

AC-14/06/2018

Item No. 4.73

UNIVERSITY OF MUMBAI



Program : M.Sc.

(Choice Based Credit System)

Course : M.Sc. Analytical Chemistry

Syllabus for Semester III & IV

(To be implemented from the Academic year 2018-2019)

<p style="text-align: center;">M.Sc. ANALYTICAL CHEMISTRY SEMESTER – III PSCHA301 QUALITY IN ANALYTICAL CHEMISTRY</p>		
UNIT I	Quality In Analytical Chemistry - I	15
	<p>1.1 Sampling: Definition, types of sample, sampling plan, quality of sample, subsampling, Sampling of raw materials, intermediates and finished products. Sample preparations – dissolution technology and decomposition, storage of samples.</p> <p>Pre-treatment of samples: soil, food and cosmetics. (8L)</p> <p>1.2 Selection of the Method: sources of methods, factors to consider when selecting a method, performance criteria for methods used, reasons for incorrect analytical results, method validation, and quality by design (PAT). (7L)</p>	
UNIT II	Quality In Analytical Chemistry - II	15
	<p>2.1 Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results. (4L)</p> <p>2.2 Signal to noise: Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction, software methods for noise reduction. (6L)</p> <p>2.3 Pharmaceutical Legislation: introduction to drug acts, drug rules (schedules), concept of regulatory affairs in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration. (5L)</p>	
UNIT III	Chromatographic Techniques -I	15
	<p>3.1 Ion exchange chromatography: Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchangers, chelating resins and their applications for separation of inorganic and organic compounds. (8L)</p> <p>3.2 Ion chromatography: Principle, instrumentation with special reference to separation and suppressor columns, applications. (2L)</p> <p>3.3 Exclusion chromatography : Theory, instrumentation and applications of gel permeation chromatography, retention behavior, inorganic molecular sieves, determination of molecular weight of polymers, (5L)</p>	

UNIT IV	Chromatographic Techniques -II	15
	<p>4.1 Supercritical fluid Chromatography: Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis. (8L)</p> <p>4.2 Affinity Chromatography: principle, instrumentation and applications (4l)</p> <p>4.3 Optimum pressure liquid chromatography (OPLC) (3L)</p>	

List of books and references:

1. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997.
2. Quality assurance in analytical Chemistry, W Funk, V Dammann, G. Donnevert VCH Weinheim 1995.
3. Amit S. Patil *et. al.*, Quality by Design (QbD) : A new concept for development of Quality pharmaceuticals, International Journal of Pharmaceutical Quality Assurance; 4(2); 13-19.
4. Lalit Singh and Vijay Sharma, Quality by Design (QbD) Approach in Pharmaceuticals: Status, Challenges and Next Steps, Drug Delivery Letters, 2015, 5, 2-8. Quality in the analytical chemistry laboratory, E Prichard, John Wiley and sons N.Y 1997
5. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Saunders, College publication.
6. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
7. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
8. Analytical Chemistry, G. D. Christain, Wiley
9. Extraction Chromatography T. Braun, G. Ghersene, Elsevier Publications 1978.
10. Supercritical Fluid Extraction, Larry Taylor Wiley publishers N.Y. 1996
11. Ion exchange separation in analytical chemistry O Samuelson John Wiley 2nd ed 1963
12. Ion exchange chromatography Ed H.F Walton Howden, Hutchenson and Rossing 1976
13. Chromatographic and electrophoresis techniques I Smith Menemann Interscience 1960

SEMESTER-III
PSCHA302
Advance Instrumental Techniques

UNIT I	Spectral Methods I	15
	1.1 Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis. (1L) 1.2 Principle, instrumentation and applications of the following: a. Secondary Ion mass spectroscopy. (4L) b. Particle-Induced X-Ray Emission (5L) c. Low-Energy Ion Scattering and Rutherford Backscattering (5L)	
UNIT II	Spectral Methods – II	15
	Principle, Instrumentation, and Applications of 2.1 Electron Spin Resonance Spectroscopy (ESR) (5L) 2.2 Mossbauer's Spectroscopy (5L) 2.3 Atomic Emission Spectroscopy- based on plasma and electrical discharge sources (5L)	
UNIT III	Electroanalytical Methods	15
	Advanced Electroanalytical Techniques:- 3.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography (3L) 3.2 Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry. (3L) 3.3 Potential Step method- Chronoamperometry (2L) 3.4 Controlled potential technique- Chronopotentiometry (2L) 3.5 Stripping Voltammetry- anodic, cathodic, and adsorption (2L) 3.6 Chemically and electrolytically modified electrodes and ultra-microelectrodes in voltammetry (3L)	
UNIT IV	Miscellaneous Techniques	15
	Principle, Instrumentation and Applications of: 4.1 Chemiluminescence techniques (3L) 4.2 Chiroptical Methods : ORD, CD (5L) 4.3 Photoacoustic spectroscopy (3L) 4.4 Spectroelectrochemistry (4L)	

List of books and references:

1. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998)

4. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F. A. Settle Jr 6th Ed CBS (1986)
5. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986)
6. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987)
7. Electrochemical Methods, A. J. Bard and L.R. Faulkner, John Wiley, New York, (1980)
8. Electroanalytical Chemistry, J.J . Lingane, 2nd Ed Interscience, New York (1958)
9. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York, 1980.
10. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes)
11. Techniques and mechanism of electrochemistry, P. A. Christian and A. Hamnett, Blachie Academic and Professional (1994)
12. Wilson and Wilson's Comprehensive Analytical Chemistry, Ed. G. Svehla. (A series of Volumes)
13. Treatise on Analytical Chemistry, Eds. I. M. Kolthoff and Others, Interscience Pub. (A series of volumes).
14. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, (A series of volumes)
15. Polarographic Methods in Analytical Chemistry, M. G. Arora, Anmol Publications Pvt Ltd
- 16 Surface Analysis –The Principal Techniques, 2nd Edition Edited by John C. Vickerman and Ian S. Gilmore 2009 John Wiley & Sons, Ltd. ISBN: 978-0-470-01763-0
17. NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry *R. V. Parish*. Ellis Horwood, Chichester

SEMESTER – III
PSCHA303
Bioanalytical Chemistry and Food Analysis

UNIT I	Bioanalytical chemistry	15
	<p>1.1 Body Fluids</p> <p>1.1.1 Composition of body fluids and detection of abnormal levels of glucose, creatinine, uric acid in blood, protein, ketone bodies and bilirubin in urine leading to diagnosis of diseases. (5L)</p> <p>1.1.2 Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals. (5L)</p> <p>1.1.3 Analytical techniques (including microbiological techniques) for vitamins. (5L)</p>	
UNIT II	Immunological Methods	15
	2.1 General processes of immune response, antigen-antibody reactions, precipitation reactions, radio, enzyme and fluoro-immuno assays.(8L)	
	2.2 Human Nutrition: Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids.(7L)	
UNIT III	Food Analysis - I	15
	3.1 Fuel value of food and importance of food nutrients (2L)	
	3.2 Food Additives – General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour. (5L)	
	3.3 Food Contaminants– Trace metals and pesticide residues, contaminants from industrial wastes (polychlorinated polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants. (8L)	
UNIT IV	Food Analysis - II	15
4.1	4.1.1 Food packaging – Introduction, types of packing materials, properties and industrial requirements.(2L)	
	4.1. 2 Processing and Quality requirements of Milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat products. (6L)	
	4.2 Analysis of Milk – Fat content, proteins, acidity, bacteriological quality and milk adulterants.(2L)	
	4.3 Analysis of Oils and Fats – acid value, sap value, iodine value. Determination of rancidity and antioxidants.(2L)	
	4.4 Analysis of spices (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils.(3L)	

List of books and References:

1. General, organic and biological chemistry, H. Stephen Stoker, Cengage Learning.
2. Advance dairy chemistry, vol 3, P. F. Fox, P. L. H. McSweeney Springer.
3. Physiological fluid dynamics vol 3, Nanjanagud Venkatanarayanasastry
Chandrasekhara Swamy Narosa Pub. House, 1992
4. Molecular Biological and Immunological Techniques and Applications for food,
edited by Bert Popping, Carmen Diaz-Amigo, Katrin Hoenicke, John Wiley & sons.
5. Food Analysis: Theory and practice, Yeshajahu Pomeranz, Clifton E. Meloan,
Springer.
6. Principles of package development, Gribbin et al
7. Modern packaging Encyclopedia and planning guide, Macgra Wreyco.
8. Food Analysis, Edited by S. Suzanne Nielsen, Springer
9. Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
10. Bioanalytical Chemistry, S. R. Mikkelesen and E. Corton, John Wiley and sons
2004
Analysis of food and beverages, George Charalanbous, Accademic press 1978

SEMESTER-III
PSCHAEC-I 304

Environmental and Certain Industrially Important Materials

UNIT I	Air Pollution	15
	<p>1.1 Sources, classification, pollutants and permissible limits.(2L)</p> <p>1.2 Sampling methods for air, flew gas ,Industrial Exhaust, stag samples etc. (2L)</p> <p>1.3 Importance of automobile exhaust control and its limits(2L)</p> <p>1.4 Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. (3L)</p> <p>1.5 Carbon credit and global issues related to air pollution.(3L)</p> <p>1.6 Greenhouse gases and their substitutes. (1L)</p> <p>1.7 Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC. (2L)</p>	
UNIT II	Water Quality Standards	15
	<p>2.1 Water: quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs, quality of potable water from natural sources. (6L)</p> <p>2.2 Bore well water quality and analytical parameters. Quality of bottled mineral water (3L)</p> <p>2.3 Process of purification of bore well water to bottled mineral water. (2L)</p> <p>2.4 Regulatory requirements for packaged drinking water (4L)</p>	
UNIT III	Other Types Of Pollution	15
	<p>3.1 Soil pollution and Soil Analysis : sources of soil pollution and their control, sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long term effect on soil quality. (6L)</p> <p>3.2 Noise Pollution : sources, effects, methods of measurements and control measures.(2L)</p>	

	<p>3.3 Thermal Pollution: definition, source, impact, control measures, working of cooling towers and cooling ponds, involved economy. (3L)</p> <p>3.4 Radioactive pollutants: source, exposure hazards, precautions in handling and safety, Long term effects. (2L)</p> <p>3.5 Environmental Audits: concept of audit, authorities, evaluation methodology, benefits and certification (2L)</p>	
UNIT IV	Industrial Materials	15
	<p>4.1 Insecticides, Pesticides: definition, classification of insecticides pesticides. Biodegradation of insecticides and pesticides (5L).</p> <p>4.2 Soaps and Detergents: classification and composition, qualitative analysis, quantitative analysis of detergents- alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents (5L)</p> <p>4.3 Petrochemical products: crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and impact on environment. (5L)</p>	

List of Books and References:

1. Environmental Chemistry, A. K. De, 2nd ED. Wiley (1989).
2. Environmental Pollution Analysis, S. M. Khopkar, John Wiely (1993).
3. Air Pollution Sampling And Analysis, Sharad Gokhale, IIT Guwahati, May 2009.
4. Environmental Pollution Analysis, S. M. Khopkar, New Age International publication (2011).
5. Water And Water Pollution (hand book) Ed., Seonard'l Ciacere, Vol I to IV, Marcel Dekker inc. N.York(1972)
6. Water pollution, Arvind kumar, APH publishing (2004)
7. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.
8. Guidelines for drinking-water quality, Third edition, (incorporating first and second addenda). WHO report.
9. Soil pollution, S.G. Misra and Dinesh Mani, APH Publishing Corporation, (2009).
10. Soil Pollution: origin, monitoring and remediation, Abraham Mirsal, Springer (2010).
11. Noise Pollution, Donald F Anthrop, Lexington Books, (1973)
12. Noise Effects Handbook: A Desk Reference to Health and Welfare Effects of Noise (1981) Available at NCL laboratories e- Library.

13. Chemistry, Emission Control, Radioactive Pollution and Indoor Air Quality Edited by Nicolas Mazzeo, InTech Publications (2011).
14. Environmental Protection Against Radioactive Pollution: N. Birsen, Kairat K. Kadyrzhanov, Springer publication , (2003).
15. Environmental law in India, Mohammad Naseem, Wolters Kluwer.
16. Environmental Protection, Law And Policy In *India* Kailash Thakur google books (1997).
17. Green chemistry An Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002)
18. Pesticide Analysis Ed K. G. Das, Dekker (1981)
19. Analytical, Agricultural Chemistry S. L Chpra J.S Kanwar Kalyani publication

20. Soil and plant Analysis C.S Piper , Hans Publication

SEMESTER – III**PSCHAEC-II 304****Pharmaceutical and Organic Analysis**

UNIT I	Pharmaceutical Analysis	15
	1.1 General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries.(7L)	
	1.2 Sources of impurities in pharmaceutical products and raw materials. (4L)	
	1.3 Standardization of finished products and their characteristics, official methods of quality control. (4L)	
UNIT II	Drugs	15
	2.1 Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests. (8L)	
	2.2 Limit tests, solubility tests, disintegration tests, stability studies, impurity profile of drugs, bioequivalence and bioavailability studies. Polymers in pharmaceuticals and novel drug delivery systems.(7L)	
UNIT III	Forensic Science	15
	3.1 Analytical Chemistry in Forensic Science: General idea.(2L)	
	3.2 Forensic Analysis: Blood, DNA profiling, Hair analysis, Alcohol in body fluids, systematic drug identification.(5L)	
	3.3 Analytical Toxicology: Isolation, identification and determination of: 3.3.1 Narcotics: Heroin, morphine and cocaine. 3.3.2 Stimulants: Amphetamines and caffeine. 3.3.3 Depressants: Benzodiazepines, Barbiturates and Mandrax. 3.3.4 Hallucinogens: LSD and Cannabis. 3.3.5 Metabolites of drugs in blood and urine of addicts. 3.3.6 Viscera, stomach wash, vomit and postmortem blood for poisons like – cyanide, arsenic, mercury, insecticides and pesticides. (8L)	
UNIT IV	Cosmetic Analysis	15
	4.1 Cosmetics: Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis.(2L)	
	4.2 Deodorants and antiperspirants: Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea.(3L)	
	4.3 Face powder: Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total).(3L)	

	4.4 Hair tonic: 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers)(3L)	
	4.5 Creams and Lotions: Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) (2L)	
	4.6 Lipsticks: General analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents.(2L)	

References

- 1) Analytical Biochemistry, David J Holmes and Hazel Peck, Longman, 1983.
- 2) Bioanalytical Chemistry, Susan R Mikkelesen and Eduardo Cotton, John Wiley and Sons, 2004.
- 3) Analysis of food and beverages, George Charalanbous, Academic press, 1978.
- 4) Harry's Cosmetology, 7th Ed, Longman Scientific Co.
- 5) Formulation and Function of Cosmetics, Joseph Stefan Jellinek, Wiley Interscience, 1971.
- 6) Cosmetic Technology, Edward Sagarin, Interscience Publishers, 1957.
- 7) Modern Cosmetics, Edgar George Thommsen, Francis Chilson, Drug and Cosmetic Industry, 1947.
- 8) Encyclopedia of Industrial Chemical Analysis, Foster Dee Snell et al, Interscience Publishers, 1967.
- 9) Government of India Publications of Food, Drug and Cosmetic Act and Rules.
- 10) The Handbook of Drug Laws, M L Mehra, University Book Agency, Ahmedabad, 1997.
- 11) Chemical Analysis of Drugs, Takeru Higuchi, Interscience Publishers, 1995.
- 12) Text book of Pharmaceutical Analysis, Kenneth Antonio Connors, Wiley, 2001.
- 13) Food Processing and Preservation, B Sivasankar, Prentice - Hall of India Private Limited, 2007.
- 14) Food Additives, R M Pandey and S K Upadhyay, INTECH, Open Science/Open Minds.
- 15) Food Science, B Srilakshmi, New Age International (P) Ltd. Publishers, 2003.
- 16) Food Contaminants: Sources and Surveillance, Edited by C Creaser, R Purchase, Elsevier, 1991.
- 17) The Chemical Analysis of Food and Food Products, Morris B Jacobs.
- 18) FSSAI (Food Safety and Standards Authority of India) Manuals of Methods of Analysis of Foods (Oils and Fats, Milk and Milk Products, Food Additives), Ministry of Health and Family Welfare, Government of India.
- 19) Fundamentals of Urine and Body Fluid Analysis, Nancy A Brunzel, Elsevier health Sciences, 2013.
- 20) Lab Manual on Blood analysis and Medical Diagnostics, Dr Gayatri Prakash, S Chand and Company Ltd, New Delhi.
- 21) Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, Jaypee Brothers Medical Publishers (P) Ltd, 2012.

- 22) Indian Pharmacopeia, Volume I and II.
- 23) Forensic Chemistry, Suzanne Bell, Pearson Prentice Hall Publication, 2006.
- 24) Forensic Chemistry, David E Newton, Infobase Publishing, 2007.
- 25) Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995.
- 26) AOAC Volume I and II.

SEMESTER-III PRACTICALS

PSCHA3P1 Group – A:

1. Determination of the pK value of an indicator.
2. Determination of copper and bismuth in mixture by photometric titration.
3. Estimation of strong acid, weak acid and salt in the given mixture conductometrically.
4. Analysis of mixture of carbonate and bicarbonate (present in ppm range) using pHmetry.
5. Determination of copper by extractive photometry using diethyldithiocarbamate.

PSCHA3P2 Group – B:

1. Estimation of drugs by non aqueous titration: Pyridoxine hydrochloride, Sulphamethoxazole.
2. Determination of percentage purity of methylene blue indicator.
3. Estimation of cholesterol and Uric acid in the given sample of blood serum
4. Estimation of fluoride in a tooth paste.
5. Determination of silica by molybdenum blue method.

PSCHA3P3 Group–C:

1. Total reducing sugars before and after inversion in honey using: (a) Cole's Ferricyanide (b) Lane - Eynon method.
2. Analysis of lactose in milk
3. Estimation of Caffeine in tea
4. Estimation of Vitamin C in lemon Juice/squash by Dichlorophenol-indophenol method
5. Iodine value of oil / fat
6. Analysis of alcoholic beverages (Beer) for alcohol content by distillation followed by specific gravity method, acidity by titration, total residue by evaporation.

PSCHA3P4 Group – D:

1. To analyze Pyrolusite for: Fe by colorimetry and / or Mn by volumetry.
2. To analyze Magnesium for Mg by complexometry.
3. Analysis of Bauxite for Ti by colorimetry / Al by gravimetry / Fe (volumetry)
4. Analysis of water sample: Total hardness and salinity.
5. Analysis of water sample: Acidity and sulphate(Benzidine method).

NOTE:

1. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.

2. A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.

Use of non-programmable calculator is allowed both at the theory and the practical examination.

**SEMSTER-IV
PSCHA401**

Quality In Analytical Chemistry

UNIT I	Separation Science	15
	<p>1.1 Membrane separation processes: operating principles and applications of microfiltration, ultra-filtration, reverse osmosis, dialysis and electro-dialysis. (8L)</p> <p>1.2 Applications of Solvent extraction in Analytical Chemistry- recapitulation of solvent extraction, roles of solvent extraction in analytical chemistry, solvent extraction in sample preparation and pretreatment steps, solvent extraction as a means of analytical determination (7L)</p>	
UNIT II	Separation, Analysis and Standardization of Herbal based products.	15
	<p>2.1 Herbs as a raw material: Defination of herb, herbal medicine, herbal Medicinal products, herbal drug preparation. Sources of herbs. Selection, identification and authentication of herbal materials, drying and processing of herbal raw materials,drying and processing of herbal raw material.(6L)</p> <p>2.2Extraction of herbal materials: Choice of solvent for extraction, methods used for extraction and principles involved in extraction.(3L)</p> <p>2.3Standardization of herbal formulation and herbal extracts: Standardization of herbal extract as per WHO cGMP guidelines, Physical, Chemical,Spectral and toxilological standardization,qualitative and quantitative esimations.(6L)</p>	

UNIT III	Green Chemistry	15
	<p>3.1 Principle and concepts of green chemistry: sustainable development and green chemistry, atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity (4L)</p> <p>3.2 Organic solvents: environmentally benign solutions, solvent free systems, supercritical fluids (only introduction) Ionic liquids as catalysts and solvents (4L)</p> <p>3.3 Emerging Green Technologies: photochemical reactions (advantages and challenges), examples. Chemistry using microwaves, sonochemistry and electrochemical synthesis. (4L)</p> <p>3.4 Designing Greener Processes: Inherently Safer Designs (ISD), Process intensification (PI) in-process monitoring. (3L)</p>	
UNIT IV	Advanced Techniques	15
	<p>4.1 Electrophoresis: introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephedax and thin layers) (2L)</p> <p>4.2 Techniques of Electrophoresis: low and high voltage, sds-page, continuous electrophoresis, capillary electrophoresis, zone, gel, isoelectric focusing, isotaechophoresis and miceller electro kinetic capillary chromatography, instrumentation, detection and applications. (8L)</p> <p>4.3 Introduction to Nanotechnology: Analytical techniques in nanotechnology, consequences of the nanoscale, (nanoparticles morphology, electronic structure, optical properties) one dimensional nano materials (nanofilms, nanolayers), two dimensional nanomaterials (nanotubes, nanowires), three dimensional nanomaterials (nanoparticles and quantum dots). (5L)</p>	

List of Books and references:

1. Research Methodology: Methods & Techniques by C R Kothari, 2e, Wishwa Publication, New Delhi
2. Research Methodology by D K Bhattacharyya, 1 e, Excel Books, New Delhi, 2003
3. How to Research by Loraine Blaxter, Christina Hughes and Molcolm Tight, Viva Books Pvt.Ltd., New Delhi

4. Chemical methods of separation, J A Dean, Van Nostrand Reinhold, 1969
5. Solvent extraction and ion exchange, J Marcus and A. S. Kertes Wiley INC 1969.
6. Extraction Chromatography, T. Braun, G. Ghersene, Elsevier Publications 1978.
7. Super critical fluid extraction, Larry Taylor Wiley publishers N.Y. 1996
8. Ion exchange separation in analytical chemistry, O Samuelson John Wiley 2nd ed 1963
9. Ion exchange chromatography, Ed H.F Walton Howden, Hutchenson and Rossing 1976
10. Chromatographic and electrophoresis techniques, I Smith Menemann Interscience 1960
11. Green chemistry and catalyst, R. A. Sheldon, Isabella Arends, Ulf Hanefeld Wiley VCH verlag GmbH & co.
12. Sustainable residential development: planning and design for green neighborhoods. Avi Friedman, McGraw Hill professional.

SEMESTER-IV**PSCHA402****Advanced Instrumental Techniques**

UNIT I	Spectral Methods III	15
	<p>NMR Spectroscopy</p> <p>1.1 Theory and Instrumentation- recapitulation, FTNMR, 2D NMR,- FID signal generation mechanism, Techniques in 2D NMR- homo nuclear correlation spectroscopy (COSY), total correlation spectroscopy (TOCSY), heteronuclear correlation (HETCOR) (9L)</p> <p>1.2 Radio waves in imaging- principle instrumentation and applications of MRI (3L)</p> <p>1.3 Application of NMR to other nuclei C¹³, P³¹ and F¹⁹ spectroscopy (3L)</p>	
UNIT-II	Spectral Methods IV	15
	<p>2.1 Mass spectroscopy: recapitulation, correlation of mass spectra with molecular structure- interpretation of mass spectra, analytical information derived from mass spectra- molecular identification, metastable peaks, Fragmentation Reactions (9L)</p> <p>2.2 Raman spectroscopy: Principle Theory Instrumentation , techniques(SERS and Resonance Raman) and Applications of Raman spectroscopy (6L)</p>	
UNIT III	Radiochemical And Thermal Methods	15
	<p>3.1 Activation analysis- NAA ,radiometric titrations and radio-release methods (7L)</p> <p>3.2 Thermal analysis- Principle, Interfacing , instrumentation and Applications of (a) Simultaneous Thermal Analysis- TG-DTA and TG-DSC (b) Evolved gas analysis- TG-MS and TG-FTIR (8L)</p>	
UNIT IV	Hyphenated Techniques	15
	<p>4.1 concept of hyphenation, need for hyphenation, possible hyphenations. (2 L)</p> <p>4.2 Interfacing devices and applications of GC – MS, ICP -MS, GC - IR, Tandem Mass Spectrometry, LC – MS: HPLC-MS, CE-MS. (13L)</p>	

List of Books and references:

1. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J. Holler
6th Edition (1998)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5th Ed.
4. Instrumental methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A.
5. Thermal methods of Analysis, P. J. Haines, Blackie Academic & Professional, London (1995)
6. Thermal Analysis, 3rd Edition W. W. Wendlandt, John Wiley, N.Y. (1986)
7. Principles and Practices of X-ray spectrometric Analysis, 2nd Ed E. P. Bertain, Plenum Press, NY, (1975)
8. Nuclear Analytical Chemistry, D. Bane, B. Forkman, B. Persson, Chartwell - Bratt Ltd (1984)
9. Standard Methods of Chemical Analysis, Eds. F. J. Welcher, Robert E. Krieger Publishing Company, A series of volumes
10. A Complete Introduction to Modern NMR Spectroscopy 1st Edition by Roger S. Macomber
11. Spectrometric Identification of Organic Compounds Hardcover – by Robert M. Silverstein Wiley
- 12 Tandem Techniques (Separation Science Series) 1st Edition by Raymond P. W. Scott John Wiley & Sons Ltd, 1997
- 13 Encyclopedia of Analytical Science, Editors-in-Chief: Paul Worsfold, Alan Townshend, and Colin Poole ISBN: 978-0-12-369397-6
14. Encyclopedia of Analytical Chemistry: Applications, Theory, and Instrumentation. Meyers Robert A Meyers
15. Introduction to Thermal Analysis Techniques and Applications Edited by Michael E. Brown
- 16 Principles and Applications of Thermal Analysis Edited by Paul Gabbott

SEMESTER – IV
PSCHA403
Selected Topics in Analytical Chemistry

UNIT I	Effluent Treatment	15
	1.1 Effluent treatment plant general construction and process flow charts(3L) 1.2 Treatment and disposal of Sewage.(3L) 1.3. Effluent parameters for metallurgical industry.(2L) 1.4 Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent.(2L) 1.5 Recovery of metals from effluent, modern methods – Electro dialysis, Electrodeposition and Ion Exchange etc.(3L) 1.6 Recycle and reuse of process and treated (effluent) water(2L)	
UNIT – II	Solid Waste Management	15
	2.1 Solid waste management: objectives, concept of recycle, reuse and recovery (3L) 2.2 Methods of solid waste disposal.(2L) 2.3 Treatment and disposal of sludge / dry cake (3L) 2.4 Managing non-decomposable solid wastes(2L) 2.5 Bio- medical waste : Introduction , Classification and methods of disposal (5L)	
UNIT – III	Plastics and Polymers	15
	3.1 Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride, ethylene, acrylic and cellulosic plastics. (5L) 3.2 Metallic impurities in plastic and their determination, (2L) 3.3 Impact of plastic on environment as pollutant.(2L) 3.4 Paints and pigments: Types of paints pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners.(3L) 3.5 Role of Organo silicones in paints and their impact on environment.(3L)	

UNIT – IV:	Metallurgy	15
	<p>4.1 Ores and minerals: Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting) (3L)</p> <p>4.2 Chemical analysis of ores for principal constituents : Galena, Pyrolusite, Bauxite, Hematite, Monazite (4L)</p> <p>4.3 Alloys: definition, analysis of Cupronickel, Magnesium, Steel And Stainless Steel, Bronze, Gun metal.(4L)</p> <p>4.4 Techniques of purification: Zone refining, analysis of high purity materials like silicon , vacuum fusion and extraction techniques. (4L)</p>	

List of Books and References:

1. Environmental Pollution Analysis, S. M. khopkar, New Age International publication (2011).
2. Water and water pollution (hand book) Ed., Seonard'l Ciacere, Vol I to IV, Marcel Dekker inc. N.Y.(1972)
3. Water pollution, Arvind kumar, APH publishing (2004)
4. Introduction to Potable Water Treatment Processes Simon Parsons, Bruce Jefferson, Paperback publication.
5. Solid waste management, K Sasikumar and Sanoop Gopi Krishna PHI publication (2009)
6. Solid waste management, Surendrakumar Northen Book Center (2009)
7. Handbook of chemical technology and pollution control 3rd Edn Martin Hocking AP Publication (2005).
8. Fundamental Concepts of Environmental Chemistry, Second Edition G. S. Sodhi , Alpha Science, 2005
9. Chemical analysis of metals ; Sampling and analysis of metal bearing ores: American Society for Testing and Materials 1980 - Technology & Engineering
10. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines, 1979.
11. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).
- 12. Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology & Engineering (1960).**

SEMESTER – IV
Course Code: PSCHAOC-I 404
(INTELLECTUAL PROPERTY RIGHTS &
CHEMINFORMATICS)

Unit 1:	[15L]
Introduction to Intellectual Property:	[2L]
Historical Perspective, Different types of IP, Importance of protecting IP.	
Patents:	[5L]
Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.	
Industrial Designs:	[2L]
Definition, How to obtain, features, International design registration.	
Copyrights:	[2L]
Introduction, How to obtain, Differences from Patents.	
Trade Marks:	[2L]
Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc.	
Geographical Indications:	[2L]
Definition, rules for registration, prevention of illegal exploitation, importance to India.	
<u>Unit 2:</u>	[15L]
Trade Secrets:	[2L]
Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.	
IP Infringement issue and enforcement:	[2L]
Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.	
Economic Value of Intellectual Property:	[2L]
Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.	
Different International agreements:	
(a) World Trade Organization (WTO):	[5L]
(i) General Agreement on Tariffs and Trade (GATT), Trade	

Related Intellectual Property Rights (TRIPS) agreement

- (ii) General Agreement on Trade Related Services (GATS)
Madrid Protocol.
- (iii) Berne Convention
- (iv) Budapest Treaty

(b) Paris Convention [6L]

WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity.

Unit III: [15L]

Introduction to Cheminformatics: [5L]

History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.

Representation of molecules and chemical reactions: [5L]

Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.

Searching Chemical Structures: [5L]

Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.

Unit IV: [15L]

Applications:

Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design, Application of Cheminformatics in Drug Design.

REFERENCES:

1. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics*. Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling*. Springer-Anamaya Pub.: New Delhi.

Course Code: PSCHAOC-II 404

PAPER – IV: RESEARCH METHODOLOGY

Unit 1:

Print:

Primary, Secondary and Tertiary sources.

Journals:

Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital:

Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources:

The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.

Unit II: DATA ANALYSIS

The Investigative Approach:

Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.

Analysis and Presentation of Data:

Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis.

Unit III: METHODS OF SCIENTIFIC RESEARCH AND WRITING SCIENTIFIC PAPERS

Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.

Writing Scientific Papers:

Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.

Unit IV: CHEMICAL SAFETY & ETHICAL HANDLING OF CHEMICALS

Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure, safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), *Practical skills in Chemistry*, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) *Data Analysis for Chemistry* Oxford University Press.
3. Topping, J., (1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) *How to use Excel in Analytical Chemistry and in general scientific data analysis* Cambridge Universty Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

Practical course

PSCHA4P1

Group – A:

1. Determination of pK value of H_3PO_4 potentiometrically
2. Estimation of Na^+ in dairy whitener by flame photometry
3. Spectrophotometric determination of pH of buffer solution.
4. Simultaneous determination of Ti^{3+} and V^{5+} spectrophotometrically by H_2O_2 method
5. To analyze Bronze for Zn by complexometric method

PSCHA4P2

Group – B:

1. Analysis of drugs by non aqueous titration: Glycine , Sodium Benzoate
2. Analysis of detergents: Active detergent matter, alkalinity and Oxygen releasing capacity
3. Determination of the purity of crystal violet
4. Estimation of Ca in Ca-pentathionate/calcium lactate tablets
5. Canned food: Limits test for tin/zinc

PSCHA4P3

Group – C:

1. Analysis of Calcium, Iron and phosphorous in milk.
2. Determination of SAP value of oil.
3. Estimation of Aldehyde in lemon grass oil / Cinnamon oil
4. Estimation of Glucose by Folin-Wu method
5. Analysis of water sample : Mn^{2+} by colorimetric method

PSCHA4P4

Group – D: Project Evaluation

NOTE:

3. The candidate is expected to submit a journal certified by the Head of the Department / institution at the time of the practical examination.

4. A candidate will not be allowed to appear for the practical examination unless he / she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.

Use of non-programmable calculator is allowed both at the theory and the practical examination.