard EDTA solution. 2. To determine the constant of the ferric thiocyanate complex by Ostwald method spectrophotometrically. 3. Spectrophotometric determination of pH of buffer solution.
5	Spectrofluorometry- 1. To determine concentration of Riboflavin in a given unknown solution fluorometrically by calibration curve method. 2. To determine concentration of Riboflavin in a given unknown solution fluorometrically by standard addition method.

6	Atomic Absorption Spectroscopy- 1. Analysis of metals ions from samples.
7	Polymer Chemistry 1. To determine the Molecular weight of a polymer by end group analysis. 2. To determine the chain linkage in polyvinyl alcohol from viscosity measurement.
8	XRD Interpretation of given XRD spectrum.
9	Pyridine-IR graph plotting and interpretation by origin software
10	Solid-UV data interpretation.
	INORGANIC PRACTICALS
1	Analysis of Cement with respect to Calcium, Magnesium, Aluminium, Iron and Silica
2	Analysis of copper ferrite (CuFe_2O_4) and determine the amount of copper and iron volumetrically.
3	To determine phosphoric acid in cold drink by molybdenum blue method
4	Estimation of Cu and Fe(III) by spectrophotometric titration. (Standardization of EDTA is expected)
5	Determination of anion or Cation exchange capacity of anion or Cation Exchange Resin.
6	Determination of Titanium from Pigment/raw material by spectrophotometry
7	Determination of Calcium from given sample of plaster of Paris
8	To determine unit cell constant or lattice constant (parameter) of crystalline solid by powdered X-ray Diffraction method.
9	To find the g Value from given Spectra (EPR Spectroscopy)
10	Determination of Phosphorus from fertilizer sample by volumetric method
11	Estimation of organic nitrogen by kjeldahl's method or semi micro kjeldahl's method from given sample (Milk powder, Soil sample, fertilizer)

12	Estimation of Borate with curcumin reagent by using spectrophotometrically from talcum powder or given sample
13	Estimation of Cobalt by Spectrophotometrically from given sample
14	SO ₄ ²⁻ by spectrophotometry
15	Estimation of Mn (II) by spectrophotometrically
16	Estimation of NH ₄ ⁺ or NH ₃ by spectrophotometry (Alkaline Phenol Perchlorate reagent)
17	Estimation of NO ₃ ⁻ or NO ₂ ⁻ by spectrophotometry
18	Interpretation of XRD small/Wide angle analysis by origin software
19	TEM Analysis for particle size distribution
20	XPS analysis
21	Visit to waste water treatment plant/ Pharmaceutical Industry/ Forensic Laboratory/ Instrumentation Laboratory and writing a detailed visit report.

References:

- 3) Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)
- 4) Standard methods of chemical analysis by F. J. Welcher
- 5) Environmental Chemistry by A. K. De
- 6) Biochemical Methods, Sadashivam and Manickem, Narosa publication
- 7) Indian Pharmacopoeia volume –I and II
- 8) Experiments in chemistry by D. V. Jahagirdar, Himalaya publication
- 9) Practical Pharmaceutical Chemistry, 4th Ed. part-2, Beckette, Stenlake
- 10) Standard Instrumental Methods of Chemical Analysis, F. J. Welcher

23ScCheP421: Analytical Toxicology and Food analysis (Theory) (2 Credits, 30 L)

Chapter No.	Toxicology and Food Analysis (2 Credits, 30 L)	
1	Narcotics and Psychotropic substances Act. Definitions –addict, cannabis (hemp), Coca derivative, Coca leaf, Manufacture medicinal Cannabis, Narcotic drug, Opium, Opium derivative, Opium poppy, poppy straw, psychotropic substance, Illicit Traffic, Prohibition Control Regulation, Offense and Penalties, Government resolutions related to Narcotic Substances	04 L
2	Toxicology Isolation, identification and determination of following Narcotics - heroin and cocaine Stimulants- caffeine, amphetamines, Mephedrone (MD) Depressants - Barbiturates, Benzodiazepines Hallucinogen – Lysergic acid diethylamide (LSD)	10 L
3	Carbohydrates Definition, classification, and Functions, Analysis of Carbohydrates by Nelson Somogyi Method, Total Carbohydrate by Anthrone Method, Estimation of Starch by Anthrone Method, Determination of Amylose	05 L
4	Proteins and Lipids Proteins - Definitions and functions, Analysis of proteins by Kjeldahl's method, Analysis of protein by Lowry method, Estimation of amino acids by colorimetric method Lipids - Estimation of oil in oilseeds, Estimation of free fatty acids, Determination of Saponification value, Iodine value, Acid value and Peroxide value of oil	05 L
5	Vitamins Classification of vitamins with Example, Each of the following vitamins with respect to functions, Deficiency diseases, daily requirement, and analytical method, Retinol (determination of retinol), Vitamin B ₁ (thiamine	04 L

	determination by fluorometry), Vitamin C (Ascorbic acid) Volumetric method using 2,6 dichlorophenol method.	
6	Determination of food preservatives Definition of food preservatives, Determination of SO ₂ by Tanners Method	02 L

References:

- 1) Practical Biochemistry in clinical Medicine by R. L Nath, 2nd Edition 1990
- 2) Textbook of Forensic pharmacy by B. M. Mithal 9th Edition 1993
- 3) Pearson's chemical analysis of food
- 4) Practical Clinical Biochemistry, Gowenlock, 6th Edition, CBS published
- 5) Practical Pharmaceutical Chemistry by Becket
- 6) Basic Analytical Toxicology By R. J. Flanagan R. A. Braithwaite, S. S.
- 7) Brown, Published by WHO, Available Online
- 8) Biochemical Methods, By S .Sadashivan, A. Manickam Sixth Edition.
- 9) Critical Reviews in food Science and Nutrition 2017, Vol. 57, No. 6, 1174-1189

23ScCheP421: Analytical Toxicology and Food analysis (Practical) (2 Credits)

Experiment No.	Toxicology and Food analysis (Practical) (2 Credits)
1	Estimation of caffeine from a given tea or coffee sample.
2	Estimation of HMF from honey.
3	Determination of total casein or lactose in milk sample (Ref 1)
4	Determination of Saponification value of given oil sample (Ref 2)
5	Determination of iodine value of given oil sample (Ref 2)
6	Isolation of lycopene from tomatoes.
7	Estimation of Tannin from tea sample by Folin -Denis method.
8	Isolation of piperine from black pepper.
9	Estimation of Vitamin A from a given sample.
10	Estimation of thiamine from a given sample by Spectrophotometry.
11	Determination of Amylose from a given sample.
12	To determine quinine sulfate from given sample by fluorometry
13	Estimation of Amino acids using ninhydrin method.
14	Estimation of Amino acids using ninhydrin method.
15	Isolation of eugenol from cloves.
16	Estimation of proline
17	Isolation and Analysis of plant materials: Resin (Ginger sample)
18	Estimation of chlorophylls in leaf pigments

References

- 1) Manual of methods of analysis of foods food safety and standards authority of India Ministry of Health and family Welfare Govt of India New Delhi 2015 Milk and Milk Products: https://old.fassai.gov.in/portals/0/pdf/Draft_manuals/MILK_AND_MILK_PRODUCTS.pdf
- 2) Biochemical Methods, third Edition, By S. Sadasivan, A. Manickam, New Age International Publisher

23ScCheP422: Safety in Chemical Laboratory (Theory) (2 Credits, 30L)

Chapter No	Safety in Chemical Laboratory (2.0 Credit, 30 L)	
1	History and importance of safety and health in Laboratory Importance of Safety and security, responsibility and accounting for safety, types of hazards and risk in chemical laboratory, Moral legal and financial reasons. Introduction to different types of Hazards	05 L
2	Establishing Effective chemical safety and security management Introduction, responsibility of laboratory safety and security, ten step to creating an effective laboratory chemical safety and security management safety	03 L
3	Personnel protective and other safety equipments Personnel clothing, foot protection, eye and face protection, safety shield, fire safety equipments, heat and smoke detector, respirators, safety showers, eye wash unit	05 L
4	Assessing routes of exposure for toxic chemicals Inhalation, contact with skin and eye, ingestion, assessing risk with acute toxicology, specific chemical hazard, First aid for contact of different chemicals on skin, eyes, and inhalation ingestion	05 L
5	Assessing hazards and risk in the laboratory Introduction, consulting source of information, evaluating the toxic risk of laboratory chemicals, assessing flammable, reactive and explosive hazards, Assessing physical hazards, assessing bio hazards	07 L
6	Managing Chemicals Introduction, green chemistry for every laboratory, purchasing chemicals, inventory and tracking of chemicals, storage of chemicals, transfer, transport, shipment of chemicals	05 L

References:

- 1) Chemical Laboratory Safety and Security, A Guide Prudent Chemical Management Edited by Lisa Moran and Tina Masciangioli Available Online www.nap.edu

2) Hand Book, Good Laboratory Practice (GLP) Available Online

23ScCheP422: Safety in Chemical Laboratory (Practical) (2 Credits)

Experiment No.	Safety in Chemical Laboratory (Practical) (2 Credits)
1	Synthesis of sulfanilamide from acetanilide and assay its purity by titrimetry.
2	Determination of Monosodium Glutamate in food by potentiometric titration.
3	Analysis of Nichrome alloy with respect to Nickel and Chromium.
4	Limit Tests: i) Iron from CaCO_3 ii) Sulphate and Chloride from Paracetamol, Dextrose or any pharmaceutical preparation
5	Synthesis and characterization of Tris acetylacetonato manganese
6	Synthesis and characterization OF Potassium tris oxalato chromate
7	Determination of iron by solvent extraction techniques using 8- hydroxyquinoline reagent.
8	Separation of mixture of Zn(II) and Mg(II) using Amberlite IRA 400 anion exchanger and quantitative estimation of separated ions Zn(II) and Mg(II) .
9	Estimation of phosphate from wastewater by calibration curve method.
10	Amperometric titration of Pb(II) with potassium dichromate solution.
11	Pharmacokinetic study of drug action
12	Estimation of amines using bromate bromide solution
13	Estimation of phenols using bromate bromide solution
14	Estimation of sucrose (cane sugar) using Fehling solution
15	Estimation of amino acid by Formol titration