

VEERNARMADSOUTH GUJARAT UNIVERSITY
M.Sc. SEMESTER-III (ANALYTICAL CHEMISTRY)
SYLLABUS TO BE EFFECTIVE FROM JUNE-2019
PRACTICAL SYLLABUS

1	Major Exercise	4- Credit
2	Viva-Voce	
3	Minor Exercise	4- Credit
4	Minor Exercise	

Major Exercise:

1. Analysis of Dolomite ore for the major constitute.
2. Analysis of Ultramarine sample for the major constitute.
3. Analysis of Portland cement for the major constitute.
4. Analysis of Zn-Chrome pigment for the major constitute.
5. Analysis of white pigment for the major constitute.
6. Potentiometric determination of Chloride, Bromide and Iodide in a mixture.
7. Analysis of Ilmenite ore for the major constitute.
8. Analysis of Haematite ore for the major constitute.
9. Analysis of Pyrolusite ore for the major constitute.
10. Separation and determination of total pigment in a paint sample.

Minor Exercise:

1. Determination of fluoride in a given solution / tooth paste by Zirconyl-Alizarin red method colorimetrically
2. Analysis of organic materials: Glycerol, Glycine.
3. Determination of Pb^{+2} as $PbCrO_4$ after precipitation from homogeneous solution.
4. Analysis of Chloride in bleaching material.
5. Determination of COD of water sample.
6. Determination of DO of water sample.
7. Determination of Ka_1 and Ka_2 of phosphoric acid.
8. Simultaneous determination of Cr^{+3} + Co^{+2} in a mixture.
9. Determination of Nitrite spectrophotometrically.
10. Biuret in the sample of urea
11. Thin layer chromatographic separation.
12. Interpretation of IR, NMR, Mass Spectra (Dry lab)
13. Constant current Coulometric titration of (i) As_2O_3 (ii) Phenol (iii) $Na_2S_2O_3$
14. Analysis of dye intermediate containing $-NH_2$ by Potentiometric titration.
15. Electrogravimetric determination of Cu^{+2} in brass.

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1	Major Exercise	4- Credit
2	Viva-Voce	
3	Minor Exercise	4- Credit
4	Minor Exercise	

Major Exercise:

1. Analysis of brass alloys for Copper, Zinc and Iron Content.
2. Analysis of German silver for Copper, Nickel and Zinc Content.
3. Analysis of stainless steel for simultaneously determination of Chromium and manganese.
4. Ion exchange separation of ($\text{Fe}^{+3} + \text{Co}^{+2}$) and determination of Fe^{+3} colorimetric.
5. Determination of total salt content by ion exchange chromatography.
6. Ion exchange separation of (Zn^{+2} and Mg^{+2}) and determination of Zn^{+2} by EDTA titration.
7. Determination of pK_{In} of Methyl red indicator.
8. Determination of pK_{In} of Bromo Phenol Blue Indicator.

Minor Exercise:

1. Analysis of Drugs (any three):
 - (A) Sulpha drugs by non-aqueous titration and argentometric titration.
 - (B) Analysis of Penicilin
 - (C) Iron formulation for iron content.
 - (D) Aspirin tablet
 - (E) Analysis of APC tablets for its aspirin and phenacetin content using UV spectrophotometry.
2. Analysis of Insecticides: Analysis of BHC.
3. Determination of Protein content of wheat flour by Kjeldahl Method.
4. Analysis of Detergent sample for PO_4 and other constituents.
5. Analysis of fertilizers by determination of nitrogen content.
6. Analysis of fruit juice for Vitamin-C.
7. Determination of saponification value of Oil and fat.
8. Spectroscopic determination of Ni^{+2} with D.M.G.
9. Conductometric determination of vanillin in Vanilla.
10. Photometric titration of ($\text{Cu}^{+2} + \text{Ca}^{+2}$) in a mixture
11. Determination of Metal: Ligand ratio in complex.
12. Flame photometric determination of Na^+ and K^+ .
13. Colorimetric estimation of titanium in the given solution by hydrogen peroxide.
14. Estimation of amino acids by colorimetry.
15. TLC separation.

Note:

- Practical examination will be for **2 days in each semester.**
- **6 hours'** duration on each day.
- 1-week industrial Training in 4th semester.

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M.Sc. SEMESTER-III (ANALYTICAL CHEMISTRY)

SYLLABUS TO BE EFFECTIVE FROM JUNE-2019

PAPER-I (AC-301)

Periods: 45

Max. Marks: 70

(ANALYTICAL METHODS OF ANALYSIS)

UNIT-I THERMAL METHODS OF ANALYSIS (11 Periods)

Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Instrument, Reference materials, Diluents, Factors affecting DTA results, Applications, Evolved gas detection and analysis, Instrumentation, application, hypernation with other techniques, Direct Injection Enthalpimetry, Applications, Numerical.

UNIT-II ELECTRICAL METHODS OF ANALYSIS (11 periods)

Liquid Junction Potential, Mass transfer, Electric Double layer, Faradic and Non-faradic Current, Polarization effect, Types of Polarization, Electrogravimetry, Constant Potential and current Electrolysis, Factors affecting the quality of deposits, Applications. Principle of Coulometry, Controlled current coulometry, Instrumentation and application of Controlled potential coulometry, Coulometric titrations (primary and secondary), endpoint detection in coulometry titration, applications and Problems

UNIT-III VOLTAMETRY METHODS OF ANALYSIS (12 Periods)

Rapid Scan Voltammetry: Principle, Rapid voltage scan at the end of the drop life, Peak current equation, Relation of peak current with the scanning rates, Summit potential equation, Comparison with DC polarography, Limitations.

Hydrodynamic Voltammetry: Principle and similarity with dc polarography, Types of electrodes used, Applications of the technique in determination of rate constant of the reaction.

Anodic Stripping Voltammetry: Concentration and stripping steps, Importance of Hanging mercury drop electrode and MTFE, Sensitivity of the technique, Adsorptive stripping, Applications, Cathodic stripping.

Cyclic Voltammetry: Principle, Forward and reverse scan, cyclic voltamogram, Detection limits, Applications.

UNIT-IV RADIO-CHEMICAL METHODS OF ANALYSIS (11 periods)

Interaction of radiation with matter, Units of radioactivity, Statistic of counting, Background corrections, Neutron activation analysis, Sources of neutrons, Theory of instrumental neutron activation analysis, Experimental considerations, Isotope dilution analysis (Direct and Inverse), Radioimmuno assay, Radiometric titrations, Radio release methods, Radiation safety, Numericals

Reference Books: on last page

VEERNARMADSOUTHGUJARAT UNIVERSITY
M.Sc. SEMESTER-IV (ANALYTICAL CHEMISTRY)
SYLLABUS TO BE EFFECTIVE FROM JUNE-2019

PAPER-I (AC-401)

Periods: 45

Max. Marks: 70

SEMESTER-IV
(ADVANCED ANALYTICAL TECHNIQUES)

UNIT-I ELECTRON SPECTROSCOPY AND MICROSCOPY (12 Periods)

Introduction, Types of surface measurements, General techniques in surface spectroscopy, Sampling surfaces, Surface contamination, X-ray Photo electron spectroscopy- Principle instrumentation and Application. Auger electron Spectroscopy-Principles, Instrumentation, application. Ion, laser and electron microprobe spectrometry, Application, Electron Microscope, SEM, STM and AFM, Numerical

UNIT-II ADVANCED CHROMATOGRAPHY AND EXTRACTION (11 periods)

Supercritical Fluid Chromatography (SFC): Properties of supercritical fluid, Instrumentation and operating variables like effect of pressure, stationary phase, mobile phase, detectors, comparison with other chromatography, application.

Super Critical fluid extraction: Introduction, Advantages, Instrumentation, Choice of SFC, Offline and Online Extraction, Application, Numerical.

UNIT-III ELECTROPHORESIS AND ELECTRO CHROMATOGRAPHY (11 Periods)

Definition, types, Free solution electrophoresis, Moving boundar electrophoresis, Zone electrophoresis, paper electrophoresis, types of stabilizing medium, location of components, electrode, source of current, requirement of electrophoretic chamber, Immunoelectrophoresis Continuous (Curtain) flow electrophoresis, Gel electrophoresis. Capillary Electrophoresis, Column, Electro Chromatography, Field Flow Fraction (FFF), Micellar electrokinetic capillary Chromatography, Application.

UNIT-IV HYPHENATED TECHNIQUES AND AUTO ANALYSER (11 periods)

MS-FTIR, ICP-MS, GC- MS, LC-MS, MS-MS, Tandem Mass Spectra, GC-FTIR. TG- FTIR, TG-MS. Auto analyser: Need for auto analyser, Instrument used in clinical laboratory, Flow Injection Analysis, Micro Fluid Disk, Discreet Automatic System, Oxygen Analyser.

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PAPER-II (AC-302)

Periods: 45

Max. Marks: 70

(MOLECULAR SPECTROSCOPY)

UNIT-I IR AND RAMAN SPECTROSCOPY (11 periods)

Theory of IR and Raman, selection rules, IR absorption, Raman scattering, Mutual exclusion rule, complimentary techniques, Instrumentation - FTIR and Raman, Cells and sampling techniques, Resonance Raman spectroscopy, Interpretation of IR spectra using correlation charts, Advantages of FTIR spectroscopy, Mid-IR Reflection – DRS, ATR, Data processing in Near IR, Applications in structure elucidation of inorganic and organic molecules.

UNIT-II NMR SPECTROSCOPY (12 periods)

Theory of NMR, Relaxation, population of energy levels, Larmor precession, chemical shift and factors affecting it, references and solvents, Spin-spin splitting, Coupling constant, Magnetic Anisotropy, Instrumentation, Shift Reagents, Interpretation of simple NMR spectra, Signal averaging, FT-NMR, Pulse FT-NMR spectroscopy, ¹³C NMR spectra, Calculation of chemical shift in ¹³C NMR, NMR in medical diagnostics, Double resonance technique, Multi-dimensional NMR, Problems to elucidate structure from NMR spectra.

UNIT-III MOLECULAR MASS SPECTROSCOPY (11 Periods)

Instrumentation, Methods of ion production (EI, CI, FI, FD, Electro Spray, MALDI), Ion separators, Ion collection and recording, Double focusing, Time of flight analyser, Quadruple-mass spectrometer, Sample handling techniques, Resolution, Parent peak, Base peak, Metastable ions isotope effect, Molecular formula from mass spectra, Nitrogen rule, Ring rule, Fragmentation rules, Behavior of classes of compounds, Interpretation of mass spectra, Additional applications, Problems to elucidate structure from mass spectral data.

UNIT-IV MOLECULAR LUMINESCENCE SPECTROSCOPY (11 periods)

Introduction to molecular luminescence (fluorescence, phosphorescence and chemiluminescence); theory of luminescence, energy level diagram, Deactivation process,; instruments for measuring fluorescence (fluorometer and spectrofluorometer);, factor affecting, Emission and excitation spectra, wavelength selector, detector, application and problems.

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VEERNARMADSOUTHGUJARAT UNIVERSITY
M.Sc. SEMESTER-IV (ANALYTICAL CHEMISTRY)
SYLLABUS TO BE EFFECTIVE FROM JUNE-2019

PAPER-II (AC-402)

Periods: 45

Max. Marks: 70

(ATOMIC SPECTROSCOPY)

UNIT-I ATOMIC X-RAY SPECTROSCOPY (11 periods)

Emission of X-ray, continuum and line spectra, X-ray absorption, absorption spectra, Apparatus, Source (monochromatic X-ray), Sample handling, Wavelength and energy dispersive device, Detector, Chemical analysis by X-ray absorption, X-ray fluorescence: Theory, instrumentation and applications, X-ray diffraction: Theory, instrumentation and applications.

UNIT-II ATOMIC ABSORPTION AND FLAME EMISSION SPECTROSCOPY (12 periods)

(a) Atomic Absorption Spectroscopy (AAS)

Principle of AAS, Instrument, Continuous sources and line sources, Flames, Flame atomizers, Non flame atomizers (furnaces), Monochromator and Detector, Interference with AAS Quantitative Analysis with AAS, Applications, Numerical.

(b) Flame Emission Spectroscopy (FES)

Flame as a source of atomic vapour, Flame atomization, Flame photometer, Applications and limitations comparison with AAS

UNIT-III ELECTRON SPIN RESONANCE SPECTROSCOPY (11 Periods)

Introduction, Factors affecting the g-value, Limitations of ESR, Difference between ESR and NMR, Instrumentation, Electron nucleus coupling, Hyperfine interactions-isotropic and anisotropic coupling constants, The spin Hamiltonian, Quantitative analysis, Sensitivity, Choice of solvent, applications of ESR, Study of free radicals, Electronic and Hyperfine splitting, Triplet states- zero field splitting and Kramer's degeneracy, Analytical applications of ESR, Structural determination by ESR, Study of inorganic compounds by ESR, Transition elements, Biological systems

UNIT-IV ATOMIC EMISSION AND FLUORESCENCE SPECTROSCOPY (11 periods)

Atomic Emission Spectroscopy:

Emission spectroscopy with plasma sources, Instrument, AES with electrical discharge, Electrodes of AES, DC- arc, spark, Laser microprobe, Salient features of the emission spectrograph, Qualitative and Quantitative analysis applications,

Fluorescence Spectroscopy: Atomic fluorescence, 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.

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VEERNARMADSOUTH GUJARAT UNIVERSITY
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PAPER-III (AC-303)

Periods: 45

Max. Marks: 70

(ELECTRO ANALYTICAL TECHNIQUES)

UNIT-I POTENTIOMETRIC TITRATION AND CHRONOPOTENTIOMETRY (11 periods)

(a) Fundamentals of potentiometry, Instrumentation, electrode system, accuracy of direct potentiometric measurements and its limitations, potentiometric titrations, neutralization titrations, end-point detection, oxidation-reduction, precipitation titrations, complexometry titrations with example, applications and advantages.

(b) Chronopotentiometry

Principle, Instrumentation and procedure, applications.

UNIT-II DC-POLAROGRAPHY (11 periods)

Theory and Applications of Polarography, Types of currents: Residual Current, Migration Current and Diffusion Current, Nature of the Limiting Current: 1) Kinetic currents, 2) Catalytic currents and 3) Adsorption currents, Electro capillary maxima, Maxima of first kind and second kind, Maxima suppressors, DME as electrode, Wave equation, Ilkovic equation (derivation), Reversible electrode reactions at DME half wave potential, Interference and removal of oxygen, Reversible Electrode Reactions of Metal Complexes at D.M.E (Ligand method) Determination of stability constants of complexes. Amperometric titrations: Principle, DME & RPE, curves, Biamperometric titration.

UNIT-III MODERN POLAROGRAPHIC METHODS (12 periods)

A.C. Polarography: Principle of Sinusoidal alternating applied potential, AC peak polarogram, Peak current equation, Characteristic of AC polarographic peak, Importance of signal to noise ratio for the sensitivity, Comparison with DC polarography.

Square-wave Polarography: Principle of alternating rectangular wave voltage applied, Frequency of square wave applied, Problems of large condenser currents in A.C., Peak polarogram, Peak current equation, Limitations of techniques.

Pulse Polarography: Effect of capillary response with frequency of applied square wave potential, Principles and difference between Normal Pulse Polarography and Differential Pulse Polarography, Importance of charging and Faradaic currents.

UNIT-IV ION SELECTIVE ELECTRODES (11 Periods)

Classification of ion selective electrodes, Solid state electrodes – Glass electrode effect of glass structure on selectivity function of the glass electrode. Acid error, Alkali error, Silver halide, Sulphide, Lanthanum fluoride ion selective electrodes. Liquid ion exchange electrode – Calcium selective ion electrodes. Gas electrodes, ammonia, sulphur dioxide, oxygen and CO₂ sensing electrode, Micro ion selective electrode, enzyme electrodes. Application and Numericals

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PAPER-III (AC-403)

Periods: 45

Max. Marks: 70

(SEPERATION TECHNIQUES)

UNIT-I SOLVENT EXTRACTION

(11 periods)

Principal of solvent extraction, Nernst distribution law, Distribution coefficient, Equations for the solute dissociating or associating in one phase, limitations of distribution law, Application : partition chromatography, Distribution ratio, selectivity ratio, Successive extractions, Extraction of metal ion with chelating agent with necessary equation, Extraction involving association of ion pairs, extraction by solvation, types of Multiple extractions, multiple extraction with successive portion, basic concept, Apparatus and bi nominal distribution for Craig pseudo/ continuous counter current extractions. True counter current extraction: Fractional distillation, Use of crown ethers and Cryptans for extraction, extraction equilibria with crown ethers, factors affection extraction with crown ether, numerical of distribution coefficient and multiple extraction.

UNIT-II THEORY OF CHROMATOGRAPHY

(11 periods)

Methods of elution, Ideal and non-ideal chromatography, Plate theory, Rate theory, Reasons for broadening of lands, Van Deemter equation and significance of terms involved, Optimum velocity, Resolution, Methods to improve resolution, GLC, Supports for liquid stationary phases, Selection of columns, FSOT, Selective Detectors- FPB, TID, Temperature programming in GC, Derivatisation in GC, Qualitative analysis from retention parameters, Quantitative analysis, Headspace Analysis, Thermal Desorption.

UNIT-III LIQUID CHROMATOGRAPHY

(12 periods)

(a) Ion-exchange Chromatography:

Resins used, Principle of exchange, Factors affecting the exchange, Capacity of resin and its determination, Techniques, IEC with eluent suppressor columns, Applications.

(b) Gel-permeation Chromatography:

Principle, Types of gels, Theoretical principles, Techniques and applications.

(c) Adsorption Chromatography:

Principle, column packings, adsorbents, mobile phase, technique of separation, detectors, identification of compounds, applications, Chiral Chromatography.

(d) Affinity Chromatography:

Introduction, classification, column matrices, affinity ligands, elution methods, applications.

UNIT-IV SOLID PHASE EXTRACTION AND MICRO EXTRACTION

(11 Periods)

(a) Solid Phase extraction (SPE): Introduction, Types of SPE media, SPE formats and apparatus, method for SPE operation, solvent selection, factors affecting SPE, selected methods of analysis for SPE, Automation and On-Line SPE

(b) Solid phase micro-extraction (SPME): Introduction, theoretical considerations, experimental, Methods of analysis: PMEGC, Methods of analysis: SPME-HPLC-MS, Automation of SPME, New development in micro extraction (liquid micro extraction, membrane micro extraction).

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PAPER-IV (AC-304)
(APPLIED ANALYSIS)

Periods: 45

Max. Marks: 70

UNIT-I ANALYSIS OF ORES AND CEMENT (11 periods)

Ores: Dolomite (For silicate, Mg and Ca content), Ilmenite (for silicate, Ti and Fe content), Monazite (Ce and Th metals), Hematite and Magnetite (silicate and Fe content), Pyrolusite (for silicate and Mn content) and bauxite (for Al and Silicate content).

Cement: Composition of cement and characterization, setting and hardening of cement, Analysis of cement for silica, calcium, magnesium, iron, sodium and potassium using ISI method.

UNIT-II ANALYSIS OF AIR AND SOIL (12 periods)

Air: Sampling, Analysis of air borne particulates using emission spectroscopy, Determination of CO, SO₂, CO₂, NO_x, H₂S, O₃ in air sample. Non-dispersive IR spectrophotometry to determine CO and CO₂.

Analysis of Soil: Moisture, pH, Total nitrogen, phosphorous, silica, lime, magnesia, sulfur, manganese.

UNIT-III CLINICAL CHEMISTRY AND FOOD PRODUCT ANALYSIS (11 Periods)

Clinical Chemistry: Determination of glucose, electrolytes, urea, cholesterol, uric acid in blood serum.

Food Products: Analysis of (i) Oils and fats, Iodine value, Saponification value, RM value, (ii) reducing and non-reducing sugars (iii) butter, honey, fruit, juices, non-alcoholic beverages, (iv) adulteration in oil, ghee, butter.

UNIT-IV ANALYSIS OF PAINTS AND PIGMENT (11 periods)

Introduction, test of Volatile and Non-volatile content, separation of pigment binder, Analysis of pigments, Identification of inorganic pigments, Analysis of white and tinted pigments, HCL insoluble, Titanium dioxide, total lead, acid soluble Al and Fe, acid soluble calcium, total zinc, antimony oxide, total sulfate, total carbonate) analysis of ultramarine blue, Black pigments, Red Lead pigments.

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Max. Marks: 70

PAPER-IV (AC-404)
(APPLIED ANALYSIS)

Periods: 45

UNIT-I ANALYSIS OF SOAPS, DETERGENTS AND ALLOYS (11 periods)

Soaps and Detergents: Classification of detergents, Action of detergents, Determination of alcohol soluble materials, moisture, active constituents, silicates, phosphates, borates etc.

Alloys: Analysis of brass, German silver, stainless steel. Bronze, Ferromanganese, Alloys of Al, Mg and Ti (Emphasis should be given on major constituent and instrumental methods such as AAS, molecular spectrophotometry, fluorescence, emission, spectroscopy for analysis of trace elements).

UNIT-II ANALYSIS OF PESTICIDE AND FERTILIZER (12 periods)

Pesticides: Analysis of Benzene hexachloride, Analysis of DDT in mixture by colorimetric methods, Determination of Dieldrin in formulation by partition chromatography, Total phosphorous in phosphorous containing pesticides, Determination of traces of pesticides using GC and HPLC, Determination of Aldrin using IR spectrophotometry.

Fertilizer: Sampling and sample preparation, water, total nitrogen by Kjeldahl method, total nitrogen by reduced iron method, Urea nitrogen by urease methods, Total phosphorous by differential spectroscopic methods, water soluble phosphorous, Potassium: potassium by flame photometric methods, Acid-base forming quantity of Fertilizer.

UNIT-III ANALYSIS OF DRUG PRODUCT (11 Periods)

Analytical methods for the following- Tablets, different types of tablets, uniformity in weight (aspirin) additives used in tablet manufacture, capsules, types of capsules, Identification, assay and Test: Rifampicin capsule, Sodium benzoate Powders, Sodium Chloride Injection, barium sulphate Suspensions, Mouthwashes (Ointments (salicylic acid) and creams Dimethicone by IR) Mannitol Injections, Sulphacetamide Eye Drops, Salbutamol Inhalation, Penicillin, Problems based on assay of these materials.

UNIT-IV ANALYSIS OF VITAMINS (11 periods)

Carr-price method of Vitamin A, Spectroscopic method for Vitamin D, Determination of total assay Vitamin E, Stability study of Vitamin K₃, Determination of Vitamin B₁, Determination of Assay of Vitamin B₂ by fluorometric method, Determination of Nicotinic Acid by cyanogen bromide method, Determination of Nicotinamide by cyanogen bromide method, Determination of Pyridoxine by Non-aqueous titration method, Spectroscopic determination of Vitamin B₁₂, Folic Acid by colorimetric method, Ascorbic Acid by iodate titration method.

Reference Books: on the last page

REFERENCE BOOKS:

1. Vogel's Text book Quantitative Chemical Analysis 5th edition by G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney.
2. Principles of Instrumental Analysis: D.A. Skoog, Holler and Crouch (Cengage learning, 7th edition)
3. Principle of Activation Analysis- P. Kruger, John Wiley and sons, (1971).
4. Nuclear Analytical Chemistry – J. Tolgyessy and S. Verga vol. 2, university Park press,(1972)
5. Radiochemistry and Nuclear methods – W.D. Ehmann and D.E. Vance, John Wiley and Sons.
6. Indian Pharmacopeia Volume I and II.
7. Extraction technique in analytical science, John R. Dean, Wiley (2009)
8. Standard methods of chemical analysis, Sixth Edition, F.J. Welcher.
9. Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Vogel, 3^{ed}, ELBS, 1964.
10. Instrumental Analysis: G. D. Caristian and J. E. O'Reilly (Allyn & Bacon Inc., New York, 2nd edition.
11. Instrumental Methods of Chemical Analysis: G. W. Ewing (McGraw-Hill, New York), 5th edition.
12. Instrumental Methods of Analysis: H. R. Willard, L. L. Merrit, J. A. Dean, F. A. Settle (Van Nostrand Reinhold Co., New York), 6th edition.
13. Modern Methods of Chemical Analysis: Pecsok, Shield & Cairns (John Wiley), 2nd edition.
14. Introduction to Instrumental Analysis (1987), R. D. Braun (McGraw-Hill Book Company), New Delhi.
15. Analytical Chemistry: Principles and Techniques: Larry G. Hargis (Prentice-Hall International edition).
16. Introduction to Modern Liquid Chromatography: L. R. Snyder & J. J. Kirkland (John Wiley & Sons, New York).
17. Treatise on Analytical Chemistry: I. M. Kolthoff & P. J. Elving (John Wiley & Sons, New York).
18. Handbook of Analytical Chemistry: L. Meites (McGraw-Hill, New York).
19. Basic concepts of Analytical Chemistry by S.M. Khopker
20. Standard Methods of Chemical Analysis: Vol. I & II (6th edition), D. Van Nostrand Co. Inc. (London).
21. Official Methods of Analysis: Published by Association of Official Analytical Chemists, Washington.
22. Instrumental Methods of Chemical Analysis: B. K. Sharma (Goel Publishing House, Meerut).
23. Instrumental methods of Chemical Analysis by H. Kaur.
24. Environmental Chemistry: B. R. Sharma, H. Kaur (Goel Publishing House, Meerut).
25. Inorganic Quantitative Analysis: A. I. Vogel (Orient Longman).
26. "Polarography", J. D. Talati (In Gujarati), University Granth Nirman Board.
27. "Polarography": Kolthoff I. M. and Lingane J. J. (Vol. I & II) (Interscience Publishers, New York).
28. "Polarographic Techniques": L. Meites (Interscience Publishers, New York).
29. Principles of Instrumental Analysis (5th ed.) by Skoog, Holler and Nieman (Saunders College Publishings).
30. Undergraduate Instrumental Analysis (5th ed.), J. W. Robinson (Marcel Dekker Inc.).
31. Fundamentals of Molecular Spectroscopy, by Banwell.
32. Electronic Absorption Spectroscopy and related techniques, D.N. Sathyanarayan, (New Age International ND. 1996) Uni. Press, Hyderabad.
33. Introduction to Spectroscopy (3rd ed.) by Pavia Lampman Kriz, Cengage Learning Harcourt College Publishers.