

**University of Pune**  
 Revised Syllabus  
**M. Sc.-II Analytical Chemistry**  
 Applicable from 2014-15

<b>Semester-III</b>		
Paper	Sections	Name of Paper
CHA-390	I & II	Electro analytical and Radio analytical methods of analysis
CHA-391	I & II	Pharmaceutical Analysis
CHA-392	I & II	Advanced analytical Techniques
CHA-380	Any Two Sections from following	
	I	Analytical Method development & validation
	II	Geochemical and alloy analysis
	III	Laboratory Automation and Sensor Based Techniques
<b>Semester-IV</b>		
Paper	Sections	Name of Paper
CHA-481	I & II	Analytical Toxicology and Food Analysis
CHA-490	I & II	Analytical spectroscopy
CHA-491	I & II	Analytical methods for analysis of fertilizers, detergents, water and Polymer, Paint and pigment
CHA-492	Method of Analysis and Applications : Any Two Sections from following	
	I	Pollution Monitoring and Control
	II	Analysis of body fluid
	III	Carbon Nanostructures and Applications of Nanotechnology
<i>Practical Courses</i>		
<i>Minimum 20% students must have complete Project work in leave of Practical course III</i>		
CHA-387	<i>Analytical chemistry Practical Course -I</i>	
CHA-487	<i>Analytical Chemistry Practical Course-II</i>	
CHA-488	<i>Analytical Chemistry Practical Course-III</i>	

**Industrial Tour and Report writing is compulsory**

## CHA-390: Electrochemical and Radio Analytical Methods of Analysis

<b>Chapter No</b>	<b>Section-I: Electrochemical Methods of Analysis (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>1</b>	<b>Coulometry: 6 lect. (Ref-4, and 1, 2, 3, 5)</b> Current voltage relationship during an electrolysis, Operating cell an at fixed applied potential, Electrolysis at constant working electrode potential, Coulometric methods of analysis, Faradays 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, problems.
<b>2</b>	<b>Voltammetry and polarographic methods of analysis. (14 L) (ref-4 , and 1, 2, 3, 5)</b> <b>A) Polarography</b> (linear scanpolarography): Polarographic principles, Instrumentation (different types of microelectrode such as dropping mercury electrode, the 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 (qualitative analysis, quantitative analysis by calibration curve and standard addition methods), specific examples of analysis – analysis of Cu, Cd, Zn, Pb, etc. from tap water and alloys., problems. <b>B) Hydrodynamic voltammetry</b> and applications of hydrodynamic voltammetry (volatametric detectors in chromatography and flow injection analysis, Voltametric oxygen sensors, amperometric titration). <b>C) Pulse Polarography:</b> different types of excitation signals in pulse polarography, Differential pulse polarography, square wave polarography, Stripping method. Voltametry with ultra microelectrode, Applications of these technique Cu and Zn from tap water by differential pulse polarography and by square wave polarography, Vitamin-C by differential pulse polarography, Determination of Pb in tap water by stripping method) <b>D) Cyclic Voltametry:</b> Principle of cyclic Voltammetry, cyclic voltamogram of $K_3[Fe(CN)_6]$ , and parathion, criteria of reversibility of electrochemical reactions, quasi-reversible and irreversible processes.
<b>4</b>	<b>Amperometry: (4 L) (Ref- 1)</b> Principle, Instrumentation, typical applications, amperometric titrations, chrono-amperometry and chrono-potentiometry.
	<b>Section-II: Radioanalytica and thermal methods of analysis (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>5</b>	<b>Radioanalytical Methods of Analysis (14 L)</b> <b>a) Activation analysis:</b> Neutron activation analysis, principle, technique, steps involved in neutron activation analysis. Radiochemical and instrumental methods of analysis, important applications of NAA. <b>b) Isotope dilution analysis:</b> Principle, types of isotope dilution analysis, typical applications of isotope dilution analysis. <b>c) Radiometric titration:</b> Principle, techniques based on complex formation and precipitation, radiometric titration curves for estimation of ions from their mixture.

6	<p><b>Thermal methods of analysis (10 L): Reference 4, 5)</b>  Principle, different methods of thermal analysis, <b>A) Thermo gravimetric methods of analysis:</b> Instrumentation, thermogram and information from thermogram, factors affecting thermogram, applications TGA for quantitative analysis (TG analysis of <math>\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}</math>, <math>\text{CuSO}_4 \cdot 5\text{H}_2\text{O}</math>, dolomite ore, etc.) and problems based TGA <b>B) Differential Thermal Analysis (DTA):</b> Instrumentation, general principles, differential thermogram, DT and TG curve together, Applications (DT analysis of mixture of polymers, DT analysis of <math>\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}</math>, DT analysis of sulfur, DT analysis of <math>\text{CuSO}_4 \cdot 5\text{H}_2\text{O}</math>). TG and DT curve for <math>\text{Mn}(\text{PH}_2\text{O}_2)_2 \cdot \text{H}_2\text{O}</math>, <b>C) Differential Scanning Calorimetry (DSC):</b> Principle, Instrumentation, and Applications (DCS curve of polyethylene terphthalate, DSC curve for isothermal crystallization of polyethylene, DSC of phenacetin), thermometric titrations, Evolved gas analysis.</p>
	<p><b>References</b></p> <ol style="list-style-type: none"> <li>1) Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987)</li> <li>2) Instrumental methods of chemical analysis by H. Willard, L. Merritt, J.A. Dean and F.A. Settle. Sixth edition CBS (1986)</li> <li>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.</li> <li>4) Vogel Text Book of quantitative analysis 6<sup>th</sup> Ed.</li> <li>5) J. chemical education, 60,302 to 308 (1983)</li> <li>6) Thermal analysis by W.W. Wendlandt, John Wiley, (1986)</li> <li>7) Cyclic Voltammetry and frontiers of electrochemistry by N.Noel and K.I. Vasu IBH, New Delhi (1990)</li> <li>8) Source book of Atomic energy by Glasstone.</li> <li>9) Principle of Activation Analysis- P. Kruger, John Wiley and sons, (1971).</li> <li>10) Nuclear Analytical Chemistry – J. Tolgyessy and S. Verga vol. 2, university Park press,(1972)</li> <li>11) Radiochemistry and Nuclear methods – W.D. Ehmann and D.E. Vance, John Wiley and Sons.</li> </ol>

## CHA-391: Pharmaceutical Analysis:

<b>Cha- pter No</b>	<b>Section-I</b> (24 L for teaching + 6 lect. tutorials), 2.0 Credit
1	<b>A) Apparatus for test and assay, Cleaning of glassware's, (6 L)</b> <b>B) Role of FDA in Pharmaceutical Industries:</b> Definitions of Drug & Cosmetics, Substandard Drugs, Role of FDA, Introduction to New Drug, Development of New Drugs- Selection of Area,, Phase I, Phase II, Phase III Application to FDA for formulation and marketing for new drug. Stability studies and Self life fixation.
2	<b>Biological Tests &amp; Assay : (5 L)</b> Introduction to biological assay, Biological assay of Heparin sodium, Determination of Amylase activity, Determination of Photolytic Activity, Test for Insulin in solution, Biological Assay of Tetanus Antitoxin, Test for Undue Toxicity.
3	<b>Microbiological Tests and Assays : (7L)</b> Microbiological test for Antibiotics Standard preparation and units of activity, Test organisms and Inoculums, Cylinder-plate assay receptacles, Turbidimetric assay receptacles, Assay Designs, Cylinder plate or Cup-plate method, Two level fractional assay, Test for Sterility,
4	<b>Physical Test, Determinations, Limit tests and Sterilization : (6 L)</b> a. Disintegration Test for Tablets and Capsules, b) Dissolution Test for Tablets and Capsules, c) moisture / water content by Karl-Fischer titration, limit tests for arsenic, heavy metals, iron, lead, sulphate, chloride, d) Ash, sulphated ash, e) Methods for Sterilization Steam Sterilization, Dry heat sterilization, Sterilization by Filtration, Gas Sterilization, Sterilization by Ionizing radiation, Sterilization by heating with Bactericides, Water for Pharmaceutical use.
	<b>Section-II (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
5	<b>Analysis of vegetable Drugs : (4L)</b> <b>Vegetable drugs:</b> Sampling, foreign organic matter, ash value, acid soluble ash, acid insoluble ash, sulphated ash, Extraction of alkaloids.
6	<b>Sources of Impurities in Pharmaceutical raw materials &amp; finished products, Shelf life of pharmaceutical product (4 L)</b> Raw materials, Method of manufacture, Atmospheric contaminations, Cross contamination, Microbial contamination, Container contamination, Packaging errors, Chemical instability, Temperature effect and Physical changes, shelf life of pharmaceutical product and determination of shelf life.
7	<b>Standardization and quality control of different raw materials and dosage form: (16 L)</b> Analysis of raw materials with respect to identification, other or related substances, loss on drying, and Assay as per IP, i) adrenaline, ii) Niacinamide iii) Cephalexin, iv) ferrous fumarate, v) isoniazid and vi) paracetamol. Problems based on assay of these materials. Brief introduction to different dosage forms with the IP requirements Analytical methods for the following- Tablets, different types of tablets, uniformity in weight (aspirin) additives used in tablet manufacture, capsules, types of capsules, (Rifampicin) Powders (Sodium benzoate), Solutions (saline NaCl) Suspensions (barium sulphate –limit test for impurity) Mouthwashes (Ointments (salicylic acid) and creams Dimethicone by IR) Injections (Mannitol), ophthalmic preparations (sulphacteamine), Aerosols (salbutamol), Blood products and reporting protocols. . Problems based on assay of these materials.

**References**

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

## CHA-392: Advances in Analytical Techniques

	<b>Sec-I: Analytical Extraction Techniques(24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>1</b>	<b>Classical approach for aqueous extraction (6L, Ref-8)</b> Introduction, Liquid-Liquid extraction (LLE) (Theory of LLE, selection of solvents, solvent extraction, problems with LLE process), purge and trap for volatile organics in aqueous samples
<b>2</b>	<b>Solid Phase extraction (SPE) (6 L, Ref-8)</b> 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>3</b>	<b>Solid phase micro-extraction (6 L, Ref-8)</b> Introduction, theoretical considerations, experimental, Methods of analysis: SPME-GC, Methods of analysis: SPME-HPLC-MS, Automation of SPME, New development in micro extraction (liquid micro extraction, membrane micro extraction).
<b>4</b>	<b>Microwave assisted extraction (3 L, Ref-8)</b> Introduction, instrumentation, Applications
<b>5</b>	<b>Supercritical Fluid Extraction (3 L, Ref-8)</b> Introduction, instrumentation, Applications
	<b>Section-II: Atomic spectroscopic analysis (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>6</b>	<b>Atomic Spectroscopy: (Reference 1-5) (12 L)</b> Theory, sources, burners, atomic emission spectra, atomic absorption spectra, effect of temperature on emission, absorption and fluorescence, electro thermal atomizers, Instrumentation for FES, radiation sources atomic absorption methods, instrumentation for AAS, spectral interferences, 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 vapor technique, Applications of AAS, AES and ICPAES, analysis of micronutrients like Mo, B, Cu, Zn essential towards the healthy growth of crops, fruits, determination of these micronutrients from soils, plants and fruits.
<b>7</b>	<b>Atomic Mass Spectroscopy: (Reference-3, 4) (6 L)</b> Features of atomic mass spectroscopy, Atomic weight in mass spectroscopy, mass to charge ratio, Types of atomic mass spectroscopy, mass spectrometers, transducer for mass spectroscopy, quadrapole mass analyzer, time of flight mass analyzer, Inductively coupled mass spectroscopy (ICPMS), Instrumentation for ICPMS, Atomic mass spectra and interferences, Applications of ICPMS,
<b>8</b>	<b>Atomic Fluorescence, Resonant Ionization and laser based-Enhanced Ionization: (Ref-1) (6 L)</b> <b>Atomic Fluorescence Spectroscopy (AFS):</b> 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. Resonant Ionization Spectroscopy, Laser-enhanced ionization spectroscopy
	<b>References:</b> 1) Introduction to Instrumental Analysis by R. D. Broun, Mc Graw 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, 6 <sup>th</sup> edition, D.A. Skoog, D.M. West and F.J. Holler, Saunders college publishing. 4) Principles of Instrumental Analysis, Skoog, Holler, Nieman, (Sixth Ed.) 5) Vogel's Textbook of Quantitative analysis 6 <sup>th</sup> Ed.

	<p>6) Modern analytical techniques in the pharmaceutical and bio analysis <b>By</b> Dr. Istvan Bak (Book Available Online).</p> <p>7) Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (free e book available on internet)</p> <p>8) Extraction technique in analytical science, John R. Dean, Wiley (2009)</p> <p>9) Practical HPLC method Development, Snyder, Kirkiand, Glajch, Wiley India Pvt. Ltd.</p>
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**CHA-380: Select any two sections from the following sections:**

**SECTION: I : Analytical Method Development & Validation**

**SECTION: II : Geochemical & alloy Analysis**

**SECTION: III : : Laboratory Automation and Sensor Based Techniques**

	<b>SECTION: I : Analytical Method Developments and validation (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>1</b>	<b>Assay Validation and Inter Laboratory Transfer (4-L, Ref-1, pp 3 to 14)</b> Introduction, fundamental definitions, Essential principles of method transfer, method validation report, the inter-laboratory qualification (ILQ) process,
<b>2</b>	<b>Statistical Analysis and analytical Figure of Merit (14 L, Ref-1, pp 15 to 68, Ref-2, pp145-197)</b> Introduction, Errors (gross errors, systematic errors, random errors), accuracy, validation parameters: Accuracy, precision, mean and standard deviation, calibration, (linear response functions (linear regression-errors in slope and the intercept, error in the estimate of concentration, standard additions), non-linear response functions and weighted regression analysis, internal standards), selectivity and specificity (chromatographic methods), limits of detections (spectrophotometric methods, chromatographic methods and related techniques, receptor binding assay), limit of quantification, sensitivity, ruggedness and robustness, analyte stability in the sample matrix, how to reduce systematic errors, mean and standard deviation, reliability of results, confidence interval, comparison of results, comparison of two means of two samples, experimental design.
<b>3</b>	<b>Overview of World Wide Regulations (2 L, Ref-1, pp 75 to 98)</b>
<b>4</b>	<b>Specific methods and Applications: Dissolution Studies (4 L, Ref-1, pp 75 to 98)</b> Introduction, Dissolution test, Apparatus – USP type –I and II, Sampling and analytical instrumentation, Single point test Vs. Dissolution profile, Calibration, regularatory guidelines, analytical validation, linearity, accuracy, precision, specificity. Ref-1, pp: <b>169 to 182</b>
	<p><b>References</b></p> <p><b>Ref-1:</b> Development and validation of Analytical Methods, Progress Pharmaceutical and Biomedical Analysis, Vol-3, Edited by Chitofer M. Riley and Tomas W. Rosanske (Elvier)</p> <p><b>Ref-2:</b> Vogel’s Textbook of quantitative Chemical Analysis, sixth Ed., Mendham, Denney, Barnes, Thomas, Pub: Pearson Education.</p> <p><b>Ref-3:</b> Handbook of modern pharmaceutical analysis, edited by Satinder Ahuja and Stephen Scypinski, Academic Press, Separation science Series, Vol-3</p> <p><b>Ref-4:</b> HPLC method Development for pharmaceuticals, Edited by Satinder Ahuja and Henrik Rasmussen, Academic Press, Separation science Series, Vol-8</p> <p><b>Ref-5:</b> Practical HPLC method Development, Snyder, Kirkiand, Glajch, Wiley India Pvt. Ltd.</p>



	<p><b>Section-II: Geochemical &amp; alloy Analysis</b>  <b>(24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>  <b>Methods and Principle of analysis, reactions involved, flow sheet and procedures. Problems based on analysis of each material</b></p>
<b>1</b>	<p><b>Analysis of Geological materials: (8 L) (Ref-1 Part-A and B, Ref - 2)</b>  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).</p>
<b>2</b>	<p><b>Analysis of Alloys: (8 L) (Ref-1 part A and B, Ref-2)</b>  Stainless Steel (for Fe, Cr, Ni, Co, Cu, Mn, W, Si, V, Mo, Ti, Pb and Zr) Bronze and Gun metal ( 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.).</p>
<b>3</b>	<p><b>Analysis of Soil: (8 L) (Ref-1)</b>  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 vii) Cation exchange capacity, viii) chemical analysis as a measure of soil fertility.</p>
	<p><b>References</b>  1) Standard methods of chemical analysis, Sixth Edition, F.J. Welcher.  2) Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Vogel, 3<sup>ed</sup>, ELBS, 1964.</p>

	<b>Section-III: Laboratory Automation and Sensor Based Techniques</b>
<b>1</b>	<b>Automated Analysis: (08 L, Ref. 3.)</b> Automated laboratory analyses, Laboratory apparatus- Continuous flow analyzers, Flow injection analyzers, Discrete-sample analyzers, Centrifugal force analyzers, Automatic titrations, Process control, process control analyzers.
<b>2</b>	<b>Minaturized Analytical systems (04 L, Ref. 4.)</b> Introduction, Concept, theory of miniaturization, microfabrication, silicon and glass micromatching, polymer replication technology, miniaturized analytical components, sampling and sample pre-treatment, system integration, serial integration, parallel integration, commercialization.
<b>3</b>	<b>Chemical Sensors (06 L, Ref. 4)</b> Introduction, definitions, Classification of chemical sensors, descriptions of chemical sensors (electrochemical sensors, potentiometric sensors, voltametric chemical sensors, sensors based on conducting properties), Optical sensors (light guides, the evanescent wave, design of fiber optic sensor, indicator mediated sensor), Calorimetric sensors (catalytic gas sensor, thermal conductivity sensor), mass sensor (piezoelectric quartz crystal resonator, surface acoustic wave sensor).
<b>4</b>	<b>Biosensors in analysis (06 L, Ref. 4)</b> Introduction, producing biological surface, Achievement of biotransduction (amperometric, potentiometric, optical).
	<b>References:</b> 1) Standard methods of chemical analysis, Sixth Edition, F.J. Welcher. 2) Quantitative Inorganic Analysis including Elementary Instrumental analysis, By A. I. Vogel, 3 <sup>ed</sup> , ELBS, 1964. 3) Instrumental methods of analysis, R. D. Braun 4) Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, Second Ed. Wiley –VCH

# Semester-IV

## CHA-481: Analytical Toxicology and Forensic Science

	<b>Sec-I: Analytical Toxicology (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
1	Diagnosis of acute poisoning, Treatment of acute poisoning, The role of the clinical toxicology laboratory (5L)
2	Diagnosis of acute poisoning, Treatment of acute poisoning, The role of the clinical toxicology laboratory (5L)
3	<b>Toxicology: (10 L)</b> Isolation, identification and determination of following 1) Narcotics- heroin and cocaine. 2) Stimulants- caffeine, amphetamines. 3) Depressants- Barbiturates, Benzodiazepines
4	<b>Narcotics and Psychotropic substances Act.(4 L)</b> Def – 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 offence and penalties
	<b>Section-II: Food Analysis (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
5	<b>Carbohydrates: (05 L, Ref-9 and 10)</b> Definition, classification, and functions, Analysis of carbohydrates from food sample by different method i) volumetric determination by Fehling's solution, ii) Colorimetric analysis of carbohydrates by Folin Wu method, Nelson Somyogi method, iii) total carbohydrates by Anthrone method, iv) Estimation of starch by anthrone method, v) Determination of amylase, vi) Estimation of pectic substances (gravimetric and colorimetric method), vii) Estimation of crude fibers
6	<b>Proteins (05 L, Ref-9 and 10)</b> Definitions and functions, Analysis of proteins by Kjeldahl's method, analysis of protein by Lowry method, Estimation of amino acids by colorimetric method, Estimation of food grain for methionine content, Protein digestibility in vitro, Protein efficiency and net protein ratio, Determination of net protein utilization, digestibility and biological value, Polyacrylamide gel electrophoresis of proteins.
7	<b>Analysis of Lipids: (04 L, Ref-9 and 10)</b> Estimation of oil in oilseeds, Estimation of free fatty acids, Saponification value of oils, iodine value, Determination of acid value of oil, determination of peroxide value of oil, Identification and quantification of fatty acids.
8	<b>Determination of food preservatives (06 L, Ref-10)</b> Definition, SO <sub>2</sub> legislation and determination by Tanners method, Nitrate and nitrites legislation and determination, boric acid legislation and determination, Benzoic acid legislation and determination, 4-hydroxybenzoate legislation and determination, ascorbic acid legislation and determination. Sweeteners: Saccharine identification and determination, Colours: Identification by general methods, Natural colours.
9	<b>Milk (02 L, Ref-9 and 10)</b> Analysis of milk and milk products: Composition of milk, analysis of milk with respect to pH, acidity, fates, casein content, lactose content, mineral content, adulteration of milk.

**. References:**

- 1) *Practical Biochemistry in clinical Mdicine- R. L Nath, Academic Publshers 2nd Edn (1990)*
- 2) *Texbook of Forenisc pharmacy- B. M. Mithal 9th Edn (1993) National Centre, Calcutta.*
- 3) *V. Malik, Drug and Cometics Act.*
- 4) *Forensic pharmacy by B.S Kuchekar, and A.M Khadatare Nirali Prakshan)*
- 5) *Shreves' Chemical Process Industries fifth edition by George Austin Mg Graw Hill*
- 6) *Practical Pharmceutical Chemistry by Becket*
- 7) *Basic Analytical Toxicology Published by WHO, By R. J. Flanagan, R. A. Braithwaite, S. S. Brown Available Online*
- 8) *Biochemical Methods, Third Edition, By S Sadashivan, A.Manickam; NEW AGE International (P) limited, PUBLICATION*
- 10) *Pearson's chemical analysis of food*

## CHA-490: Analytical Spectroscopy

	<b>Section I (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>1</b>	<b>Electron spectroscopy: (6 L, Rfe-1, Ref-6)</b> Introduction, principle of ESCA, electron spectroscopy for chemical analysis, ESCA satellite peaks, spectral splitting, ESCA chemical shifts, Apparatus used for ESCA, X-ray source, samples, Analyzers, Detectors, Chemical analysis using ESCA, Applications, Auger electron microscopy, Ultraviolet photoelectron spectroscopy.
<b>2</b>	<b>X- ray Methods of Analysis: (10 L, Ref-1 and Ref-6)</b> Principle, Theory- X-ray spectral lines, X-ray tube, X-ray emission, Absorptive apparatus: Sources, Collimation, sample handling, wavelength dispersive devices, Energy dispersive devices, detectors, readout device, Chemical analysis using X-ray absorption, X-ray Fluorescence- instrumentation and chemical analysis, X-ray Diffraction, Chemical analysis with X-ray diffraction, numerical problems.
<b>3</b>	<b>An Introduction to Microscopy (surface characterization techniques): (8 L, Ref. 8 and Ref-6)</b> 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, the transmission electron microscope.
	<b>Section II (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>4</b>	<b>Chemiluminescences: (6 L, Ref-1)</b> Introduction, principle, types. Measurement of chemiluminescence, Instrumentation quantitative chemiluminescences. Gas phase chemiluminescence's analysis. Chemiluminescences titrations, Electro-chemiluminescence.
<b>5</b>	<b>Fluorescence and phosphorescence (6L, Ref-1 and Ref- 7)</b> Introduction, Fluorescence, photo luminescent theory, electron transitions during photoluminescence, factors affecting photoluminescence, luminescent apparatus, optical extractive sources, wavelength selectors, detectors ad readout devices, photo luminescent spectra, photo luminescent analysis, analysis of non-photoluminating compounds, determinations of mixtures, specific examples of analysis using photoluminescence, problems
<b>6</b>	<b>Nuclear magnetic resonance spectroscopy: (12 L, Ref-5, and 1, 6)</b> <b><sup>1</sup>H-NMR:</b> Introduction, theory, Instrumentation, Chemical shifts, spin-spin splitting, protons on heteroatom's, coupling protons with other nuclei, solvents, qualitative and quantitative analysis, problems. <b><sup>13</sup>C NMR:</b> Introduction, interpretation <sup>13</sup> C NMR spectra, Chemical shifts, Spin coupling, quantitative analysis, problems. <b>2-D NMR:</b> introduction, <sup>1</sup> H - <sup>1</sup> H connectivity, <sup>1</sup> H - <sup>13</sup> C connectivity, <sup>13</sup> C - <sup>13</sup> C connectivity, Through space <sup>1</sup> H - <sup>1</sup> H proximity, option and how to use them, problems.

**References:**

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

**CHA-491: Analytical methods for Analysis of fertilizers, detergents,  
Water, and Polymer, Paint and pigment**

	<b>Section-I : Analysis of fertilizers, soap and detergents, and waste water (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>1</b>	<b>Analysis of Fertilizers: (6 L, Ref-1)</b> Sampling and sample preparation, water, total nitrogen: Kjeldahl method, total nitrogen by reduced iron method, urea nitrogen, total Kjeldahl nitrogen methods and spectrophotometric method, Ammonia nitrogen. Phosphorus: total phosphorus, available and non-available, alkali metric ammonium molybdophosphate method, water soluble phosphorous, citrate insoluble phosphate, Potassium: potassium by sodium tetra phenyl borate method, flame photometric methods
<b>2</b>	<b>Analysis of soaps and detergents: (8-L, Ref-1)</b> General scheme of analysis, sampling, alcohol soluble materials, moisture and volatile matter, active ingredient and equivalent combined $\text{SO}_3^{3-}$ , <b>Tests for soaps:</b> total fatty acids, fatty anhydride combined alkali, and anhydrous soap, Unsaponified and unsaponifiable matter, Free alkali or free acid, titer test, Iodine value, saponification value, free glycerol, <b>Tests for synthetic detergents:</b> Unsulfonated or unsulfated matter, ester $\text{SO}_3$ , Combined alcohols, total combined $\text{SO}_3$ , Alkalinity, chlorides, silicate, phosphate, borates, <b>UV spectroscopic analysis of detergents:</b> Biodegradability of detergents, Determination of sodium alkyl benzene sulfonate, determination of sodium toluene sulfonate, determination of sodium xylene sulfonate, determination of germicides in soaps and detergents.
<b>3</b>	<b>Water pollution and analysis of polluted water: (10 L, Ref-1 and 3)</b> Water pollutants, waste water treatment: domestic waste water treatment, aerobic treatment process, anaerobic treatment process, industrial waste water treatment, The purpose of chemical analysis, sampling of water, pH of water, specific conductance, determination of acidity and alkalinity, Chemical oxygen demand, biological oxygen demand, dissolved oxygen, turbidity, determination of aluminum, arsenic, boron, cadmium, calcium, carbon dioxide, chloride, residual chlorine, Chlorine demand, chromium, Chromium, cyanide, total hardness, iron, lead manganese, Zn, methane, nitrate, nitrite, ammonia nitrogen, phenols, phosphates, silica, sulphate, sulfide, anionic detergents, tannin and lignin.
	<b>Section-II: Polymer analysis (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>4</b>	<b>Introduction to polymers:</b> Brief history to polymers, how polymers are made, classification of polymers (02)
<b>5</b>	<b>Analysis and testing of polymers: (10 L)</b> a) Chemical analysis of polymers: X-ray diffraction analysis, thermal analysis, TGA, DTA. b) Physical testing of polymers: Mechanical properties, Fatigue testing, impact testing, tear resistance, hardness, abrasion resistance. c) Thermal properties: Softening temperature, flammability. d) Optical properties: transmittance, color, gloss, haze and transparency. e) Electrical properties: dielectric constant and loss factor, resistively, dielectric strength, electronic properties. f) Chemical properties: resistance to solvents, vapor permeability, weathering.
<b>6</b>	<b>Measurement of molecular weight and size: (4 L)</b> End group analysis, colligative properties measurements, solution viscosity and molecular size.

7	<p><b>Analysis of Paints and Pigment (8-L, Ref-1)</b>  Introduction, test on the total coating, water content, <u>separation of pigment binder, and thinner of solvent type coating, separation of pigment binder, and thinner of latex paints,</u> Identification of the binder, Identification of polymer resins and oils, Identification of plasticizer, Analysis of the vehicle, Identification and Analysis of pigments, Identification of inorganic pigments, Analysis of white and tinted pigments 9outline of general procedure, HCL insoluble, Titanium dioxide, total lead, acid soluble Al and Fe, acid soluble calcium, total zinc, antimony oxide, total sulfate, total carbonate) analysis of colored pigments, Black pigments, other pigments, identification and analysis of thinners.</p>
	<p><b>References</b></p> <ol style="list-style-type: none"> <li>1) Standard methods of chemical analysis, volume 3, part-B, F.J. Welcher.</li> <li>2) Standard methods of water and waste water analysis by A.K. De.</li> <li>3) Environmental Chemistry, A. K. De</li> <li>3) Textbook of polymer science 3<sup>rd</sup> edition by F.W.Billmeyer (1994).</li> <li>4) Principles of polymer systems by F. Rodrigue, Tata Mc Graw Hill, New Delhi.</li> <li>5) Principles of polymer systems by P.J.Flory, Cornell University press, New York.</li> <li>6) Polymer chemistry-an introduction Seymour-Carraher-Marcel Dekker. Inc. New York.</li> <li>7) Polymer Science by V.R. Gowarikar, N.B. Vishvanathane, New Age International Ltd. publisher (1998)</li> <li>8) Polymer Science by Vasant Gowarikar, Wiley Easteren New York (1998).</li> <li>7) Principle of polymer science, Bahadur and sastri, Narosa publishing house.</li> </ol>



## CHA-492 : Method of Analysis and Applications

		<b>Method of Analysis and Applications : Any Two Sections from following</b>	
		<b>I</b>	<b>Pollution Monitoring and Control</b>
		<b>II</b>	<b>Analysis of Body Fluid</b>
		<b>III</b>	<b>Carbon Nanostructures and Applications of Nanotechnology</b>
		<b>SECTION: I : Pollution Monitoring and Control (24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>	
<b>1</b>	<b>A) Removal of Heavy Toxic Metals</b> Chromium, Mercury, Lead, Cadmium, Arsenic, analytical methods of determination of small amount of the metal pollutants, copper recovery, treatments of waste to remove heavy metals, recovery techniques.		
<b>2</b>	<b>Removal of Particulate matters:</b> Particulate matter and dynamics of particles separation, Particulate matter in gas stream, filtering gravity separation, liquid scrubbing cyclones separation, electrostatic precipitations safety of workers analysis of particulate matter.		
<b>3</b>	<b>Removal of sulphur dioxide and nitrogenous materials</b> Origin of SO <sub>2</sub> and its hazards, Analysis of SO <sub>2</sub> control methods, desulphurization of fuels, Indian coal and Indian crude oil. Economics of SO <sub>2</sub> control measures. NO <sub>x</sub> , dissolved NO <sub>x</sub> , nitrites, ammonia, Urea and other nitrogen compounds in the effluent fertilizers explosive, industrial effluents, effluents from nitro aromatic industries, analytical methodology, photochemistry of air pollutions.		
		<b>References</b> 1) Pollution control in processes industries, S.P. Mahajan (J.W) 2) Air pollution control and design hand book and recovery, P.N. Chennsiof and R.A. Young 3) Refuse recycling and recovering (J.W) 4) Resources recovery and recycling hand book and industrial wastes, M. Sitting (NDS) 5) Sulphur in enviornment Vol. I and II,, J.O. Niagh (J.W.) 6) The Industry/EPA controntation, P.S. Minor (MGH) 7) Toxic and harazdous waste disposal Vol. I, R.B. Pojaselc (AAS) 8) Environmental pollution analysis, S.M. Khopkar 9) Environmental pollution analysis, A.K. Dee 10) Industrial safety handbook, W. Handley 11) Inorganic chemistry, J.E. Huheey et al, 1993	

	<p><b>Section-II: Analysis of body fluid</b> (24 L for teaching + 6 lect. tutorials), 2.0 Credit</p>
<b>1</b>	<p><b>Collection of Specimens: (02 lec., Ref-1)</b> Blood: Collection of Blood specimens, storage and preservation, Urine: Collection of Urine, physical characteristics of urea, preservation and storage, Faeces: Collection and preservation.</p>
<b>2</b>	<p><b>Analysis of Blood and urine: (06 lect, Ref-1)</b> Determination of blood and plasma glucose by glucose oxidase method, Determination of urine for glucose, Determination of ketone bodies in blood, Oral Glucose tolerance test, Determination of serum creatinin, estimation of serum bilirubin, Estimation of serum cholesterol, determination of blood hemoglobin, Urate: determination of serum urate, Determination of urea in urine by urease method and by direct colorimetry, Estimation of Na, K, Ca by flame photometry, inorganic phosphate by colorimetry.</p>
<b>3</b>	<p><b>Determination of vitamins in body fluid: (08 lect., Ref-1, and 2)</b> Classification of vitamins with example, Each vitamin must be explained with respect of functions, deficiency diseases, daily requirement, and analytical method i) Retinol (determination of retinol and serum carotene in serum using TFA), Vit D<sub>3</sub> (cholecalciferol), Vitamin E (Tocopherols, Determination of serum tocopherol by spectrophotometry by dipyrindyl method), Vitamin B<sub>1</sub> (thiamine determination by flurometry), Vitamin B<sub>2</sub> (riboflavin, Photofluorometric method), Vitamin B<sub>6</sub> (Pyidoxine, Fluorometric determination of Xanthuric acid), Nicotinic acid and Niacin: determination by fluorometry, Ascorbic acid (vitamin –c) Volumetric method using 2,6 dichlorophenol method, colorimetric determination of leucocyte ascorbate.</p>
<b>4</b>	<p><b>Immunoanalytical Techniques: (Reference-3, 4, (06 L, Ref-1)</b> Radioimmunoassay, its principle and applications, instrumentation for radio bioassay, clinical application of the radioimmunoassay of insulin, Estrogen and progesterone, receptor techniques of breast cancer. Enzyme- linked immunosorbent assay (ELISA), Types of ELISA, principles, practical aspects, applications.</p>
<b>5</b>	<p><b>Organ function tests: (02 L, Ref-1)</b> Liver function tests and kidney function tests</p>
	<p>1) Practical Clinical Biochemistry, Gowenlock, CBS published, 6<sup>th</sup> Ed. 2) Biochemical methods of analysis S. Sadasivam and A. Manickam, Narosa Publication</p>

	<b>Section-III: Carbon Nanostructures and Applications of Nanotechnology</b> <b>(24 L for teaching + 6 lect. tutorials), 2.0 Credit</b>
<b>1</b>	<b>Carbon Nanostructures</b> Introduction, carbon molecules, carbon clusters, carbon nanotubes, application of carbon nanotubes (09 Lect) ( <i>Ref 1, Page 103-133</i> )
<b>2</b>	<b>Biomedical applications</b> Introduction, biological sciences, photodynamic therapy in targeted drugs, advances in manufacturing, biomedical sensor and biosensors, quantum dot technology in cancer treatment, nanoparticle as a drug carrier (12 Lect) ( <i>Ref 2, Page 93-148</i> ).
<b>3</b>	<b>Environmental impacts of nanotechnology</b> Introduction, engineered nonmaterial's in the body, routes of entry, toxic mechanisms, environmental implications of nanoparticles, toxicological health effects, relevant parameters in nanoparticle toxicology, integrated concept of risk assessment of nanoparticles (09 Lect) ( <i>Ref 2, Page 181-210</i> ).
	<b>References</b> 1. Introduction to nanotechnology by C.P. Poole, Jr & F. J. Owens, John Wiley and Sons (2009). 2. Nanobiotechnology by Subbiah balagi, MJP Publishers, India (2010).

### CHA-387: Practical Course-I: Analysis of materials ( 6 Credits)

Experiment No	Name of experiment
1	Analysis of Bronze with respect to Copper and Tin
2	Determination of aluminium and magnesium from Magnalium alloy
3	Analysis of Dolomite ore for Ca, Mg and Silicate material
4	Analysis of bauxite ore
5	Analysis of Cement with respect to SiO <sub>2</sub> , Calcium, Iron, Magnesium and Aluminium
6	Analysis of Zn-Chrome pigment for Cr and Zn
7	Spectrophotometric determination of lead in leaves using dithizone-chelating agent
8	Determination of alcohol from given sample by Spectrophotometrically
9	Determination of Nitrogen from Fertilizer sample
10	Estimation of Iron from sydent
11	Limit Tests: i) Iron from CaCO <sub>3</sub> ii) Sulphate and Chloride from Paracetamol, Dextrose or any pharmaceutical Preparation
12	Analysis of Salbutal sulphate from asthma inhaler by UV spectrophotometry.
13	Estimation of Cu and Fe(III) by spectrophotometric titration. (Standardization of EDTA is expected).
14	Determination of Phosphate from fertilizer sample by volumetric method.
15	Removal of dyes on activated charcoal by column chromatography
16	Determine amount of magnesium from given talcum powder
17	Determination of COD from waste water
18	Analysis of water with respect to sulphate & Chloride
19	To analyse given sample of Magnalium alloy and determine percentage of aluminium gravimetrically and magnesium complexometrically.
20	Determination of calcium from given sample of plaster of Paris
21	Analysis of nicrome alloy with respect to nickel and chromium
22	Determination of cation exchange capacity of cation exchange resin or anion exchange capacity of anion exchange resin
23	Determination of organic carbon in soil
24	Determination of total cation concentration in waste water sample by cation exchange resin.
25	Analysis of copper ferrite (CuFe <sub>2</sub> O <sub>4</sub> ) and determine amount of copper and iron volumetrically
26	To determine phosphoric acid in cold drink by molybdenum blue method.
27	Determination of Titanium from pigment/raw material

*Perform any 22 experiments [11 Experiments per Semester]*

*Industrial Tour and Report writing is Compulsory*

## References:

Ref-1: Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3<sup>rd</sup> Ed. ELBS (1964)

Ref-2: Standard methods of chemical analysis by F. J. Welcher

Ref-3: Environmental Chemistry by A. K. De

Ref-4: Biochemical Methods, Sadashivam and Manickem, Narosa publication

Ref-5: Indian Pharmacopoeia volume –I and II

Ref-6: Experiments in chemistry by D. V. Jahagirdar, Himalaya publication

Ref-7: Practical Pharmaceutical Chemistry, 4<sup>th</sup> Ed. part-2, Beckett, Stenlake

Ref-8: Standard Instrumental methods of Chemical Analysis, F. J. Welcher

## CHA- 487: Practical Course-II: Instrumental Analysis (6 Credits)

Experiment No	Name of experiment
1	Estimation of aspirin from given tablet by spectrophotometry
2	Determination of Strength of commercial phosphoric acid by potentiometric titrations using standard solution of sodium hydroxide
3	Spectrophotometric determination of inorganic phosphorous in human serum or urine
4	To determine chloride and iodide from given mixture by potentiometry
5	Analysis of Riboflavin from vitamin supplementary capsules / syrup / tablet sample by Photofluometry
6	Determination of amount of each copper and Bismuth or Copper and Iron(III) from the given mixture by spectrophotometric titration using standard EDTA solution
7	Determination of relative strength of acetic acid, chloroacetic acid and trichloroacetic acid through measuring their $K_a$ value by conductivity measurement method
8	Photometric determination of aluminium from given antacid tablet by working curve method.
9	Determination of commercial vinegar by potentiometric titration and its confirmation by conductometry.
10	Determination of boric acid by conductometry.
11	Determination of calcium from dairy whitener by Flame photometry
12	Determination of Na and K from water sample by flame photometry binary method/internal standard method.
13	Determination of Na and K from water sample by flame photometry. Calibration curve method or by standard addition method
14	Determination of $SO_4^{2-}$ and $Cl^-$ by turbidimetric method (turbidimetric titration or calibration curve method)
15	Estimation of micronutrient from food by AAS (any two elements such as Fe, Cu, Zn, Mo, B, Mn)
16	Determination of Cu and Zn in brass alloy by polarography
17	Analysis of Paracetamol by HPLC
18	Determination of purity of Sugar sample by optical rotation by polarimetry
19	Estimation of Ca and Mg from form the mixture their oxalate by recording their TGA curve
20	Estimation of micronutrient from soil by AAS (any two elements)
21	Analysis of Alcohol from wine by GC
22	Estimation of waste water sample for heavy metals (any two elements) by AAS
23	Separation of proteins by gel filtration chromatography thereby determination molecular weight of protein sample by gel filtration chromatography
24	Determination of glucose from saline sample by polarimetrically.
25	To Determine amount of each p-nitrophenol and m-nitrophenol from the given mixture by spectrophotometric titration using standard NaOH solution ( $\lambda_{max}$ 280 nm)
26	To study the stoichiometry of ferric sulphate complex by Jobs Method.

27	To determine concentration in mg/lit of sulphate in given water sample by Nephelometrically.
28	To determine constant of ferric thiocyanate complex by Ostwald method Spectrophotometrically.
29	Spectrophotometric determination of aluminium using eriochrome Cyanine R

***Perform any 22 experiments [11 Experiments per Semester]***

- 1: Pharmacopoeia of India
- 2: Biochemical methods, Sadashivam and Manickem, New Age international Publication
- 3: General Chemistry Experiments, by Elias, Universities Press
- 4: Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, Thomas, Pearson education.
- 6: Experiments in chemistry by D. V. Jahagirdar (Himalaya publication)
- 7: An introduction to practical Biochemistry, Third Ed. by Plummer, Tata McGraw Publishing Company.
- 8: Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogel's, 3<sup>rd</sup> Ed. ELBS (1964)
- 9: Environmental Chemistry by A.K. De 3<sup>rd</sup> Ed. Wiley Eastern Ltd.

## CHA-488: Practical Course-III (6 Credits)

### Analysis of Pharmaceutical, food and Bio analytical Samples OR Project work

Experiment No	Name of experiment
1	Analysis of paracetamol as per IP with respect to Identification, ash and assay
2	Analysis of caffeine in tablet as per IP with respect to identification, assay
3	Tablet dissolution and disintegration test for paracetamol tablet as per IP
4	Moisture content in pharmaceutical/food sample by Karl fisher titration method
5	Analysis of quinine sulphate from tablet by Photoflurometry
6	Assay of local anaesthetic (benzocaine) by non aqueous titration method.
7	Assay of thiamine from given sample
8	Determination of phosphorus content in serum by spectrophotometry
9	Analysis of paracetamol as per IP with respect to identification tests, ash and assay
10	Detection of amino acids by ninhydrin after thin layer chromatographic separation
11	Isolation of B-carotene from spinach leaves or lycopene from tomato and its purification on silica gel column.
12	Estimation of glucose from Blood sample by glucose oxidase method
13	Estimation of reducing sugars from food sample by spectrophotometry.
14	Estimation of ketone bodies from serum and creatinine from urine by kit method or colorimetry
15	Determination of cholesterol from blood or food sample or milk.
16	Estimation of tannin from tea sample by Folin-Denis method
17	Estimation of Fe from Syrup by spectrophotometric Method
18	Estimation of proteins in food sample by Lowry method
19	Estimation of HMF from Honey
20	Estimation of tannin from tea sample by Folin-Denis method
21	Estimation of reducing sugars from food sample sample by spectrophotometry
22	Estimation of sulphur from sulphur fungicide.
23	Determination of iron from pharmaceutical preparation by titration with ceric ammonium sulphate.
24	Separation of amino acids by two dimensional chromatography.
25	Determination of glucose from glucon D by titration wit Fehling solution.
26	Estimation of blood urea by kit method colorimetry.
27	Estimation of Vit. C using Dichlorophenol, Indophenols by volumetric method.

*Perform any 22 experiments [11 Experiments per Semester]*



## Reference

1. Organic Laboratory technique a micro scale approach by Donald L. Pavia, Gary M.Lampman, George S. Kriz, Randall G. Engel second edition.
2. Practical clinical Biochemistry, Harold Varley (4th Edition), CBS publishers and Distributers. New Delhi -110002.
3. R. Ikan; natural products.
4. Peach and Tracy; Methods of Plant analysis Vol- VII.
5. Pavia and others; Organic Laboratory Techniques, (Second Edition,1995), Sannders Series(Harcofst Brace
- 6 :Analytical Chemistry by Gary Christain, 6th edition, 2008