

**Resolution Number: AC/I (19-20).2.RPS5**

**S.P. Mandali's  
Ramnarain Ruia Autonomous College**



**Syllabus for Semester III and IV**

Program: M.Sc. in Analytical Chemistry

Course Code: (RPSCHEA)

(Credit Based Semester and Grading System with effect from the  
academic year 2019–2020)

### Semester III

Course Code	Unit	Topic	Credits	Lectures
RPSCHEA301	I	Quality in Analytical Chemistry - I	4	15
	II	Quality in Analytical Chemistry - II		15
	III	Chromatographic Techniques -I		15
	IV	Chromatographic Techniques -II		15
RPSCHEA302	I	Spectral Methods I	4	15
	II	Spectral Methods II		15
	III	Electroanalytical Methods		15
	IV	Miscellaneous Techniques		15
RPSCHEA303	I	Bioanalytical chemistry	4	15
	II	Immunological Methods		15
	III	Food Analysis - I		15
	IV	Food Analysis - II		15
RPSCHEAEC-I 304	I	Air Pollution	4	15
	II	Water Quality Standards		15
	III	Other Types Of Pollution		15
	IV	Green Chemistry		15
RPSCHEAEC-II 304	I	Pharmaceutical Analysis	4	15
	II	Drugs		15
	III	Forensic Science		15
	IV	Cosmetic Analysis		15
RPSCHEA3P1		<b>Practical</b>	8	16
RPSCHEA3P2				
RPSCHEA3P3				
RPSCHEA3P4				

## Semester IV

Course Code	Unit	Topic	Credits	Lectures
RPSCHEA401	I	Separation Science	4	15
	II	Separation, Analysis and Standardization of Herbal based products.		15
	III	Industrial Materials		15
	IV	Advanced Techniques		15
RPSCHEA402	I	Spectral Methods III	4	15
	II	Spectral Methods IV		15
	III	Radiochemical And Thermal Methods		15
	IV	Hyphenated Techniques		15
RPSCHEA403	I	Effluent Treatment	4	15
	II	Solid Waste Management		15
	III	Plastics and Polymers		15
	IV	Metallurgy		15
RPSCHEAOC-I 404	I	Introduction to Intellectual Property - I	4	15
	II	Introduction to Intellectual Property - II		15
	III	Introduction to Cheminformatics		15
	IV	Application of Cheminformatics		15
RPSCHEAOC-II 404	I	Review of Literature	4	15
	II	Data Analysis		15
	III	Methods of Scientific Research and Writing Scientific Papers		15
	IV	Chemical Safety & Ethical Handling of Chemicals		15
RPSCHEA4P1	<b>Practical</b>		8	16
RPSCHEA4P2				
RPSCHEA4P3				
RPSCHEA4P4				

**Detail Syllabus**

**SEMESTER III**

**Paper-I**

**Course Code: RPSCHEA301**

**Credits: 4**

**Quality in analytical chemistry**

<b>Unit I</b>	<b>Quality in Analytical Chemistry - I</b>	<b>Lectures</b>
	<p>1.1. Sampling: Definition, types of sample, sampling plan, quality of sample, sub-sampling, Sampling of raw materials, intermediates and finished products. Sample preparations – dissolution technology and decomposition, storage of samples. 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>	<b>15</b>
<b>Unit II</b>	<b>Quality in Analytical Chemistry - II</b>	
	<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 and software methods for noise reduction. (6L)</p> <p>2.3. Principle, process and application of solid phase extraction and Solid phase micro extraction (5L)</p>	<b>15</b>
<b>Unit III</b>	<b>Chromatographic Techniques -I</b>	
	<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 and application to biomolecule (5L)</p>	<b>15</b>
<b>Unit IV</b>	<b>Chromatographic Techniques -II</b>	
	<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. (7L)</p> <p>4.2. Affinity Chromatography: principle, instrumentation and applications (3L)</p> <p>4.3. Ultra pressure liquid chromatography (UPLC) (3L)</p> <p>4.4. Inverse Chromatography (2L)</p>	<b>15</b>

### 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 2<sup>nd</sup> 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

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – III**  
**RPSCHEA302**  
**Credits 4**

**Advance Instrumental Techniques**

Unit I	Spectral Methods I	Lectures
	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. (3L) b. Particle-Induced X-Ray Emission (4L) c. Low-Energy Ion Scattering and Rutherford Backscattering (3L) d. EDX, X-ray diffraction, recapitulation of AFM (4L)	<b>15</b>
Unit II	Spectral Methods – II	
	Principle, Instrumentation, and Applications of 2.1. Electron Spin Resonance Spectroscopy (ESR) (3L) 2.2. Mossbauer's Spectroscopy (3L) 2.3. Atomic Emission Spectroscopy- based on plasma and electrical discharge sources, quantitation with arc and spark sources (5L) 2.4. Spectral interference in AAS, background correction. ( 2L) 2.5. Chemical interference in ICP ( 2L)	<b>15</b>
Unit III	Electroanalytical Methods	
	Advanced Electroanalytical Techniques:- 3.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography, Differential double 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, Biosensor (3L)	<b>15</b>
Unit IV	Miscellaneous Techniques	
	Principle, Instrumentation and Applications of: 4.1. Chemiluminescence techniques (3L) 4.2. Chiroptical Methods : ORD, CD (special application for Bioanalysis) (5L) 4.3. Photoacoustic spectroscopy (3L) 4.4. Spectroelectrochemistry (4L)	<b>15</b>

### List of books and references:

1. Analytical Chemistry, G. D. Christian, 4<sup>th</sup> 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,  
5<sup>th</sup> Edition (1998)
4. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F. A.  
Settle Jr 6<sup>th</sup> Ed CBS (1986)
5. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A.  
Settle Jr 7<sup>th</sup> 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, 2<sup>nd</sup> 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, 2<sup>nd</sup> 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

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – III**  
**RPSCHEA303**  
**Credits 4**  
**Bioanalytical Chemistry and Food Analysis**

Unit I	Bioanalytical chemistry	Lectures
	<p>Body Fluids</p> <p>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>1.2. Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals. (5L)</p> <p>1.3. Analytical techniques (including microbiological techniques) for vitamins. (5L)</p>	15
Unit II	Immunological Methods	
	<p>2.1. General processes of immune response, antigen-antibody reactions, precipitation reactions, radio, enzyme and fluoro-immuno assays.(8L)</p> <p>2.2. Human Nutrition: Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids.(7L)</p>	15
Unit III	Food Analysis - I	
	<p>3.1. Fuel value of food and importance of food nutrients (2L)</p> <p>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)</p> <p>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. Identification and estimation technique use for contamination (8L)</p>	15
Unit IV	Food Analysis - II	
	<p>4.1. Food packaging – Introduction, types of packing materials, properties and industrial requirements.(2L)</p> <p>4.2. Processing and Quality requirements of Milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat Products. (6L)</p> <p>4.3 Analysis of Milk – Fat content, proteins, acidity, bacteriological quality and milk adulterants.(2L)</p> <p>4.4. Analysis of Oils and Fats – acid value, sap value, iodine value. Determination of rancidity and antioxidants.(2L)</p> <p>4.5. Analysis of spices (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils.(3L)                      (Emphasis on analytical techniques)</p>	15



### 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
11. Analysis of food and beverages, George Charalanbous, Accademic press 1978

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – III**  
**RPSCHEAEC-I 304**  
**Credits 4**

**Environmental and Certain Industrially Important Materials**

Unit I	Air Pollution	Lectures
	1.1. Sources, classification, pollutants and permissible limits.(2L) 1.2 Sampling methods for air, flew gas ,Industrial Exhaust, stag samples etc. (2L) 1.3. Importance of automobile exhaust control and its limits(2L) 1.4. Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. (3L) 1.5. Carbon credit and global issues related to air pollution.(3L) 1.6. Greenhouse gases and their substitutes. (1L) 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)	15
Unit II	Water Quality Standards	
	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) 2.2. Bore well water quality and analytical parameters. Quality of bottled mineral water (3L) 2.3. Process of purification of bore well water to bottled mineral water. (2L) 2.4 Regulatory requirements for packaged drinking water (4L)	15
Unit III	Other Types Of Pollution	
	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) 3.2 Noise Pollution : sources, effects, methods of measurements and control measures.(2L) 3.3 Thermal Pollution: definition, source, impact, control measures, working of cooling towers and cooling ponds, involved economy (3L) 3.4 Radioactive pollutants: source, exposure hazards, precautions in handling and safety, Long term effects. (2L) 3.5 Environmental Audits: concept of audit, authorities, evaluation methodology, benefits and certification (2L)	15
Unit IV	Green Chemistry	
	4.1. Principle and concepts of green chemistry: sustainable development and green chemistry, atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity (4L) 4.2. Organic solvents: environmentally benign solutions, solvent free systems, supercritical fluids (only introduction) Ionic liquids as catalysts and solvents (4L) 4.3 Emerging Green Technologies: photochemical reactions (advantages and challenges), examples. Chemistry using microwaves, sonochemistry and electrochemical synthesis. (4L) 4.4. Designing Greener Processes: Inherently Safer Designs (ISD), Process intensification (PI) in-process monitoring. (3L)	15

### List of Books and References:

1. Environmental Chemistry, A. K. De, 2<sup>nd</sup> 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

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – III**  
**RPSCHEAEC-II 304**  
**Credits 4**

**Pharmaceutical and Organic Analysis**

Unit I	Pharmaceutical Analysis	Lectures
	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.(5L) 1.2 Sources of impurities in pharmaceutical products and raw materials. (3L) 1.3 Standardization of finished products and their characteristics, official methods of quality control. (3L) 1.4. 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. (4L)	15
Unit II	Drugs	
	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. (6L) 2.2 Limit tests, solubility tests, disintegration tests, stability studies (4) 2.3 bioequivalence and bioavailability studies. (2L) 2.4 impurity profile of drugs (2L) 2.5. Polymers in pharmaceuticals and novel drug delivery systems.(1L)	15
Unit III	Forensic Science	
	3.1 Analytical Chemistry in Forensic Science: General idea.(2L) 3.2 Forensic Analysis: Blood, DNA profiling, Hair analysis, Finger prints 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)	15
Unit IV	Cosmetic Analysis	
	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)	15

## 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) Harry's Cosmetology, 7<sup>th</sup> Ed, Longman Scientific Co.
- 4) Formulation and Function of Cosmetics, Joseph Stefan Jellinek, Wiley Interscience, 1971.
- 5) Cosmetic Technology, Edward Sagarin, Interscience Publishers, 1957.
- 6) Modern Cosmetics, Edgar George Thommsen, Francis Chilson, Drug and Cosmetic Industry, 1947.
- 7) Encyclopedia of Industrial Chemical Analysis, Foster Dee Snell et al, Interscience Publishers, 1967.
- 8) Government of India Publications of Food, Drug and Cosmetic Act and Rules.
- 9) The Handbook of Drug Laws, M L Mehra, University Book Agency, Ahmedabad, 1997.
- 10) Chemical Analysis of Drugs, Takeru Higuchi, Interscience Publishers, 1995.
- 11) Text book of Pharmaceutical Analysis, Kenneth Antonio Connors, Wiley, 2001.
- 12) Food Processing and Preservation, B Sivasankar, Prentice - Hall of India Private Limited, 2007.
- 13) Food Additives, R M Pandey and S K Upadhyay, INTECH, Open Science/Open Minds.
- 14) Food Science, B Srilakshmi, New Age International (P) Ltd. Publishers, 2003.
- 15) Food Contaminants: Sources and Surveillance, Edited by C Creaser, R Purchase, Elseiver, 1991.
- 16) The Chemical Analysis of Food and Food Products, Morris B Jacobs.
- 17) 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.
- 18) Fundamentals of Urine and Body Fluid Analysis, Nancy A Brunzel, Elsevier health Sciences, 2013.
- 19) Lab Manual on Blood analysis and Medical Diagnostics, Dr Gayatri Prakash, S Chand and Company Ltd, New Delhi.
- 20) Manual of Medical Laboratory Techniques, S Ramakrishnan and K N Sulochana, Jaypee Brothers Medical Publishers (P) Ltd, 2012.
- 21) Indian Pharmacopeia, Volume I and II.
- 22) Forensic Chemistry, Suzanne Bell, Pearson Prentice Hall Publication, 2006.
- 23) Forensic Chemistry, David E Newton, Infobase Publishing, 2007.
- 24) Encyclopedia of Analytical Chemistry, Volume 3, Academic Press, 1995.
- 25) AOAC Volume I and II.

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – III**  
**Practical**

**RPSCHEA3P1: Group A**

1. Determination of the pK value of an indicator.
2. Determination of aniline and ethanolamine in a mixture of two in acetonitrile by potentiometric titration.
3. Determination of mixture of halides potentiometrically.
4. Estimation of strong acid, weak acid and salt in the given mixture conductometrically.
5. Analysis of mixture of carbonate and bicarbonate using pH metry
6. Simultaneous determination of mixture of metal ions (copper and lead) by electrogravimetry.
7. Separation of parabenes using HPLC. Find number of theoretical plates
8. Separation of alcohol / ester by GC.

**RPSCHEA3P2: Group B**

1. Estimation of drugs by non aqueous titration: Pyridoxine hydrochloride, Mebendazole.
2. Determination of percent purity of methylene blue.
3. Estimation of cholesterol and Uric acid in the given sample of blood serum
4. Estimation of Glucose by Folin-Wu method.
5. Estimation of fluoride in a tooth paste
6. Estimation of Ca in Ca-pentathionate/calcium lactate tablets
7. TLC separation of amino acids.

**RPSCHEA 3P3: 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 Vitamin C in lemon Juice/squash by Dichlorophenol- indophenol method
4. Analysis of oil sample for the determination of SAP value, Iodine value and acid value.
5. Estimation of aldehyde in lemon oil / Cinnamon oil
6. Analysis of milk for its Ca, P and Fe content .
7. Caffeine in tea by HPLC and UV.

**RPSCHEA 3P4: Group D**

1. Determination of Silica by molybdenum blue method.
2. Estimation of copper by extractive photometry.
3. Estimation of Glycine by Sorensen formol titration .
4. Separation of Ni(II) and Co(II) using anion exchanger column.
5. Estimation of vitamin C using  $\text{KBrO}_3$  method.
6. Analysis of detergents: Active detergent matter, alkalinity and Oxygen releasing capacity.

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – IV**  
**RPSCHEA 401**  
**Credits 4**

**Quality in Analytical Chemistry**

Unit I	Separation Science	Lectures
	<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. Solvent extraction in sample preparation SPE, SPME, Liquid - liquid extraction, microwave extraction. (4L)</p> <p>1.3 concept of pH 1/2, expression for pH ½ and its significance (1L)</p> <p>1.4 Craig countercurrent extraction, Theoretical treatment and application in biological sample.(2L)</p>	15
Unit II	Separation, Analysis and Standardization of Herbal based products.	
	<p>2.1. Herbs as a raw material: Definition 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 toxicological standardization, qualitative and quantitative estimations.(6L)</p>	15
Unit III	Industrial Materials	
	<p>3.1 Insecticides, Pesticides: definition, classification of insecticides pesticides. Biodegradation of insecticides and pesticides (5L).</p> <p>3.2 Soaps and Detergents: classification and composition, qualitative analysis, quantitative analysis of detergents- alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents (5L)</p> <p>3.3 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>	15
Unit IV	Advanced Techniques	
	<p>4.1. Electrophoresis: introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephedax and thin layers) (7L)</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>	15

### **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.



**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – IV**  
**RPSCHEA 402**  
**Credits 4**  
**Advance Instrumentation technique**

Unit I	Spectral Methods III	Lectures
	<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 C<sup>13</sup>, P<sup>31</sup> and F<sup>19</sup> spectroscopy (3L)</p>	15
Unit II	Spectral Methods IV	
	<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, meta stable 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>	15
Unit III	Radiochemical And Thermal Methods	
	<p>3.1 Activation analysis- NAA ,radiometric titrations and radio-release methods (3L)</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> <p>3.3. Principle, instrumentation and application of Head space GC and UPLC (4L)</p>	15
Unit IV	Hyphenated Techniques	
	<p>4.1 concept of hyphenation, need for hyphenation, possible hyphenations. (2L)</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>	15

### List of Books and references:

1. Analytical Chemistry, G. D. Christian, 4<sup>th</sup> Ed. John Wiley, New York (1986)
2. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West and F. J Holler Holt- Saunders 6<sup>th</sup> Edition (1998)
3. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann 5<sup>th</sup> 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, 3<sup>rd</sup> Edition W. W. Wendlandt, John Wiley, N.Y. (1986)
7. Principles and Practices of X-ray spectrometric Analysis, 2<sup>nd</sup> 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 1<sup>st</sup> Edition by Roger S. Macomber
11. Spectrometric Identification of Organic Compounds Hardcover – by Robert M. Silverstein Wiley
- 12 Tandem Techniques (Separation Science Series) 1<sup>st</sup> 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

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – IV**  
**RPSCHEA 403**  
**Credits 4**

**Environmental and Certain Industrially Important Materials**

Unit I	Effluent Treatment	Lectures
	1.1. Effluent treatment: primary secondary and tertiary (2L) 1.2 Plant general construction and process flow charts(3L) 1.3 Treatment and disposal of sewage.(3L) 1.4. Effluent parameters for metallurgical industry Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent.(2L) 1.4 Recycle and reuse of process and treated (effluent) water(2L) 1.5 Recovery of metals from effluent, modern methods – electro dialysis, electrodeposition and Ion Exchange etc.(3L)	15
Unit II	Solid Waste Management	
	2.1. Solid waste types and characteristic (2L) 2.2. Solid waste management: objectives, concept of recycle, reuse and recovery (3L) 2.3. Methods of solid waste disposal.(2L) 2.4. Treatment and disposal of sludge / dry cake (3L) 2.5 Managing non-decomposable solid wastes (2L) 2.6 Bio- medical waste : Introduction , Classification and methods of disposal (2L) 2.7 Treatment and disposal of sewage (1L)	15
Unit III	Plastics and Polymers	
	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)	15
Unit IV	Metallurgy	
	4.1. Ores and minerals: Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting ) (3L) 4.2. Chemical analysis of ores for principal constituents : Galena, Pyrolusite, Bauxite, Hematite, Monazite (4L) 4.3 Alloys: definition, analysis of Cupronickel, Magnesium, Steel And Stainless Steel, Bronze, Gun metal.(4L) 4.4 Techniques of purification: Zone refining, analysis of high purity materials like silicon, vacuum fusion and extraction techniques. (4L)	15

### 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 3<sup>rd</sup> 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).

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – IV**  
**RPSCHEAOC-I 404**  
**Credits 4**

**Intellectual Property Rights & Cheminformatics**

Unit I	Introduction to Intellectual Property	Lectures
	<p><b>Introduction to Intellectual Property:</b>  Historical Perspective, Different types of IP, Importance of protecting IP.</p> <p><b>Patents:</b>  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.</p> <p><b>Industrial Designs:</b>  Definition, How to obtain, features, International design registration.</p> <p><b>Copyrights:</b>  Introduction, How to obtain, Differences from Patents.</p> <p><b>Trade Marks:</b>  Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc.</p> <p><b>Geographical Indications:</b>  Definition, rules for registration, prevention of illegal exploitation, importance to India.</p>	15
Unit II	Introduction to Intellectual Property-II	15 L
	<p><b>Trade Secrets:</b>  Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.</p> <p><b>IP Infringement issue and enforcement:</b>  Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.</p> <p><b>Economic Value of Intellectual Property:</b>  Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.</p> <p><b>Different International agreements:</b></p> <p>(a) <b>World Trade Organization (WTO):</b></p> <ul style="list-style-type: none"> <li>(i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement</li> <li>(ii) General Agreement on Trade Related Services (GATS) Madrid Protocol.</li> <li>(iii) Berne Convention</li> <li>(iv) Budapest Treaty</li> </ul> <p>(b) <b>Paris Convention</b></p> <p><b>WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity.</b></p>	15

<b>Unit III</b>	<b>Introduction to Cheminformatics</b>	
	<p><b>Introduction to Cheminformatics</b></p> <p>History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.</p> <p><b>Representation of molecules and chemical reactions:</b></p> <p>Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.</p> <p><b>Searching Chemical Structures:</b></p> <p>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.</p>	15
<b>Unit IV</b>	<b>Applications</b>	
	<p><b>Applications:</b> 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.</p>	15

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – IV**  
**RPSCHEAOC-II 404**  
**Credits 4**  
**Research methodology**

Unit I	Review of Literature	Lectures
	<p><b>Print:</b> Primary, Secondary and Tertiary sources.</p> <p><b>Journals:</b> 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.</p> <p><b>Digital:</b> 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.</p> <p><b>Information Technology and Library Resources:</b> The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.</p>	15
Unit II	Data Analysis	
	<p><b>The Investigative Approach:</b> Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.</p> <p><b>Analysis and Presentation of Data:</b> 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.</p>	15
Unit III	Methods of Scientific Research and Writing Scientific Papers	
	<p>Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.</p> <p><b>Writing Scientific Papers:</b> Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.</p>	15
Unit IV	Chemical Safety & Ethical Handling of Chemicals	
	<p>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.</p>	15

**Ramnarain Ruia Autonomous College**  
**M.Sc. Analytical Chemistry**  
**SEMESTER – IV**  
**Practical**

**RPSCHEA4P1: Group A**

1. Analysis of tamra bhasma by AAS and UV
2. Estimation of Na<sup>+</sup> in dairy whitener by flame photometry
3. Spectrophotometric determination of pH of buffer solution.
4. Simultaneous determination of Ti<sup>3+</sup> and V<sup>5+</sup> spectrophotometrically by H<sub>2</sub>O<sub>2</sub> method
5. Estimation of Aspirin by conductometrically.
6. Recording and interpretation of IR spectra of given compound.
7. Identification of components of essential oils by GCMS.
8. Determination of water in organic solvent by Karl Fischer method.

**RPSCHEA4P2: Group B**

1. To analyze Pyrolusite for: Fe by redox titration and / or Mn by colorimetry.
2. To analyze galena for: Pb by Complexometric
3. Analysis of Cupronickel alloy by electrogravimetry.
4. To analyze Magnesium for Mg titrimetrically.
6. To analyze Bronze for Zn by volumetric method
7. To analyze Steel for: Ni and Cr

**RPSCHEA4P3: Group C**

**Interpretation of spectral data (UV, IR, PMR, CMR, Mass spectra, XRD, Thermal)**

A student will be given UV, IR, PMR, CMR, Mass spectra, of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc

**(Minimum 8 spectral analysis)**

**RPSCHEA4P4: Group D**

Project Evaluation



## MODALITY OF ASSESSMENT

### Theory Examination Pattern:

#### A) Internal Assessment - 40%:

40 marks.

Sr No	Evaluation type	Marks
1	Presentation	20
2	Assignment	10
3	Active participation	10
	<b>Total</b>	<b>40</b>

#### B) External examination - 60 %

##### Semester End Theory Assessment - 60 marks

- i. Duration - These examinations shall be of **2.5 hours** duration.
- ii. Paper Pattern:
  1. There shall be **04** questions each of **15** marks. On each unit there will be one question.
  2. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions on
Q.1)A)	Any 3 out of 5	12	Unit I
Q.1)B)	Any 1 out of 2	3	
Q.2)A)	Any 3 out of 5	12	Unit II
Q.2)B)	Any 1 out of 2	3	
Q.3)A)	Any 3 out of 5	12	Unit III
Q.3)B)	Any 1 out of 2	3	
Q.4)A)	Any 3 out of 5	12	Unit IV
Q.4)B)	Any 1 out of 2	3	

**Practical Examination Pattern:**

**Semester end practical examination: 50 marks**

<b>Experimental work</b>	<b>40</b>
<b>Viva</b>	<b>05</b>
<b>Journal</b>	<b>05</b>
<b>Total</b>	<b>50</b>

**PRACTICAL BOOK/JOURNAL**

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

**In case of loss of Journal, a Lost Certificate should be obtained from Head/ Co-ordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.**

**Overall Examination and Marks Distribution Pattern**

**Semester: III and IV**

<b>Course</b>	<b>301/401</b>			<b>302/402</b>			<b>Grand Total</b>
	<b>Internal</b>	<b>External</b>	<b>Total</b>	<b>Internal</b>	<b>External</b>	<b>Total</b>	
<b>Theory</b>	<b>40</b>	<b>60</b>	<b>100</b>	<b>40</b>	<b>60</b>	<b>100</b>	<b>200</b>
<b>Practicals</b>			<b>50</b>			<b>50</b>	<b>100</b>

<b>Course</b>	<b>303/403</b>			<b>304/404</b>			<b>Grand Total</b>
	<b>Internal</b>	<b>External</b>	<b>Total</b>	<b>Internal</b>	<b>External</b>	<b>Total</b>	
<b>Theory</b>	<b>40</b>	<b>60</b>	<b>100</b>	<b>40</b>	<b>60</b>	<b>100</b>	<b>200</b>
<b>Practicals</b>			<b>50</b>			<b>50</b>	<b>100</b>

**Total: 600 marks**