

**UNIVERSITY OF MADRAS**  
**SCHOOL OF CHEMICAL SCIENCES**  
**DEPARTMENT OF ANALYTICAL CHEMISTRY**

<b>COARSE CODE &amp; TITLE</b>	<b>CORE/ ELECTIVE/ SUPPORTIVE</b>	<b>CREDIT</b>
<b>SEMESTER – I</b>		
CHE C001-Fundamentals of Analytical Chemistry	C	3
CHE E001-Electronics and Computers for Chemists	E	3
<b>SEMESTER - II</b>		
CHE C002-Analytical Instrumentation	C	3
CHE C003-Analytical Chemistry Practical-I	C	3
CHE E002-Analysis of Complex Materials	E	3
<b>SEMESTER – III</b>		
CHE C004-Practical - Analysis of Complex Materials and Separation Techniques	C	3
CHE C005-Practical - Instrumental methods	C	3
CHE C601- Physical methods in chemistry	C	4
CHE E003-Classical and Radioanalytical Methods of Analysis	E	3
CHE E601- Biological chemistry	E	3
<b>SEMESTER – IV</b>		
CHE C006 -Optical and Surface Analytical Techniques	C	4
CHE C007 -Separation Techniques	C	4
CHE C008 -Project	C	6
CHE E004 - Electroanalytical Chemistry	E	3
CHE E005 –Introduction to Chromatographic Techniques	E	3

## FIRST SEMESTER

### CORE PAPER

#### CHE C001 - FUNDAMENTALS OF ANALYTICAL CHEMISTRY

##### Unit I

###### **Treatment of Analytical Data and Sampling:**

Nature of quantitative measurements and treatment of data. Basic statistical concepts – Errors-random and systematic, mean, median, precision and accuracy, significant figures, Gaussian distribution curves, Null Hypothesis, Confidence interval of mean, Rejection of data (Q test), Student's t, F tests. Regression and correlation. Quality control and control chart.

Principles of sampling methods for solid, liquids and gases. Gross sampling, Sampler's responsibility and pitfalls, hazards of sampling.

##### Unit II

**Chemical Equilibria** - Activity concept, equilibrium constant and applications, ionisation constants of acids and bases. Concept of pH, hydrolysis of salts, hydrolysis constant and degree of hydrolysis, Buffers – types, range and capacity, dissociation of polyprotic acids, common ion effect, salt effect.

**Neutralization reactions** – Theory of acid-base titrations, theory and choice of indicators, mono and polyprotic systems, titration curves and feasibility of reactions, calculation of pH during titrations.

##### Unit III

**Redox titration** – Redox potentials, theory and feasibility of redox titration, calculation of potentials at different stages of titrations, redox indicators, their choice and applications.

**Precipitation titrations** – Theory and types, Mohr, Volhard and Fajan's methods. Adsorption indicators – theory, choice and applications.

**Complexometric titrations** – Theory, Stepwise and overall formation constants, Titrations involving chelates (EDTA). Metallochromic indicators – Theory and Choice. Masking and demasking and extractive methods. Direct, indirect (including substitution) titration and applications.

**Text Books:**

1. Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing, VI Edition, 1991, and VII Edition, 1996.
2. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
4. Analytical Chemistry – Gary D. Christian, John Wiley & Sons, INC, V Edition, 2001.
5. Statistics for Analytical Chemistry – J.C. Miller and J.N. Miller, Ellis Harwood, Chichester, 1984.

**Reference Books:**

1. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
2. Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975.
3. Analytical Chemistry- An Introduction – Skoog, West & Holler, Saunders College Publishing, VI Edition, 1994.
4. Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
5. Statistics for Analytical Chemists – R. Caulcutt and R. Boddy, Chapman and Hall Publications, London, 1982.

## ELECTIVE PAPER

### CHE E001 - ELECTRONICS AND COMPUTERS FOR CHEMISTS

#### Unit I

**Basic electronics** – Resistors, capacitors, transistors, operational amplifiers, integrated circuits, integrators, differentiators, rectifiers and battery eliminators, signal to noise ratio, optimization and limit of detection.

#### Unit II

**Computers in chemistry** - Basic structure of a computer – input / output devices, memory and storage systems, central processing unit, peripherals, computer codes and arithmetic, binary number systems – floating point representation, floating point arithmetic, computational errors.

Principles and techniques of programming, High and low level languages, flow charts, operating systems, essentials of BASIC.

#### Unit III

**Chemistry programs in BASIC** – pH calculations – monobasic and polybasic acid systems, buffers, equilibrium constants, solubility products, spectrophotometric analysis of mixtures (Seidal method), standard deviation, F and t tests, regression analysis, half-wave potential calculations.

**Text Books:**

1. Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
2. Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Electronic Principle – A.P. Malvino, PMH Publishers, III Edition, 1984.
4. BASIC Programming for Chemists – Peter C. Jurs, T.L. Isenhour and C.L. Wilkins, John Wiley and Sons, 1987.
5. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.

**Reference Books:**

1. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.
2. BASIC Programming – B.J. Holmes, Galgotia Book source Pub., 1983.
3. Programming for BASIC – M. Subramanian, A.H. Wheeler and Co. Pvt, Ltd., II Edition, 1987.
4. Programming and Computing with Fortran IV - K. P. Sharma, Affiliated East-West Press, Pvt. Ltd., 1976.
5. Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing, V Edition, 2000.

## SECOND SEMESTER

### CORE PAPER

### CHE C002 - ANALYTICAL INSTRUMENTATION

#### Unit I

##### **Absorption and Molecular Spectrometry:**

Beer-Lambert's law, Filter photometry, UV-visible Spectrophotometry – Photometric titrations, Reaction rates, Complex studies.

Fluorimetry – Principles of fluorescence, Instrumentation and Applications.

Turbidimetry and Nephelometry – Theory, Instrumentation and Applications.

#### Unit II

**Flame Photometry** – Theory, Instrumentation and a few important applications.

**Emission Techniques** – Theory, techniques of excitation, electrodes and their shapes, flame and plasma emission spectrometry – instrumentation and application.

**Atomic Absorption Spectrometry** – Theory, instrumentation (flame and flameless atomization) and applications.

#### Unit III

##### **Chromatographic Techniques:**

**Classical forms of chromatography** – Introduction, principle and applications of thin layer chromatography and paper chromatography.

**Modern chromatographic techniques** – Principle and applications of Gas chromatography and High performance liquid chromatography.

**Text Books:**

1. Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
2. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
4. Principles of Instrumental Analysis – Skoog and Leary, Saunders College Publ. IV Edition, 1992.
5. Analytical Chemistry – Gary D. Christian, Wiley, New York, V Edition, 2001.
6. Handbook of Instrumental Techniques for Analytical chemistry – F. Settle, Prentice Hall inc, 1997

**Reference Books:**

1. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle , CBS Publ. & Distributors, VI Edition, 1986.
2. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
3. Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975.
4. Analytical Chemistry Principles – J.H. Kennedy, Saunders College Publishing, New York, II Edition, 1990.
5. Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
6. Quantitative Chemical Analysis – D.C. Harris, W.H. Freeman Publication, IV Edition, 1995.

## **CORE PAPER**

### **CHE C003- ANALYTICAL CHEMISTRY- PRACTICAL-I**

#### **Spectrophotometry:**

1. Determination of Iron /Cobalt.
2. Determination of dissociation constant of an indicator.
3. Determination of Binary mixtures.
4. Determination of Mn in steel.

#### **Gas Chromatography:**

1. Determination of efficiency of a column.
2. Determination of  $R_t$  values for various organic compounds.
3. Resolution of mixtures - Hydrocarbons, alcohols.

#### **Polarography:**

1. Recording of a polarogram.
2. Determination of half-wave potentials of metal ions/mixture of metal ions.
3. Determination of dissolved oxygen.
4. Cathodic, anodic and mixed current voltage curves.
5. Resolution of waves.

#### **Potentiometry/ pHmetry:**

1. Determination of  $pK_a$  of an acid.
2. Determination of zinc with ferrocyanide.
3. Determination of ferrous ion with dichromate.
4. Determination of carbonate/bicarbonate and mixtures.

#### **References:**

1. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle , CBS Publ. & Distributors, VI Edition, 1986.
2. Text Book of Quantitative Inorganic Analysis – A. I. Vogel, ELBS, III and IV Edition.
3. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
4. Principles of Instrumental Analysis D. A. Skoog, Saunders College Pub. Co., III Edition, 1985.



## **ELECTIVE PAPER**

### **CHE E002 - ANALYSIS OF COMPLEX MATERIALS**

#### **Unit I**

**Ore and Alloy Analysis** – Sample preparation – Decomposition and dissolution of the sample, Fusion process, use of fluxes – acid and alkaline fluxes.

General procedure of complete analysis of Ores and Alloys – Oxide Ore- Haematite, Carbonate Ore – Dolomite, Alloys – Solder and Brass.

#### **Unit II**

##### **Analysis of Organic Compounds:**

Elemental analysis – Decomposition of organic compounds – Dry and wet ashing. Fusion - alkali metal fusion. Analysis of carbon, nitrogen and hydrogen in organic compounds.

Determination of traces of water in liquids and solids. Direct and indirect methods – use of Karl-Fischer's reagent, Dean and Stark method.

Functional group analysis: Amine, phenolic – OH, alcoholic – OH, vicinal hydroxyl, aldehyde and ketonic group analysis. Unsaturation in oils and fats – Bromination and iodine number. Rancidity.

#### **Unit III**

**Fuel Analysis** - Solids, liquids and gaseous fuels – Sampling procedure, ultimate and proximate analysis, specific volatile index, ash content, Calorific value by bomb calorimeter and Junker's gas calorimeter.

**Liquid fuels** – Flash point, viscosity, carbon residue, aniline point, pour point – Determination and significance.

**Text Books:**

1. Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edn., 1982.
2. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
3. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle , CBS Publ. & Distributors, VI Edition, 1986.
4. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
5. Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
6. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
7. Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982.
8. Quantitative Organic Analysis – S. Siggia and J.G. Hanna, Wiley –Intersci. Publ. IV Edition, 1979.

**Reference Books:**

1. Fuel Testing – G.W. Himus, Leonard Hill, 1954.
2. Technical Methods of Analysis – R.C. Griffin, McGraw Hill, 1965.
3. Chemistry of Engineering Materials – C.V. Agarwal, TARA Publicaions, II Edition, 1965.

## THIRD SEMESTER

### CORE PAPER

#### CHE C004 - ANALYSIS OF COMPLEX MATERIALS AND SEPARATION TECHNIQUES - PRACTICAL

##### **Analysis of Complex Materials employing titrimetric and gravimetric methods:**

1. Alloys – solder, cupro-nickel alloy, stainless steel, brass, aluminium alloy.
2. Carbonate and sulphide ores, cement.
3. Zinc dust, hydrogen peroxide, bleaching powder.
4. Pharmaceuticals – Aspirin, Ascorbic acid.

##### **Chromatographic Techniques:**

Thin layer chromatography - Separation of cations and anions, dyes in ink.

Paper chromatography - Separation of cations.

Ion-exchange chromatography - Separation of Zn and Mg.  
Separation of Cd and Zn.

## **CORE PAPER**

### **CHE C005 - INSTRUMENTAL METHODS- PRACTICAL**

#### **Spectrophotometry:**

1. Determination of Mn in steel.
2. Analysis of Permanganate – Dichromate mixture.
3. Determination of nitrite in water.
4. Determination of phosphate in water.
5. Photometric titration of copper and bismuth using EDTA.

#### **Potentiometry:**

1. Determination of cobalt using ferricyanide.
2. Complexometric titrations with EDTA.
3. Determination of chloride and iodide in a mixture.
4. Determination of chloride in tap water/ground water.

#### **Conductometry:**

1. Conductometric titrations.
2. Hardness of water.

#### **Biamperometry:**

1. Determination of Ferrous with ceric sulphate
2. Determination of thiosulphate.

#### **Gas Chromatography:**

1. Separation of hydrocarbons.

#### **Flame Photometry:**

1. Determination of sodium, potassium and calcium.
2. Determination of potassium in combined fertilizer.
3. Determination of calcium in wine.
4. Simultaneous determination of sodium and potassium in soil samples.

#### **Nephelometry:**

1. Determination of sulphate.

#### **Fluorimetry:**

1. Determination of Quinine.

## **CORE PAPRE**

### **CHE C601 PHYSICAL METHODS IN CHEMISTRY**

#### **Unit I**

Electronic spectroscopy, application of group theory, formaldehyde butadiene, dissociation energy of diatomic molecules, Photoelectron Spectroscopy, esca.

#### **Unit II**

NMR – Principles, theory, chemical shift, spectra of organic molecules, coupling constants, Karplus curve, J values, <sup>13</sup>C-NMR-decoupling – double resonance techniques – Noe, and pulse techniques, FTNMR, NMR of phosphorous and Fluorine containing molecules.

#### **Unit III**

Mass spectra – Molecular ion peak, meta stable peak, techniques, Application in determining structure of compounds. ESR-g-value, anisotropy, simple organic radicals, transition metals and coordination compounds.

#### **Unit IV**

X-ray diffraction – Bragg equation, space groups and point groups, diffraction methods. Mossbauer spectroscopy –theory and applications, Fe and Sn systems, Thermal methods of analysis – TGA, DTA and DSC – Principle and applications.

## **ELECTIVE PAPER**

### **CHE E003 – CLASSICAL AND RADIOANALYTICAL METHODS OF ANALYSIS**

#### **Unit I**

##### **Analysis of Complex Materials:**

Ore Analysis – Sample preparation – Decomposition and dissolution of sample, fusion process, use of fluxes – acid and alkaline fluxes.

General procedure of complete analysis of ores – oxides, sulphide and carbonate ores, one/two examples of each, cement, silicate, glass and industrial glasses.

Alloy analysis – Sample preparation, Ferrous and non-ferrous alloys : steel, solder, brass and bronze, aluminium alloy, etc.

##### **Analysis of Organic Compounds:**

Elemental analysis – Decomposition of organic compounds – Dry, and wet ashing. Fusion – lime, alkali metal fusion. Analysis of carbon, nitrogen, hydrogen, sulphur and halogens in organic compounds, equipment and methods, instrumental, Pregal method, Automatic CHN analysers.

Determination of traces of water in liquids and solids. Direct and indirect methods – use of Karl-Fischer's reagent, Dean and Stark method and instrumental methods.

Functional group analysis - Amine, phenolic-OH, alcoholic-OH, vicinal hydroxyl, methoxyl, ketonic, aldehyde group analysis. Unsaturation in organic compounds including oils and fats – Bromination, hydrogenation, iodine number, Rancidity.

#### **Unit II**

##### **Fuel Analysis:**

Solids, liquids and gaseous fuels – sampling procedure, ultimate and proximate analysis, specific volatile index, ash content, Calorific value by bomb calorimeter and Junker's gas calorimeter.

Liquid fuels – Flash point, viscosity, carbon residue, aniline point, pour point.

Gaseous fuels – Analysis of producer gas, water gas and industrial gases. Chemical and physical methods of analysis.

### Unit III

#### Radioanalytical Techniques :

Characteristics of radiation, Nuclear instrumentation, measurements of radioactivity – Gas ionisation, semiconductor, Nuclear emulsion and autoradiography.

Sample preparation for analysis, Isotopic dilution analysis, Radioimmunoassay. Direct, reverse and special radiometric titrations. Applications of Radiochromatography and Radioelectrophoresis..Activation analysis.

#### Text Books:

1. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle , CBS Publ. & Distributors, VI Edition, 1986.
2. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
3. Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
4. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
5. Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982.
6. Quantitative Organic Analysis – S. Siggia and J.G. Hanna, Wiley –Intersci. Publ. IV Edition, 1979.

#### Reference Books:

1. Fuel Testing – G.W. Himus, Leonard Hill, 1954.
2. Technical Methods of Analysis – R.C. Griffin, McGraw Hill, 1965.
3. Chemistry of Engineering Materials – C.V. Agarwal, TARA Publications, II Edition, 1965.
4. Principles of Radiochemistry – D.D. Sood, N. Ramamoorthy and A.V.R. Reddy, Eds., IANCAS, Bombay, 1993.

## **ELECTIVE PAPRE**

### **CHE E601 BIOLOGICAL CHEMISTRY**

#### **UNIT-I**

##### **Bioorganic Chemistry**

Origin of elements in biological systems.

Carbohydrates, Proteins, Lipids,

Nucleic acids - types of nucleic acids, structure of DNA, Metal -DNA and RNA interactions - potential binding sites. Functions of metal ions in genetic regulation. Replication, transcription and translation.

#### **UNIT-II**

##### **Bioinorganic Chemistry**

Essential and trace metal ions.

Enzymes - Nomenclature and classification.

Coenzymes - Vitamin B12 coenzymes, carboxypeptidase and Superoxide dismutase.

Heme-enzyme - Peroxidase and catalases.

Oxygen carriers - Hemeproteins - Hemoglobin, myoglobin - Structure Oxygenation and stereochemistry - Bohr effect. Non-heme oxygen carriers - Hemerythrin and hemocyanin.

Nitrogen fixation - Introduction, types of nitrogen fixing micro organisms. Nitrogenase enzyme - Metal clusters in nitrogenase - redox property - Dinitrogen complexes - transition metal complexes of dinitrogen - nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia.

Biological redox systems: Cytochromes -Classification, cytochrome a, b and c. Cytochrome P-450.

Iron - sulphur proteins - rubredoxin and ferredoxin.

Photosynthesis and chlorophyll's.

#### **UNIT-III**

##### **Biophysical Chemistry**

Thermodynamics and biology – Basic concepts of structure and functionality – membranes – structure, function transport properties, aspects of electrochemical phenomena – active transport, ionophores, biological energy storage and Phosphate hydrolysis.

Enzymes - Nomenclature and classification, chemical kinetics, the free energy of activation and the effects of catalysts, kinetics of enzyme catalysed reactions – Michelis - Menton equation - Effect of pH, temperature on enzyme reactions, Factors contributing to the catalytic efficiency of enzymes, Study by spectroscopic methods.

#### **UNIT-IV**

##### **Application of Bioinorganic Chemistry:**

##### **Bioanalytical Chemistry**

Toxicity & medicine.

Medicinal : Toxicity of Hg, Cd, Zn, Pb, As, Sb.

Anti cancer agents.

Metal ion poisoning : Failure of metal ion control systems, role of metal ions in diagnosis and treatment - use of radio isotopes.

Pollution studies : Effluents and treatment.

Inorganic plant nutrition and indicator plants for mineral exploration.



**Text Books:**

1. Williams, D.R. - Introduction to Bioinorganic Chemistry
2. Fiabre, F.M., and Williams D.R. - The Principles of Bioinorganic Chemistry, Royal Society of Chemistry, Monograph for Teachers - 31.
3. Purcell, K.F. and Kotz, J.C., - Inorganic Chemistry
4. Elements of Bioinorganic Chemistry - G.N. Mughherjee and Arabinda Das, 1993.
5. Bioinorganic Chemistry - M. Satake and Y. Mido, Discovery Publishing House, New Delhi (1996).

**Reference Books:**

1. G. Eichorn, G. - Inorganic Bio-Chemistry Vol. I and II, Elsevier, 1973.
2. J.W. Huheey - Inorganic Chemistry, Harper and Row.
3. Metal ions in Biological Systems, Vol. I to XV, H. Siegel (Ed.)
4. R.W. Hay - Bio Inorganic Chemistry.

## FOURTH SEMESTER

### CORE PAPER

#### CHE C006 - OPTICAL AND SURFACE ANALYTICAL TECHNIQUES

##### Unit I

**Polarimetry** – Theory and instrumentation specific and molecular rotations, applications, spectropolarimetry.

**Refractometry** – Theory, instrumentation, specific and molecular refraction, Abbe, Pulfrich and immersion types, applications.

##### Unit II

**Chemical Microscopy** – Microscope – parts and optical path, numerical aperture and significance.

Techniques – Kofler's hot stage microscope, other techniques of microscopy, application and qualitative study.

**Electron Microscopy** – Principle, Microscope and its operation, sample preparations, applications to analysis, electron probe analyser, ion microscopy.

##### Unit III

**X-Ray Spectroscopy** – Fundamental principles of absorption, emission, fluorescence and diffraction of x-rays, instrumentation – sources, filters, monochromator, detectors and signal processors, qualitative and quantitative applications of x-ray spectroscopy.

##### Unit IV

**Electron spectroscopy for Chemical Analysis (ESCA)** – Principle, Instrumentation – X-ray source, detectors, magnetic shielding and its applications – Quantitative analysis, chemical shifts, oxidation state and structure.

**Auger electron spectroscopy** – Theory, Principle, instrumentation and general applications – qualitative analysis and depth profiling of solid surfaces.

**Text Books:**

1. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle , CBS Publ. & Distributors, VI Edition, 1986.
2. Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986.
3. Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
4. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
5. Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
5. Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982.
6. Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing, VI Edition, 1991, and VII Edition, 1996.

**Reference Books :**

1. Chemical Instrumentation – H.A. Stuobel, Addison – Wesley Publ. Co., 1976.
2. Handbook of Chemical Microscopy – E.M. Chamot and C.W. Mason, John Wiley, Vol. I – II, 1944.
3. Treatise on Analytical Chemistry – Kolthoff and Elwing (all series).
4. Comprehensive Analytical Chemistry – Wilson and Wilson (all series).
5. Handbook of Instrumental Techniques for Analytical chemistry – F. Settle, Prentice Hall inc, 1997.
6. Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing, V Edition, 2000.

## CORE PAPER

### CHE C007 - SEPARATION TECHNIQUES

#### Unit I

**Distillation** – Principle – theoretical plates and HFTP, Applications

**Solvent Extraction** – Distribution law, Batch and continuous extraction. Extraction of solids-applications.

**Floatation** – Theory, cell and its operation and applications.

**Dialysis** – Theory, membranes and their choice, Electro dialysis- applications

#### Unit II

**Chromatographic Methods** - General aspects of chromatography, classification, mechanism, Band broadening and column efficiency.

**Column chromatography** – Construction and operation of column, choice of adsorbents, eluents and applications.

**Paper chromatography** – Mechanism of separation, qualitative and quantitative applications.

**Thin layer Chromatography** –Choice of adsorbent, solvents and applications. High performance thin layer chromatography (HPTLC).

**Ion-exchange chromatography** – Techniques and applications.

#### Unit III

**Gas Chromatography** – Types, nature and selection of stationary and mobile phases, solid supports and their choice, columns – packed, open and capillary, sampling methods, instrumentation, detectors – types, sensitivity, limit of detection, operative principles of TCD, FID and ECD, comparison of detectors, temperature programming, derivative chromatography, hyphenated techniques qualitative and quantitative applications GC-MS and GC-IR.

#### Unit IV

**High Performance Liquid Chromatography** - Theory and equipments, types of pumps and their choice, types of columns and choice of column materials, detectors and applications.

**Size exclusion chromatography** – Theory, gel filtration and gel permeation Supercritical fluid chromatography.

**Text Books:**

1. Thin Layer Chromatograph – Egon Stahl, Toppan Printing Co., Pvt, Ltd., II Edn., 1969.
2. Physical and Chemical Methods of Separation – E.W. Beg. McGraw Hill, 1963.
3. Gas Chromatography ( Analytical Chemistry by Open Learning) – John Willet, John Wiley & Sons, 1991.
4. Instrumental Methods of Analysis – Willard, Merrit, Dean and Settle, VI Edition, CBS Publishers and Distributors, 1986.
5. Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
6. Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing, V Edition, 2000.

**Reference Books :**

1. Treatise on Analytical Chemistry – Kolthoff and Elwing (all series).
2. Quantitative Analysis – Day and Underwood.
3. Comprehensive Analytical Chemistry – Wilson and Wilson (all series).
4. Physico – Chemical Techniques of Analysis – P.B. Janardhan, Vol. I & II.
5. Principles and Methods of Chemical Analysis – F. Walton, Prentice Hall, II Edn., 1966.
6. Modern Analytical Chemistry – W.F. Pickering, Maroel Dec, 1971.
7. Gas Analysis and Testing of Gaseous Materials – Alteri, Mmer. Gas Asso. 1965.
8. Chromatography –Harry and Calvin, Van Nostrand Reinhold Company, II Edition, 1967.
9. Quantitative Analysis Using Chromatographic Techniques – E.Katz, John Wiley & Sons Ltd, 1987.

## **ELECTIVE PAPER**

### **CHE E004 - ELECTROANALYTICAL CHEMISTRY**

#### **Unit I**

**Potentiometry** - Standard and Formal potentials, Types of electrodes – Glass membrane and Ion-selective electrodes – mechanism of electrode response and evaluation of selectivity coefficient, Applications of Ion-selective electrodes. Methods – manual titrimeters and automated titrators, Direct potentiometry and potentiometric titrations including differential methods, acid – base titrations in non-aqueous systems, Titrations involving polarised electrodes. Bipotentiometry – Principle, instrumentation and applications.

#### **Unit II**

**Electrogravimetry** – Theory, electro negativity, order of deposition, over potential, polarization curves, constant potential and consecutive deposition, Selective deposition, constant current deposition and deposition of complex ions.

#### **Unit III**

**Voltammetry** –Polarography- DME, polarograms, currents in polarography, polarographic maxima, effect of dissolved oxygen and application to chemical analysis, amperometric titrations, pulse polarography – normal and differential pulse, square wave polarography, stripping methods – cathodic and anodic stripping, linear sweep voltammetry, cyclic voltammetry, types of electrodes and chemically modified electrodes.

#### **Unit IV**

**Coulometric analysis** - Theory, Faraday's laws, types of coulometres, coulometric titrations, external and internal generation, coulogravimetry and applications.

**Text Books:**

1. Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edn., 1982.
2. Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edn., 1982.
3. Instrumental Methods of Analysis – Willard, Merrit, Dean and Settle, VI Edition, CBS Publishers and Distributors, 1986.
4. Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
5. Principles of Polarography – Kapoor and Aggarwal, Wiley Eastern Limited, 1991.

**Reference Books:**

1. Chemical Instrumentation – H.A. Stoubel, Addison – Wesley Publication Company, 1976.
2. Stripping Analysis – J. Wang, VCH Publication, 1985.
3. Modern Polarographic methods in Analytical Chemistry – A.M. Bond, Maroel Decker Inc., 1980.
4. Laboratory Techniques in Electro analytical chemistry – P.T. Kissinger and W.R. Heineman, Maracel Dec., Inc., 1984 , & II Edition, 1996.
5. Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
6. Modern Electrochemistry – Fundamentals of Electrodeics – John O' M.Bockris & A.K.N. Reddy, Plenum Publishers, New York, 2000.

## **ELECTIVE PAPER**

### **CHE E005 – INTRODUCTION TO CHROMATOGRAPHIC TECHNIQUES**

#### **Unit I**

Principles of chromatography, planar (TLC/paper) chromatographic techniques - principle, materials, development, different modes of developing techniques, visualization, qualitative and quantitative analysis.

#### **Unit II**

Gas chromatography – Principle, instrumentation – columns and detectors, applications.

#### **Unit III**

High Performance Liquid Chromatography – Theory, columns, detectors and applications.

#### **Text Books:**

1. Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
2. Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.
3. Physical and Chemical Methods of Separation – E.W. Berg, McGraw Hill Publications, 1963.
4. Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.