

# S.N.D.T. WOMEN'S UNIVERSITY



**Proposed Syllabus for  
M.Sc. Programme  
Subject: Analytical Chemistry  
Revised-2014**

**Eligibility:** B. Sc. with 5 units of 4 credits each (Annual System) or 32 credits (Semester System) of Chemistry.

**FACULTY : Science**

**TOTAL CREDIT : 96**

**COURSE : Masters in Analytical Chemistry (M.Sc.)**

**SEMESTER I**

| Paper | Title                                   | Hrs/wk | Internal | External | Total Marks | Credit |
|-------|-----------------------------------------|--------|----------|----------|-------------|--------|
| 1001  | Fundamentals of Analytical Chemistry    | 4      | 50       | 50       | 100         | 4      |
| 1002  | Food & Biochemical Analysis             | 4      | 50       | 50       | 100         | 4      |
| 1003  | Environmental Science                   | 4      | 50       | 50       | 100         | 4      |
| 1004  | Drug Laws and Packaging                 | 4      | 50       | 50       | 100         | 4      |
| 1005  | Practical Analytical Chemistry          | 8      | 50       | 50       | 100         | 4      |
| 1006  | Practical Food and Biochemical Analysis | 8      | 50       | 50       | 100         | 4      |
| Total |                                         |        |          |          | 600         | 24     |

**SEMESTER II**

| Paper | Title                                      | Hrs/wk | Internal | External | Total Marks | Credit |
|-------|--------------------------------------------|--------|----------|----------|-------------|--------|
| 2001  | Electro Analytical & Spectroscopic Methods | 4      | 50       | 50       | 100         | 4      |
| 2002  | Pharmaceutical Analysis                    | 4      | 50       | 50       | 100         | 4      |
| 2003  | Cosmetics Formulations & QC                | 4      | 50       | 50       | 100         | 4      |
| 2004  | Research Methodology                       | 4      | 50       | 50       | 100         | 4      |
| 2005  | Practical Spectroscopy and Chromatography  | 8      | 50       | 50       | 100         | 4      |
| 2006  | Practical Pharmaceutical Analysis          | 8      | 50       | 50       | 100         | 4      |
| Total |                                            |        |          |          | 600         | 24     |

**SEMESTER III**

| Paper | Title                                           | Hrs/wk | Internal | External | Total Marks | Credit |
|-------|-------------------------------------------------|--------|----------|----------|-------------|--------|
| 3001  | Advanced Chromatography & Spectroscopic Methods | 4      | 50       | 50       | 100         | 4      |
| 3002  | Organic Analysis                                | 4      | 50       | 50       | 100         | 4      |
| 3003  | Microbiological Methods of Analysis             | 4      | 50       | 50       | 100         | 4      |

|       |                                          |   |    |    |     |    |
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| 3004  | Elective Paper                           | 4 | 50 | 50 | 100 | 4  |
| 3005  | Practical Advanced Spectroscopic Methods | 8 | 50 | 50 | 100 | 4  |
| 3006  | Practical Organic Analysis               | 8 | 50 | 50 | 100 | 4  |
| Total |                                          |   |    |    | 600 | 24 |

#### SEMESTER IV

| Paper | Title                                       | Hrs/wk | Internal | External | Total Marks | Credit |
|-------|---------------------------------------------|--------|----------|----------|-------------|--------|
| 4001  | Advanced Analytical Techniques (9 wks)      | 4      | 50       | 50       | 100         | 4      |
| 4002  | Practical Advanced Anal. Techniques (9 wks) | 8      | 50       | 50       | 100         | 4      |
| 4003  | Research Project (9 wks)                    | 12     | 100      | 100      | 200         | 8      |
| 4004  | In-plant training (6 weeks)                 | 40     | 100      | 100      | 200         | 8      |
| Total |                                             |        |          |          | 600         | 24     |

**25 Marks, 1 credit, 15Hrs (1 lecture=1 hour)**

#### Elective

1. Industrial Products & Forensic Analysis
2. Medicinal Chemistry
3. Biosensors, Agrochemicals & Organic Polymers

#### Methodology

1. Lectures, Tutorials
2. Self study/ Internet/ Websites
3. Home assignments

#### Internal Assessment (Any One)

1. Presentation on one of the topic from the text
2. Community extension work
3. Field survey

| <b>SEMESTER I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                   |
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| <b>Code: 1001</b>                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Title: Fundamentals of Analytical Chemistry</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To understand the basic concepts of analytical techniques.<br/>           ii) Able to prepare standard solutions.<br/>           iii) To acquire knowledge of theoretical concepts of volumetric techniques.<br/>           iv) To develop expertise in collection, preparation and preservation of samples.<br/>           v) Participants will use statistical aids to compile, tabulate, evaluate and present analytical data.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                   |
| <b>Paper I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>Analytical Basics:<br/>           a) Analytical chemistry - Scope, functions and analytical process.<br/>           b) Sampling: Collection, Preservation and preparation of sample, Techniques of sampling solids, liquids and gases; Operation of drying and preparing a solution of the analyte.<br/>           c) Chemometrics</p> <p>Topics to be covered in the form of numerical problems: Concentration of a solution based on volume and mass units, Calculation of ppm, ppb and dilution of the solutions, Concept of mmol and kgmol, Stoichiometry of chemical reactions, Limiting reactant, Theoretical and practical yield, Calculation of pH of acids, bases and acidic and basic buffers; Concept of formation constant, Stability and instability constant, Stepwise formation constants.</p> | 15 Lectures       |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <p>Volumetric Methods of Analysis<br/>           Introduction to Volumetric Methods:<br/>           Calibration of volumetric apparatus, Primary and Secondary Standards, Principles of volumetric analysis, Acid-base titration. Titration in non-aqueous solvents, Complexometric titrations, Precipitation titrations, Redox titrations, Theoretical aspects of titration curves and end point evaluation, Choice and suitability of indicators in each case.</p>                                                                                                                                                                                                                                                                                                                                             | 15 Lectures       |

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| Unit III | <p>Separation Methods:</p> <p>a) Solvent extraction: Efficiency of extraction, Selectivity of extraction, Extraction system, Method of Extraction, applications.</p> <p>b) Solid Phase Extraction: Principle, process and applications.</p> <p>c) Planer Chromatography: Principles, Classification of chromatographic techniques, Technique and applications of paper chromatography, Thin-layer chromatography.</p> <p>d) HPTLC conversion of TLC to quantitative measurements, densitometric detectors, fluorimetric detectors.</p> | 15 Lectures |
| Unit IV  | <p>Statistics:</p> <p>Evaluation of Analytical Data, Precision and Accuracy, Types of Errors, Normal Distribution Curve, Standard deviation, Confidence limit.</p> <p>Graphical presentation of result- Method of average, Method of Linear least square, Significant figures.</p> <p>Statistical aid to hypothesis testing: t-test, F-test, chi- 2 test, Correlation.</p>                                                                                                                                                             | 15 Lectures |

#### Reference Books:

1. Skoog D. A., West D. M., Holler and Crouch, Fundamentals of Analytical Chemistry, Cengage Learning, Wiley-VCH Weinheim, 2011.
2. J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas, Vogel's Quantitative Chemical Analysis, Pearson Education, ELBS, 6<sup>th</sup> Edition, 2009.
3. Fifeild F.W. and Kealey D, Principle & Practice of Analytical Chemistry, Blackwell Science, 5<sup>th</sup> Edition, 2000.
4. Gary D. Christian, Purnendu Dasgupta, Kevin Schug, Analytical Chemistry, John Wiley, 7<sup>th</sup> Edition, 2013.
5. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 6<sup>th</sup> Edition, 2006.
6. Ahuja & Jespersen, Modern Instrumental Analysis, Elsevier Science, 1<sup>st</sup> Edition, 2006.
7. D.C. Harris, Exploring Chemical Analysis, W.H. Freeman, 3<sup>rd</sup> Edition, 2005.
8. Edited by Pradyot Patnaik, Dean's Analytical Chemistry Handbook, McGraw Hill, 2<sup>nd</sup> Edition, 2004.
9. Klaus Danzer, Analytical Chemistry, Springer-BBH, 2007.
10. A.L. Underwood, Quantitative Analysis, Prentice-Hall of India Pvt Ltd., 1999.

| SEMESTER I        |                                             |                   |
|-------------------|---------------------------------------------|-------------------|
| <b>Code: 1002</b> | <b>Title: Food and Biochemical Analysis</b> | <b>Credits: 4</b> |

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| <p><b>Objectives:</b> i) To understand regulation and legislation related to food safety.<br/> ii) Able to compare quality parameters of various food products.<br/> iii) Able to perform methods of biochemical analysis.<br/> iv) Participant will be able to use methods of food analysis for various products.<br/> v) This knowledge will enable them to perform better in food industries.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                 |
| <b>Paper II</b>                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>60 Hours</b> |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                               | <p>a) Regulations &amp; Legislation of Food:<br/> Norms, Rules and Regulations, Food Safety and standards Act 2006, Statistical Process Control, Process Quality and Control Limits.</p> <p>b) Food Additives &amp; Preservatives<br/> Characteristics of Food Preservatives, Anti-oxidants, Emulsifiers and stabilizers, Improvers and Bleaching agents, Artificial sweetening agents.</p>                                                                           | 15Lectures      |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                              | <p>a) Food Quality Parameters:<br/> Composition &amp; Impurities in Food, Common Adulterants found in food and Tests. Determination of Moisture, Ash value, Calorific value of foods, Saponification value, Acid value, Iodine value, Peroxide value of edible oil.</p> <p>b) Food colors<br/> Role of permitted colors, Classification of food colors with chemical structures, Synthetic colors and natural colors, Advantages and Disadvantages of food color.</p> | 15Lectures      |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                             | <p>a) Biochemical analysis:<br/> Analysis of blood sample, Serum plasma, Urine test, Blood sugar, Electrolytes in body, Substance Glutamic-Oxaloacetic Transaminase Test (SGOT), Substance Glutamate Pyruvate Transaminase (SGPT), Sputum.</p> <p>b) Body profile:<br/> Liver profile, Renal profile, Thyroid profile.</p>                                                                                                                                            | 15Lectures      |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                              | <p>a) Food analysis:<br/> Wheat flour, Milk &amp; Milk products, Tea &amp; Coffee, Honey, Jam &amp; Jelly.</p> <p>b) Bread, Biscuits, Ice Cream, Butter, Cheese, Soft drinks, Alcoholic beverages, Cereals and pulses, Confectionery, Fruits, Vegetable, Egg, Fish, Meat.</p>                                                                                                                                                                                         | 15Lectures      |

**Reference Books:**

1. George Latimer, Official Methods of Analysis of AOAC International (AOAC = Associate of Analytical Communities), Publication – AOAC, 19<sup>th</sup> Edition, 2012.
2. Suzanne Nielson, Food Analysis, Springer, 2010.
3. Yeshajahu Pomeranz, Meloon Editor, Food Analysis Theory & Practice, Springer, 2002.
4. Kirk Sawyer, Pearson Composition & Analysis of Food, Longman Scientific & Technical, 9<sup>th</sup> Edition, 1992.
5. D. B. Wetzel & G. Charalambous, Instrumental Methods in Food and Beverages Analysis, Elsevier Publication, 1998.
6. M.B. Jacob, Chemical Analysis of Food and Food Products, CBSPB Publisher, 3<sup>rd</sup> Edition, 2006.
7. M. L. Nollet, Handbook of Food Analysis, CRC Press, 2<sup>nd</sup> edition, 2004.
8. Semih Otles, Handbook of Food Analysis Instruments, CRC Press, 2008.
9. V. Villavecchia, Treatise on Applied Analytical Chemistry, Methods and Standards for the Chemical Analysis of Industrial and Food Vol I & II, Nabu Press, 2012.
10. Editor Dr. Pico Yolanda, Chemical Analysis of Food: Techniques and Applications, Academic Press, 2012.
11. Semih Otles, Methods of Analysis of Food Components and Additives, CRC Press, 2<sup>nd</sup> Edition, 2011.

| <b>SEMESTER I</b>                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                  |
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| <b>Code: 1003</b>                                                                                                                                                                                                                                                                                                                                                     | <b>Title: Environmental Science</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Credits 4</b> |
| <p><b>Objectives:</b> i) To identify different types of environmental pollutants and their global impact.<br/>           ii) To compare causes and effects of pollutants on human life.<br/>           iii) To correlate various methods for control of environmental pollution.<br/>           iv) Acquire knowledge to promote better environmental conditions.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                  |
| <b>Paper III</b>                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>60 Hours</b>  |
| UNIT I                                                                                                                                                                                                                                                                                                                                                                | a) Air pollution: Sources and sinks of gas pollutants, classification & effects of air pollutants on ecosystem, Air pollution problems in India, Pollution problems in industrial area, Global air pollution problems, Greenhouse effect, Acid rain, Ozone depletion and their consequences on environment, Major air pollution disasters.<br>b) Water pollution: Types of sources and classification of water pollutants, Industrial water pollution, Constituents of aquatic environment, Oxygen contents of water and aquatic life, Oxygen electrode and its use, Mercury pollution and estimation of organomercurials in industrial water, effects of water pollutants on ecosystem. | 15lectures       |

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| UNIT II  | a) Methods of control of air pollution: Electrostatic precipitation, wet & dry scrubber, filters, gravity and cyclonic separation, Adsorption, absorption and condensation of gaseous effluent.<br>b) Methods of control of water pollution: water and waste water treatment, aerobic and anaerobic, aeration of water, principle of coagulation, flocculation, softening, disinfection, demineralization and fluoridation.                                                                                                                                                                                    | 15 lectures |
| UNIT III | Sampling & analysis of air and water pollutants:<br>a) Methods of sampling gaseous, liquid and solid pollutants, Separation of selected Cations & Anions, Analysis of total cationic and anionic burdens of water. Analysis of gases CO, CO <sub>2</sub> , NO <sub>2</sub> , SO <sub>2</sub> , H <sub>2</sub> S. Analysis of toxic heavy metals Cd, Cr, As, Pb, Cu.<br>b) Pesticide: residue analysis, soil pollution, sources of pesticides residue in the environment, pesticides degradation by natural forces, effect of pesticide residue on life, Analytical techniques for pesticides residue analysis. | 15 lectures |
| UNIT IV  | a) Radiation pollution: Classification & effects of radiation, effects of ionizing radiation on man, effects of non-ionizing radiation on life, radioactivity and nuclear fallout, protection and control from radiation.<br>b) Environmental toxicology: Chemical solutions to environmental problems biodegradability, principles of decomposition for better industrial processes.                                                                                                                                                                                                                          | 15 lectures |

#### Reference Books:

1. A.K. De, Environmental Chemistry, New Age International Publication, 5<sup>th</sup> Edition, 2005.
2. Wark K. & Werner C., Edited by David and Liptak, Air Pollution, CRC press LLC, 3<sup>rd</sup> Edition, 2000.
3. S.P. Mahajan, Environmental Pollution Control in Process Industries, Tata McGraw Hill Publishing Co. Ltd, 2008.
4. B. K. Sharma & H. Kaur, Environmental Pollution, Krishna Prakashan Media Pvt Ltd, 2001.
5. R. K. Trivedi, P. K. Goyal, Introduction to Air pollution, ABD publisher, 2003.
6. P. K. Goyal, Water Pollution: Causes Effect and control, New Age International Publication, 2006.
7. S. M. Khopkar, Environmental Pollution Analysis, New Age International Publication, 2011.
8. C. S. Rao, Environmental Pollution Control Engineering, New Age International, 2007.
9. R. Engel, Edited By Ryden Powell, Migula Anderson, Environmental Sciences, Baltic Univ. Publication, 2003.
10. Arvind Kumar, Water Pollution, APH Publishing, 2004.



11. G. S. Sodhi, Fundamental Concepts of Environmental Chemistry, Alpha Science, 2<sup>nd</sup> Edition, 2005.
12. S. G. Misra & Dinesh Mani, Soil Pollution, APH Publishing Corporation, 2009.
13. S. S. Dara, A Textbook of Environmental Chemistry & Pollution Control, S. Chand Ltd, New Delhi, 2006.

| <b>SEMESTER-I</b>                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                   |
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| <b>Code: 1004</b>                                                                                                                                                                                                                                                                                                                                                                                | <b>Title: Drug Laws &amp; Packaging</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To understand the basic regulation and legislation of drugs.<br/>           ii) Able to use prevention of food adulteration .<br/>           iii) To compare standards of ISI and AGMARK.<br/>           iv) To identify better packaging materials based on advantages and limitations.<br/>           v) To promote good practices to become better professional.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                   |
| <b>Paper III</b>                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                           | a) Legislation and Regulation of Drug: Pharmaceuticals Act, Drugs and Cosmetics Act 1940, US FDA Requirements, EU requirements, International Conference on Harmonization (ICH) guidelines.<br>b) Prevention of Food Adulteration Act & Rules (PFA 1954): Fruit Product Order, Meat Product Order.                                                                                                                                                                                                                                                                                                            | 15Lectures        |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                          | a) Statutory status of pharmacopoeia: Structure of Pharmacopoeia CODEX, Mandatory requirements, Guidelines for license for pharmaceutical industry, Violation of drug laws and statutory punishment.<br>b) Pharmacopoeia: IP, USP, British pharmacopoeia, European pharmacopoeia, National Formulary (NF), Monographs.                                                                                                                                                                                                                                                                                        | 15Lectures        |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                         | Food Standard Laboratories:<br>The role of Govt. Authorities, their qualification, duties, powers and procedure to be followed.<br>ISI (Indian Standard for Industrial Products), AGMARK (Standardization & grading of Agriculture and allied produce) and other standard for goods & Cosmetic particularly with reference the testing of foods, drug and cosmetic and the raw material concerned.<br>i) Record to be maintained under the Acts<br>ii) Requirements of Quality Control Department for 'WHO' certification, ISO standardization,<br>iii) Implementation process of Accreditation of analytical | 15Lectures        |

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|         | laboratory.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |             |
| Unit IV | <p>a) Packaging materials: Role of packaging material in drug, Food &amp; cosmetic industry, Classification of packaging materials-Glass, Metal, Polymer with their advantages and disadvantages; Testing of material for Packing, Legal consideration in Packing.</p> <p>b) Good Practices: Philosophy of Good manufacturing Practices, Good documentation practices (GDP).<br/>         Concept of good manufacturing practices (CGMP),<br/>         Concept of good laboratory practices (CGLP).</p> | 15 Lectures |

**Reference Books:**

1. Handbook on Modern Packaging Industries, NIIR Project Consultancy Services, Asia Pacific Business Press Inc., 2<sup>nd</sup> Edition, 2010.
2. Edward Baur, Pharmaceutical Packaging Handbook, Publisher Taylor and Francis, 2009.
3. G. L. Robertson, Food Packaging Principle & Practice, CRC Press, 3<sup>rd</sup> Edition, 2012.
4. Mehta, Handbook of Drug Laws, University Book Agency Allahabad.
5. Govt. of India Publications of Food Drug Cosmetic Acts and Rules.
6. Malik Vijay, Laws Relating to Drugs And Cosmetics, Eastern book comp, 23<sup>rd</sup> Edition, 2013.

**PRACTICAL ANALYTICAL CHEMISTRY**

- Objectives:**
- i) Able to prepare standard solutions of various concentrations.
  - ii) To develop skills in volumetric titrations.
  - iii) Able to separate and estimate elements by solvent extraction method.
  - iv) Able to separate and estimate elements and compounds by chromatographic methods.

| Code: 1005                                  | PRACTICAL                                                                                                                                                                   | 4 Credits    |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Volumetric Analysis                         | Preparation and Standardization of commonly used titrants, Acid-base titration, redox titration, complexometric titration, Precipitation titration, Non-aqueous titrations. | 8 Hours/week |
| Solvent Extraction & Chromatographic Method | Separation and estimation of elements                                                                                                                                       |              |

**PRACTICAL FOOD AND BIOCHEMICAL ANALYSIS**

- Objectives:**
- i) Able to analyze milk and milk products.
  - ii) To compare analysis of tea and coffee.
  - iii) To develop skills in analytical methods of food products

|                   |                                                                                                                   |                  |
|-------------------|-------------------------------------------------------------------------------------------------------------------|------------------|
| <b>Code: 1006</b> | <b>PRACTICAL</b>                                                                                                  | <b>4 Credits</b> |
| Food Analysis     | Milk and Milk Products, Tea, Coffee, Honey, Preservatives. Jam, Jelly, Squash, Edible Oil, Pickle, Sauce, Vinegar | 8 Hours/week     |

## SEMESTER II

|                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
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| <b>Code: 2001</b>                                                                                                                                                                                                                                                                                                                    | <b>Title: Electro Analytical and Spectroscopic Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To compare basic concepts of electro analytical and spectroscopic methods.<br/> ii) Able to correlate principle and working of different types of instruments used for analysis.<br/> iii) Able to use these techniques in research and analysis.<br/> iv) To apply these techniques in the work place.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                   |
| <b>Paper I</b>                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                               | Electro Analytical Methods-I<br>a) Potentiometry: Electrodes, electrode systems, Determination of cell Electro Motive Force (EMF), Potentiometric titrations.<br>b) Ion Selective electrodes: solid state, precipitate, liquid-liquid, Enzyme and Gas sensing electrodes with applications, Ion selective field effect transistors, Bio-catalytic membrane electrodes, Enzyme based biosensors.                                                                                                   | 15 Lectures       |
| Unit II                                                                                                                                                                                                                                                                                                                              | Electro analytical methods-II<br>a) Polarography: Basic principles, Diffusion current, polarized electrode, Microelectrode, Dropping Mercury Electrode, Ilkovic equation, Polarographic wave, Qualitative, and Quantitative analysis.<br>b) Stripping Methods of analysis.<br>c) Coulometry at controlled potential, coulometric titration                                                                                                                                                        | 15 Lectures       |
| Unit III                                                                                                                                                                                                                                                                                                                             | Absorption Spectroscopic methods<br>a) UV-Visible molecular Absorption Spectroscopy: Instrumentation, Absorbing species, Qualitative and Quantitative analysis.<br>b) Atomic absorption Spectrometry: Theory of atomic absorption spectrometry, Instrumentation, interferences.<br>c) Molecular IR absorption Spectroscopy: Theory of Infrared Absorption, Spectrometry, Instrumentation, Sample handling, Qualitative and Quantitative analysis, Fourier Transform Infrared Spectrometry (FTIR). | 15 Lectures       |

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| Unit IV | Emission Spectroscopic methods<br>a) Molecular Fluorescence spectroscopy: Theory of fluorescence and phosphorescence, variable that affects fluorescence and phosphorescence. Instruments for measuring fluorescence, phosphorescence, application of fluorescence and phosphorescence.<br>b) Flame emission spectroscopy: Instrumentation, Flame characteristics, Flame processes, Emission Spectra, Quantitative measurements, Interferences, Applications.<br>c) Turbidimetry and Nephelometry: Theory, Instrumentation, Applications. | 15 Lectures |
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### Reference Books:

1. Skoog D. A., West D.M., Holler and Crouch, Fundamentals of Analytical Chemistry, Cengage Learning, Wiley-VCH Weinheim, 2011.
2. J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, Vogel's Quantitative Chemical Analysis, Pearson Education, ELBS, 6<sup>th</sup> Edition, 2009.
3. Fifield F. W. and Kealey D, Principle & Practice of Analytical Chemistry, Blackwell Science, 5<sup>th</sup> Edition, 2000.
4. Gary D. Christian, Purnendu Dasgupta, Kevin Schug, Analytical Chemistry, John Wiley, 7<sup>th</sup> Edition, 2013.
5. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 6th Edition, 2006.
6. Ahuja & Jespersen, Modern Instrumental Analysis, Elsevier Science, 1<sup>st</sup> Edition, 2006.
7. D.C. Harris, Exploring Chemical Analysis, W.H. Freeman, 3<sup>rd</sup> Edition, 2005.
8. Edited by Pradyot Patnaik, Dean's Analytical Chemistry Handbook, McGraw Hill, 2<sup>nd</sup> Edition, 2004.
9. Klaus Danzer, Analytical Chemistry, Springer-BBH, 2007.
10. A.L. Underwood, Quantitative Analysis, Prentice-Hall of India Pvt Ltd., 1999.

| SEMESTER-II                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                      |                   |
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| <b>Code: 2002</b>                                                                                                                                                                                                                                                                                         | <b>Title: Pharmaceutical Analysis</b>                                                                                                                                                                                                                                | <b>Credits: 4</b> |
| <b>Objectives:</b> i) To identify active drug ingredients in drug products.<br>ii) To understand dosage form and its mode of administration.<br>iii) Able to refer and compare pharmacopoeias for different parameters and analysis.<br>iv) To correlate basic concept of QA and QC in pharma industries. |                                                                                                                                                                                                                                                                      |                   |
| <b>Paper II</b>                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                      | <b>60 Hours</b>   |
| UNIT I                                                                                                                                                                                                                                                                                                    | Introduction:<br>a) Active Pharmaceutical Ingredients (API) and drug products.<br>b) Dosage form: Brief information on manufacturing and administration-Tablets, Capsules, Injections, Ointments, Creams, Oral solution, Aerosol.<br>c) Control release formulation. | 15 Lectures       |

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| UNIT II  | <p>a) Introduction to Pharmacopoeia and its importance.</p> <p>b) Application of analytical techniques in pharmaceutical industries</p> <ul style="list-style-type: none"> <li>- Official sources of Impurities and limit test (As, Pb, Fe, Chloride, Sulphate).</li> <li>- Techniques of Analysis: Introduction, physical tests, chemical tests, conventional test, Gravimetric, Volumetric.</li> <li>- Instrumental Techniques : UV-Visible, IR, Flame photometry, Chromatography (TLC, HPLC, GC).</li> </ul> | 15 Lectures |
| UNIT III | <p>a) Assay of main classes of drugs Chemotherapeutic agents: Introduction, Type, Properties, Method of Analysis.</p> <p>b) Dissolution and Disintegration, Assay of drugs, Vitamin C, Vitamin B<sub>2</sub>, Aspirin, Ibuprofen, Streptomycin sulphate, Calcium lactate, Iron tablets (Aurtrin, Fefol capsule), Laxative substances, Anta-acid.</p>                                                                                                                                                            | 15 Lectures |
| UNIT IV  | <p>a) Quality Assurance (QA)</p> <ul style="list-style-type: none"> <li>- Concept of Total Quality Management,</li> <li>- Documentation and its importance in QA.</li> </ul> <p>b) Quality Control (QC)</p> <ul style="list-style-type: none"> <li>- Change control management, Out of specifications (OOS), Deviation reporting, Stability studies (QA Pharma), Quality control, laboratory responsibilities, routine controls, Calibration of instruments, Standard test procedures.</li> </ul>               | 15 Lectures |

#### Reference Books:

1. Beckett & Stenlake, Practical Pharmaceutical Chemistry Vol (I) (II), CBS Publisher, 4<sup>th</sup> Edition, 2006.
2. V. K. Selvaraj, Practical Pharmaceutical Chemistry, Campus Books International Publisher, 2012.
3. Editor J. D. Nally, Good Manufacturing Practices for Pharmaceuticals, CRC Press, 6<sup>th</sup> Edition, 2006.
4. Edited by A. A. Signore and T. Jacobs, Good Design Practices for GMP Pharmaceutical Facilities, CRC Press, 2005.
5. Indian Pharmacopoeia (Latest Edition)
6. British Pharmacopoeia (Latest Edition)
7. Edited by Allen, Loyd Jr., Remington The Science & Practice of Pharmacy, Publication - Pharmaceutical Press, 22<sup>nd</sup> Edition, 2012.
8. D.G. Watson, Pharmaceutical Analysis, Churchill Livingstone Publisher, 3<sup>rd</sup> Edition, 2012.
9. Edited by L. Ohannesian and A. Streeter, Handbook of Pharmaceutical Analysis, CRC Press, 2001.
10. M. E. Aulton, Dosage Form, Churchill Livingstone Publisher, 2<sup>nd</sup> Edition, 2001.
11. J. Wiley, Text Books of pharmaceutical Analysis, Connors, 2001
12. Higuchi, Chemical Analysis of Drug, Interscience, 1995.

| <b>SEMESTER II</b>                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                   |
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| <b>Code: 2003</b>                                                                                                                                                                                                                                                                                                                                                                                | <b>Title: Cosmetics Formulation &amp; Quality Control</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) Enable to understand processes of cosmetic formulations.<br/>           ii) To comprehend advantages and limitations of raw materials used in cosmetic formulations.<br/>           iii) Able to assess importance of quality control process in cosmetic industries.<br/>           iv) Able to perform analysis of cosmetic formulations for professional growth.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                   |
| <b>Paper IV</b>                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                           | a) Introduction, Common processes used for cosmetic formulations, raw materials used in cosmetics.<br>b) Colors: Natural and synthetic, their advantages & limitations.<br>c) Perfumes: Natural and synthetic, their advantages & limitations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 15 Lectures       |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                          | a)Cosmetic formulation:<br>Introduction, Characteristics, BIS standards of: Skin creams, Face Powders, Lipsticks, Shampoos, Manicure preparations, Hair grooming preparations, Nail lacquers, Dentifrices.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 15 Lectures       |
| Unit III                                                                                                                                                                                                                                                                                                                                                                                         | a) Herbal Cosmetics products for: Skin, Nails, hairs, dentifrices.<br>b) Test methods for cosmetic products: Contact urticaria, Primary & secondary irritants, Skin sensitivity, Patch, Photo-patch, Repeated insult etc.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 15 Lectures       |
| Unit IV                                                                                                                                                                                                                                                                                                                                                                                          | a) Quality control of:<br>Cosmetics raw materials- Goods inspection report, determination of specific microorganisms (Escherichia, salmonella, pseudomonas, staphylococcus etc) and total viable aerobic count (membrane filtration, plate count, serial dilution);<br>Intermediate and bulk finished products–Fineness, texture, apparent density, color shade & match, odor, uniformity of emulsion, softening point, melting range, foam and foam stability.<br>b) Analysis of cosmetics: Face powder (fats and fatty acids, boric acid, zinc, total titanium & iron), Lipstick (separation of waxes and oil & analysis of dyes), Nail enamel (Bismuth Oxy Chloride, free formaldehyde), Shampoo (analysis of nonvolatile matter, borate, sulphate, phosphates, surfactants), Creams (types of emulsion, % water, ash & chloroform soluble material). | 15 Lectures       |

**Reference Books:**

1. Edited by Martin M. Reiger, Harry's Cosmeticology, Chemical Publishing Co. Inc, 8<sup>th</sup> Edition, 2009.
2. P.P. Sharma, Cosmetics, Formulations, Manufacturing and Quality Control, Vandana Publication Ltd, 4<sup>th</sup> Edition, 2010.
3. M. S. Balsam & E. D. Sagarin, Cosmetics Science & Technology, Wiley Interscience Publication, 2<sup>nd</sup> Edition, 2008.
4. H. Panda, Herbal Cosmetics, Asia Pacific Business Press Inc., 2008.
5. B. M. Mittal & R. N. Saha, Handbook of Cosmetics, VallabhPrakashan, New Delhi, 2008.
6. S. Nanda and R. K. Khar, Cosmetic Technology, Birla Publications Pvt Ltd, 1<sup>st</sup> Edition, 2006.
7. George Latimer, Official Methods of Analysis of AOAC International (AOAC = Associate of Analytical Communities), 19<sup>th</sup> Edition, Publication – AOAC, 2012.
8. M. L. Schlossman, Chemistry and Manufacture of Cosmetics, Allured Publishing Corporation, 4<sup>th</sup> Edition, 2009.
9. A. O. Barel, N. Paye, H. I. Maibach, A Handbook of Cosmetics Science and Technology, 3<sup>rd</sup> Edition, 2009.
10. A. Salvador, A. Chisvert, Analysis of Cosmetic Products, Publisher – Elsevier, 2011.
11. P. Elsner, H. I. Maibach, Cosmeceuticals and Active Cosmetics, Taylor & Francis, 2<sup>nd</sup> Edition, 2005.

| Code: 2004                                                                                                                                                                                                                                                                                                                                                                                                                                               | Title: Research Methodology                                                                                                                                                                                                                                                                                                                                                                                                                                  | Credits: 4  |
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| <p><b>Objectives:</b> i) Participants will be able to work more efficiently with knowledge of basic principles.<br/>           ii) Able to collect data, literature survey for research project.<br/>           iii) Able to use statistical tests for analysis and presentation of data.<br/>           iv) Participant will be better equipped with the knowledge of chemical safety and disaster management to work in research field/industries.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |             |
| Paper IV                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 60Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                      |             |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                                                                                   | a) Fundamental Laboratory Techniques: Basic principles, Health and safety, Working with liquids, Basic laboratory procedures I & II, Principles of solution chemistry, pH and buffer solutions.<br>b) The investigative approach: Making and recording measurements, SI units (International System of Units) and their use, Scientific method and design of experiments, Project work. Collection of Data (primary, secondary), literature survey & review. | 15 lectures |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                                                                                  | a) Analysis and presentation of data: Using graphs, Presenting data in tables, Hints for solving numerical problems, Descriptive statistics, Choosing and using statistical tests, drawing chemical structures, Chemo metrics, Computational chemistry.                                                                                                                                                                                                      | 15 lectures |

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|          | b) Statistical Packages for Social Science (SPSS) Workshop.                                                                                                                                                                                                           |             |
| Unit III | a) Chemical safety: General safety and operational rules, Safety equipments, Personal protective equipments, Compressed gas safety, Safety practices for disposal of broken glassware, Chemicals, Centrifuge safety, Treated biomedical wastes and scientific ethics. | 15 lectures |
| Unit IV  | Disaster Management:<br>Emergency response to: Chemical spills, Radiation spills, Biohazard spills, Leaking compressed gas cylinders, Fires, Medical emergency, Accident reporting (Bhopal gas tragedy, Chernobyl three mile island).                                 | 15 lectures |

### Reference Books:

1. J. R. Dean, A. M. Jones, D. Holmes, R. Reed, J. Weyers and A Jones, Practical Skills in Chemistry, Pearson Education Ltd. [Prentice Hall], 2002.
2. C. R. Kothari, Research Methodology: Methods and Techniques, New Age International, 2013.
3. A. K. Singh, Tests, Measurements and Research Methods in Behavioral Sciences, Bharti Bhawan Publisher And Distributor, 2012.
4. Martyn Denscombe, The Good Research Guide, McGraw-Hill International, 2007.
5. Ranjit Kumar, Research Methodology, Sage Publication Ltd, 3<sup>rd</sup> Edition, 2011.
6. Edited by J.C. Taylor, Advances in Chemistry Research, Vol 17, Nova Science Publishers INC, 2013.
7. Oklahoma State University Laboratory Safety Manual, 1999.
8. Margaret Diane LeCompte, Wendy L. Millroy, Judith Preissle, The Handbook of Qualitative Research in Education, Academic Press Inc
9. Bohdan O, Szuprouiez, Multimedia Networking, Mcgraw-Hill
10. Introduction to Research, Tynes Hillway Houghton Wiffin Company, 2005.

### PRACTICAL SPECTROSCOPY AND CHROMATOGRAPHY

- Objectives:** i) Able to handle colorimetric instrument for analysis.  
ii) To develop skills in chromatographic techniques for analysis.

| Code: 2005     | PRACTICAL                                                                                                                  | 4 Credits    |
|----------------|----------------------------------------------------------------------------------------------------------------------------|--------------|
| Spectroscopy   | Colorimetric analysis of elements, Mixture, Simultaneous estimation of metals, pk value of indicator by Spectrophotometry. | 8 Hours/week |
| Chromatography | Chromatography- Ion- exchange chromatography, Thin layer chromatography.                                                   |              |



### PRACTICAL PHARMACEUTICAL ANALYSIS

- Objectives:** i) Able to analyze various drugs by standard methods.  
ii) Able to compare dissolution and disintegration test for different drugs.

| Code: 2006              | PRACTICAL                                                                                     | 4 Credits    |
|-------------------------|-----------------------------------------------------------------------------------------------|--------------|
| Pharmaceutical Analysis | Assay of alkaloids, Vitamins, Antibiotics, Sulpha drugs, Anta-acids, Anti-bacterials.         | 8 Hours/week |
|                         | Dissolution test, Disintegration test, Weight variation test, Test for uniformity of content. |              |

| SEMESTER III                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                              |                   |
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| Code: 3001                                                                                                                                                                                                                                                 | <b>Title: Advanced Chromatography and Spectroscopic Methods</b>                                                                                                                                                                                                                                                                              | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To comprehend basic concept of chromatographic and spectroscopic methods.<br/>ii) To correlate principle and instrumentation of various instruments used.<br/>iii) Able to compare chromatographic and spectroscopic methods.</p> |                                                                                                                                                                                                                                                                                                                                              |                   |
| Paper I                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                              | 60 Hours          |
| Unit I                                                                                                                                                                                                                                                     | Column Chromatography I<br>Introduction to column chromatography<br>Gas chromatography: Principle of GLC, Instruments for GLC, Gas Chromatographic Columns and Stationary phases, Applications.<br>Size Exclusion Chromatography: Column packing, Theory of size of exclusion chromatography, Application of size exclusion chromatography.  | 15 lectures       |
| Unit II                                                                                                                                                                                                                                                    | Column chromatography II<br>HPLC: Principle and Instrumentation.<br>Ion Chromatography: Ion exchange equilibria, Ion-exchange packing's, Applications of Ion Chromatography<br>Super Critical Fluid Chromatography: Properties of SFC- Instrumentation and operating variables, Comparison with other types of chromatography, Applications. | 15 lectures       |

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| Unit III | <p>Advanced Spectroscopic Methods I</p> <p>Mass spectrometry: Molecular Mass Spectra, Ion sources, Analyzers, Detectors, Mass Spectrometers, Application of Molecular Mass Spectrometry, Secondary Ion Mass Spectrometry.</p> <p>Atomic Emission Spectroscopy Inductively Coupled Plasma: Principle, Instrumentations and applications.</p> <p>Nuclear Magnetic Resonance: Theory of NMR-Quantum description, Classical description of NMR, Relaxation Processes in NMR. Environmental effects on NMR Spectra-Chemical shift, spin splitting, Rules governing the interpretation of first order spectra, effect of chemical exchange, NMR Spectrometers, Applications of proton NMR, C-13 NMR.</p> | 15 lectures |
| Unit IV  | <p>Advanced Spectroscopic Methods II</p> <p>Raman spectroscopy: Theory of Raman spectroscopy, Instrumentation, Application.</p> <p>Hyphenated Methods:</p> <p>Gas Chromatography – Mass Spectrometry (GC-MS ), Gas Chromatography – IR Spectrometry (GC-IR), Liquid Chromatography – Mass Spectrometry (LC-MS), Tandem Mass Spectrometry (MS-MS), Inductively Coupled Plasma – Mass Spectrometry (ICP-MS).</p>                                                                                                                                                                                                                                                                                     | 15 Lectures |

### Reference Books:

1. Skoog D. A., West D. M., Holler and Crouch, Fundamentals of Analytical Chemistry, Cengage Learning, Wiley-VCH Weinheim, 2011.
2. J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, Vogel's Quantitative Chemical Analysis, Pearson Education, ELBS, 6<sup>th</sup> Edition, 2009.
3. Fifeild F. W. and Kealey D, Principle & Practice of Analytical Chemistry, Blackwell Science, 5<sup>th</sup> Edition, 2000.
4. Gary D. Christian, Purnendu Dasgupta, Kevin Schug, Analytical Chemistry, John Wiley, 7<sup>th</sup> Edition, 2013.
5. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 6<sup>th</sup> Edition, 2006.
6. Ahuja & Jespersen, Modern Instrumental Analysis, Elsevier Science, 1<sup>st</sup> Edition, 2006.
7. D.C. Harris, Exploring Chemical Analysis, W.H. Freeman, 3<sup>rd</sup> Edition, 2005.
8. Edited by Pradyot Patnaik, Dean's Analytical Chemistry Handbook, McGraw Hill, 2<sup>nd</sup> Edition, 2004.
9. Klaus Danzer, Analytical Chemistry, Springer-BBH, 2007.
10. A. L. Underwood, Quantitative Analysis, Prentice-Hall of India Pvt Ltd., 1999.

| <b>SEMESTER III</b>                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                           |                   |
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| <b>Code: 3002</b>                                                                                                                                                                                                                                                                                                                                        | <b>Title: Organic Analysis</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>Credits: 4</b> |
| <p><b>Objectives:</b> I) To comprehend spectroscopic methods for characterization of organic compounds.<br/>           II) Able to identify spectra for structure elucidation.<br/>           III) To compile implication of significance and application of carbon Nanotubes.<br/>           IV) Able to correlate importance of organic synthesis.</p> |                                                                                                                                                                                                                                                                                                                                                                                                           |                   |
| <b>Paper II</b>                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                           | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                                                   | a) UV-visible Spectroscopy: Introduction, Electronic transitions, Applications, Calculation of $\lambda$ max.<br>b) IR-Spectroscopy: Basic concept, Fundamental vibrations, Functional group frequencies, Identification of organic compounds.                                                                                                                                                            | 15 Lectures       |
| Unit II                                                                                                                                                                                                                                                                                                                                                  | a) HNMR: Use of HNMR for characterization and structural elucidation of organic compounds and interpretation of spectra.<br>b) CNMR: Use of CNMR for characterization and structural elucidation of organic compounds and interpretation of spectra.<br>c) Mass Spectroscopy: Ionization on electron impact, Mass Spectrum, detection of isotopes, Fragmentation and spectra of few classes of compounds. | 15 Lectures       |
| Unit III                                                                                                                                                                                                                                                                                                                                                 | a) Functional group analysis: Introduction, principles & methods of analysis.<br>b) Nanotechnology: Introduction; Carbon nanotubes: Significance, Preparative methods, Types SWNT, MWNT and applications. Nanomaterials.                                                                                                                                                                                  | 15 Lectures       |
| Unit IV                                                                                                                                                                                                                                                                                                                                                  | a) Organic synthesis: Principles of organic synthesis, Wacker process, Ziegler Natta, Grignard Reaction, Williamson Synthesis.<br>b) Organic trace analysis: Introduction, Units, Sampling, Concentration techniques and estimation methods.<br>c) Micro-elemental analysis of C,H,N,O and halogens.                                                                                                      | 15 Lectures       |

**Reference Books:**

1. Donald L. Pavia, George S. Kriz, James R. Vyvyan, Spectroscopy by Lampmen, Cengage Learning India Pvt Ltd, 4<sup>th</sup> Edition, 2012.
2. R. A. Sheldon, Isabella Arends, ULF Hanefeld, Green Chemistry & Catalyst, Wiley VCH Verlag GmbH and Company, 2007.
3. J.H. Clark, D.J. Macquarrie, Handbook of Green Chemistry and Technology, John Wiley & Sons, 2008.
4. Sulbha K. Kulkarni, Nanotechnology Principles and Practices, Capital Publishing Company, 2007.
5. A. I. Vogel, Elementary Practical Organic Chemistry: Small Scale Preparations Part I, Dorlin Kindersley India Pvt. Ltd., 2011.
6. Edited by M. B. Smith, March's Advance Organic Chemistry, John Wiley & Sons, 7<sup>th</sup> Edition, 2013.
7. P. S. Kalsi, Spectroscopy of Organic Compounds, New Age International, 6<sup>th</sup> Edition, 2004.
8. Mzike Lancaster, Green Chemistry an Introductory Text, Royal Society of Chemistry, 2002.
9. R. M. Silversteime and G. C. Bassler, Spectrometric Identification of Organic Compounds, Johan Wiley Publication, 1991.
10. S. Siggia and J.G. Hanna, Quantitative Organic Analysis Via Functional Groups, Wiley Interscience, 1979.
11. Harald Gunther, NMR Spectroscopy, Wiley –VCH Weinheim, 2013.

| SEMESTER III                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                 |                   |
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| <b>Code: 3003</b>                                                                                                                                                                                                                                                                                                                                                            | <b>Title: Microbiological Methods of Analysis</b>                                                                                                                                                                                                               | <b>Credits: 4</b> |
| <b>Objectives:</b> i) To identify microorganism based on their morphology.<br>ii) To prepare various culture medium for different microorganisms.<br>iii) Able to use various methods of staining for microorganism.<br>iv) Able to compare sign and symptoms of food, water, air borne diseases.<br>v) To use methods of precaution for air, water and food borne diseases. |                                                                                                                                                                                                                                                                 |                   |
| <b>Paper III</b>                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                 | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                                                                       | a) Introduction of Microorganisms:<br>General Characteristics of Algae, Protozoa, Mycoses, Pathogens, Pyrogens, Molds, Fungi, Yeasts and Parasites.<br>b) Staining method: Gram staining, Acid-base staining, Staining of spores, Staining of bacterial spores. | 15 Lectures       |
| Unit II                                                                                                                                                                                                                                                                                                                                                                      | a) Viruses:<br>Introduction to viruses, Classification, Replication cycle, Effects of viruses on the host cell, Viruses of medical importance, Rubella viruses infection,                                                                                       | 15 Lectures       |

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|          | <p>Laboratory test for Polioviruses, Lentiviruses and AIDS (Acquired Immunodeficiency Syndrome), Detection tests for HIV (Human Immunodeficiency Virus).</p> <p>b) Bacteria:<br/>Introduction to bacteriology, Basic features of bacteria, Classification, Shape and structure of bacteria, Factors affecting growth of bacteria.</p>                                                                                         |             |
| Unit III | <p>a) Culturing of Microorganism<br/>Introduction, Composition and types of culture media, Preparation of culture media, Quality control of various culture media.</p> <p>b) Control of microorganism<br/>Control of microorganisms by chemical agents, Characteristics of an ideal chemical agents, Major groups of disinfectants and antiseptics, Evaluation of antimicrobial potency of disinfectants and antiseptics.</p> | 15 Lectures |
| Unit IV  | <p>a) Food borne diseases:<br/>Bacteria responsible for food borne diseases, Signs and Symptoms of bacterial infection, Antibacterial drugs.</p> <p>b) Water-borne diseases:<br/>Microbiology of drinking water, Microorganism responsible for water borne diseases, Signs &amp; Symptoms</p> <p>c) Airborne diseases:<br/>Air borne diseases and microorganism, Signs&amp; symptoms</p>                                      | 15 Lectures |

#### Reference Books:

1. Godkar P. S. and Godkar D. P., Textbook of Medical Laboratory Technology, Bhilani Publishing House, 2<sup>nd</sup> Edition, Mumbai, 2006.
2. Chatterjea M. N. & Shinde R., Textbook of Medical Biochemistry, J. P. Brothers Medical Publishers PVT, New Delhi, 8<sup>th</sup> Edition, 2012.
3. Jindal Meenakshi, Introduction to Waste Water Treatment Process, Mangalam Publication, Delhi, 1<sup>st</sup> Edition, 2009.
4. Jay James, Modern Food Microbiology, CBS Publisher & Distributor, 2005.
5. K. Vijya Ramesh, Food Microbiology, MJP Publisher, Chennai, 2007.
6. Pelczar M., Chan E. C. S., Krieg Noel R., Microbiology, Tata McGraw Hill, New Delhi, 2003.
7. Doyle M., Beuchat L., Food Microbiology, Fundamentals and Frontiers, Montville ASM Press Washington D. C., 2013.
8. Prescott, Harley and Klein, Textbook of Microbiology, Mc-Graw Hill, 7<sup>th</sup> Edition, 2008.
9. A. Anantnarayan and C. K. Panikar, Textbook of Microbiology, Orient Longman Pvt.Ltd., 7<sup>th</sup> Edition, 2005.

| <b>SEMESTER III</b>                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |
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| <b>Code: 3004A</b>                                                                                                                                                                                                                                                                                                                                                                      | <b>ELECTIVE I: Industrial Product and Forensic Analysis</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To familiarize importance of industrial products.<br/>           ii) To compare content analysis of different types of steel, cements and ceramics.<br/>           iii) To acquire knowledge of surfactants as pollutant.<br/>           iv) To comprehend soil and fertilizer analysis.<br/>           v) To compare forensic analysis of blood and hair.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |
| <b>Paper IV</b>                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>60 Hours</b>   |
| Unit I                                                                                                                                                                                                                                                                                                                                                                                  | <p>Analysis of Steel &amp; Cement</p> <p>a) Analysis of Steel and Ferrous materials: Sampling, Analysis of steel and ferrous alloy: Carbon, Silicon, Manganese, phosphorous, sulphur, nickel, chromium, vanadium, tungsten, molybdenum, cobalt, titanium.</p> <p>b) Analysis of Cement and building materials: Type of cement, Sampling, Analysis of Cement and building materials: Silicon dioxide, aluminium oxide, ferric oxide, calcium oxide, magnesium oxide, sulphur trioxide, sulphide-sulphur, loss on ignition, insoluble residue, sodium and potassium oxide.</p>                                                                                                    | 15 Lectures       |
| Unit II                                                                                                                                                                                                                                                                                                                                                                                 | <p>Analysis of Ceramic materials:</p> <p>a) Analysis of quartz: Volatile residue, Zirconium dioxide, Aluminium oxide, Calcium and magnesium oxides, Sodium and potassium oxide.</p> <p>b) Analysis of Clays and feldspars: Determination of moisture, Silicon dioxide, Total oxides, Ferric oxides, Titanium dioxide, Aluminium oxide, Calcium oxide, Magnesium oxide.</p> <p>c) Analysis of glasses: Types of glasses, determination of lead and lead glass.</p> <p>d) Analysis of ceramics: Determination of Titanium dioxides, and Aluminium oxide from oxide ceramics.</p> <p>e) Analysis of ferrous slags: Determination of iron, calcium and magnesium, total oxides.</p> | 15 Lectures       |

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| Unit III | <p>Analysis of other products</p> <p>a) Surfactants and Detergents: Introduction to different pollutants, Classification, Representative methods of analysis.</p> <p>b) Effluent water analysis: Introduction to different pollutants, Classification, Representative methods of analysis.</p> <p>c) Soil and fertilizer analysis: Characteristic of different soils, Classification, Representative methods of analysis of soil parameters, pH texture, Water retaining capacity, Sodium Absorption Ratio (SAR) value, NPK value of fertilizers.</p> | 15 Lectures |
| Unit IV  | <p>Forensic Science</p> <p>a) Forensic Analysis: Overview, destructive &amp; nondestructive techniques, data interpretation.</p> <p>b) Blood Analysis: Blood preservation and ageing effect, analysis of blood components &amp; exogenic substances, blood stain analysis.</p> <p>c) Hair analysis: Structure and composition of hair, Morphological examination, Chemical analysis of hair components &amp; components remaining on or in hair.</p>                                                                                                  | 15 Lectures |

#### Reference Books:

1. F. J. Welcher, Standard Methods of Chemical Analysis, Vol. 2, (Part A & B), Von Nostrand & Rober E. Krieger Publishing Co. New York, 5<sup>th</sup> Edition, 2000.
2. Edited by J. Mendham, R. C. Denney, M. Thomas, B. Sivasankar, Vogel's Quantitative Chemical Analysis, Dorlin Kindersley (India) Pvt. Ltd, 6<sup>th</sup> Edition, 2009.
3. William D. Callister Jr., D. G. Rethwisch, Fundamentals of Materials Science & Engineering, John Wiley and Sons. Inc., New York, 4<sup>th</sup> Edition, 2012.
4. Suzanne Bell, Forensic Chemistry, Pearson Education Publishers, 2<sup>nd</sup> Edition, 2012.
5. Lwrance Kobilinsky, Forensic Chemistry Handbook, Wiley Interscience, 2011.
6. J. I. Khan, T. J. Kenedy, D. R. Christian, Basic Principles of Forensic Chemistry, Humana Press, 2011.
7. Robert A. Meyers, Encyclopedia of Analytical Chemistry, Wiley Interscience, 2012.
8. V. Raghavan, Material Science & Engineering, PHI Learning Pvt Ltd Publisher, 5<sup>th</sup> Edition, 2004.
9. Thomas M. Schmitt, Analysis of Surfactants, Marcel Dekker Inc, 2<sup>nd</sup> Edition, 2001.

| SEMESTER III                                                                                                                                                       |                                         |                   |
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| <b>Code: 3004B</b>                                                                                                                                                 | <b>ELECTIVE II: Medicinal Chemistry</b> | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To familiarize students with various types of medicines.<br/>ii) Able to compare mode of administration and bioavailability of drugs.</p> |                                         |                   |

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| iii) To comprehend different types of antibiotics and sulpha drugs.<br>iv) To compare drugs acting on CNS.<br>v) To compile drugs action and toxic effects of steroids. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                 |
| <b>Paper IV</b>                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>60 Hours</b> |
| UNIT I                                                                                                                                                                  | General consideration of following drugs: The development of the following classes of drugs including structure activity relationship, mode of action and mechanism of action of drugs in that class, mode of administration, bioavailability and its relation to structure, chemical nomenclature, generic names and toxic effects.<br>1. Antiseptic and disinfectants<br>2. Chemotherapeutic agents; chemotherapy of acid fast infection (Anti-tubercular and anti-leprotic agents)<br>3. Chemotherapeutic agents of parasitic infection, antimalarials, anti-amoebic, anti-trypanosomiasis and antihelminthic agents<br>4. Antifungal agents<br>5. Anti-viral agents<br>6. Anti-neoplastic agents. | 15 Lectures     |
| UNIT II                                                                                                                                                                 | 1. Antibiotics<br>2. Sulphonamides<br>3. Diuretics<br>4. Hypoglycemic agents<br>5. Diagnostic agents and pharmaceutical aids<br>6. Miscellaneous drugs like anticoagulants and antilipemic agents.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 15 Lectures     |
| UNIT III                                                                                                                                                                | Drugs acting on central nervous system :<br>1. General anesthetics, hypnotics and sedative anti-convulsants<br>2. Analgesics: narcotic agents<br>3. Anti-pyretic, anti-rheumatics and anti-inflammatory agents<br>4. CNS Stimulants<br>5. Psychotherapeutics agents; major and minor tranquilizers, anti-depressant<br>6. Local anesthetics                                                                                                                                                                                                                                                                                                                                                           | 15 Lectures     |
| UNIT IV                                                                                                                                                                 | Drugs acting on nervous system:<br>1. Cholinergic stimulants and blocking agents<br>2. Adrenergic stimulants and blocking agents<br>3. Hypotensive agents and cardiovascular drugs<br>4. Vitamins and co-enzyme<br>5. Antihistamines<br>6. Corticosteroids, sex steroids, oral contraceptives and synthetic estrogens.                                                                                                                                                                                                                                                                                                                                                                                | 15 Lectures     |

**Reference Books:**



1. Edited by Donald J. Abraham, Burger's Medicinal Chemistry and Drug Discovery, 7<sup>th</sup> Edition, Wiley Publication, 2010.
2. Thomas L. Lemke, David A. Williams, V. Roche & S.W. Zito, Foye's Principles of Medicinal Chemistry, Published by Lippincott Williams & Wilkins, 7<sup>th</sup> Edition, 2012.
3. Gareth Thomas, Medicinal Chemistry, Wiley Interscience Publication, 2<sup>nd</sup> Edition, 2011.
4. V. Alagarsamy, Textbook of Medicinal Chemistry, Reed Elsevier India Pvt. Ltd, 2010.
5. G. P. Ellis & G. B. West, Progress in Medicinal Chemistry, Vol 9, North Holland Publishing Co., 2011.
6. D. Sriram & P. Yogeewari, Medicinal Chemistry, Publisher Dorling Kindersley (India) Pvt. Ltd, 2008.
7. Graham L. Patrik, An Introduction to Medicinal Chemistry, Oxford University Press, 5<sup>th</sup> Edition, 2013.
8. Ashutosh Kar, Medicinal Chemistry, Lippincott Williams & Wilkins, 2007.
9. Hugo Kubinyi, QSAR: Hansch Analysis and Related Approaches, Wiley Interscience Publication, 2008.
10. Dr. S. S. Kadam, Principles of Medicinal Chemistry, Pragati Books Pvt Ltd, 2008.

| <b>SEMESTER III</b>                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>Code: 3004C</b>                                                                                                                                                                                                            | <b>ELECTIVE III: Biosensors, Agrochemicals &amp; Organic Polymers</b>                                                                                                                                                                                                                                                                                                                                                                                               | <b>Credits: 4</b> |
| <b>Objectives:</b> i) To understand basic concept of biosensors and their applications.<br>ii) To identify different types of agrochemicals and their analysis.<br>iii) To study synthesis and analysis of organic polymers . |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                   |
| <b>Paper IV</b>                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>60 Hours</b>   |
| UNIT I                                                                                                                                                                                                                        | Biosensors:<br>Definition, components and types of Biosensors.<br>Enzyme based Biosensors.<br>Immobilization of Enzymes.<br>Types of Transducers, fabrication of probes for sensors and evaluation of sensor performance.<br>Application of Biosensors.                                                                                                                                                                                                             | 15 Lectures       |
| UNIT II                                                                                                                                                                                                                       | Analysis of Agrochemicals:<br>Introduction, Classification, Mechanism of action and synthesis.<br>Insecticides: DDT (Dichloro Diphenyl Trichloro Ethane), BHC (Benzene Hexa Chloride), Aldrin, Endosulfon, Malathion, parathion.<br>Herbicides: 2,4-dichloro phenoxy acetic acid, Dalapon, Paraquat, Banalin, Butacarb.<br>Fungicides: Bordeaux mixture, Copper oxychloride, Zineb, Benomyl (Benlate).<br>Analysis of pesticides residue and toxicological effects. | 15 Lectures       |
| UNIT III                                                                                                                                                                                                                      | Organic Polymers:<br>Basic Concepts, Polymers, monomers, molecular weight and molar                                                                                                                                                                                                                                                                                                                                                                                 | 15 Lectures       |

|         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |             |
|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|
|         | <p>mass, end groups, degree of polymerization.</p> <p>Nomenclature Classification of polymer-thermoplastic, thermosetting.</p> <p>Copolymers – random, alternate, block and graft copolymers, Molecular architecture, Polymerization and functionality.</p> <p>Polymerization processes – addition and step polymerization.</p> <p>Mechanism of polymerization – free radical and ionic.</p> <p>Heterogeneous polymerization – Zeigler-Natta catalysis.</p> <p>Optical Activity in polymers, stereo isomers-isotactic, atactic and syndiotactic polymers.</p> |             |
| UNIT IV | <p>Analysis of Polymers:</p> <p>Molecular weight of polymers - Arithmetic weight average and number average molecular weights of polymers.</p> <p>Determination of molecular weight of polymers, End-Group analysis, Cryoscopy, Light scattering, Viscosity, and gel permeation chromatographic methods.</p> <p>Thermal Transition in Polymers, Tg and Tm and their relation, Differential Scanning Calorimetry (DSC), Thermal Gravimetric Analysis (TGA), Spectral method of analysis.</p>                                                                   | 15 Lectures |

#### Reference Books:

1. V. C. Yang, T. T. Ngo, Biosensors and Their Applications, Kluwer Academic Publisher Newyork, 2000.
2. Rajmohan Joshi, Biosensors, Isha Books India, 2006.
3. J. J. Murphy, Handbook of Residue Analytical Methods for Agrochemicals by Wiley Interscience Publication, 2003.
4. Edited by Q. A. Acton, Agrochemicals: Advances in Research & Application, Scholarly Editions Book, 2012.
5. W. Brown, C. Foote, I. Iverson, E. Anslyn, Organic Chemistry (Organic Polymers), Cengage Learning Publisher, 2008.
6. F. W. Bilmayer, Text Book of Polymer Science, Wiley India Pvt. Ltd., 2008.
7. V. K. Ahluwalia, A. Mishra, Polymer Science A Text Book, Taylor and Francis Group Publisher, 2008.
8. Manas Chanda, Introduction to Polymer Science and Chemistry, CRC Press (Taylor and Francis Group), 2<sup>nd</sup> Edition, 2013.
9. S. J. Knowles, Quantitative Analysis of Agrochemicals by Spectroscopy Technique, University of Reading Publisher, 1996.
10. A. Townshed, Encyclopedia in Analytical Science, Academic Press, 1995.

#### PRACTICAL ADVANCED SPECTROSCOPIC METHODS

- Objectives:** i) To compare different methods of spectroscopic analysis.  
ii) To develop skills in flame photometry and fluorimetry instruments.

| <b>Code: 3005</b>                            | <b>PRACTICAL</b>                                                                                                                                   | <b>4 Credits</b> |
|----------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Advanced spectral methods<br>UV spectroscopy | Spectroscopic determination of elements,<br>Standard addition method and method of least squares,<br>extractive photometry, photometric titration. | 8 hours/week     |
| Fluorimetry                                  | Fluorometric determinations of organic compounds by<br>Calibration curve, standard addition method.                                                |                  |
| Flame photometry                             | Flame photometric determination of alkali metals by<br>calibration curve method.                                                                   |                  |

### PRACTICAL ORGANIC ANALYSIS

**Objectives:** i) To develop skill in identification of organic compounds on the basis of their spectra.

ii) Able to estimate organic compounds on the basis of functional groups.

| <b>Code: 3006</b>                                | <b>PRACTICAL</b>                                                                                                                                                                                                                                              | <b>4 Credits</b> |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| Identification & Estimation of Functional Groups | Identification: Alcoholic, phenolic carbonyl, carboxylic, ester, nitro, amino group, amide group, degree of unsaturation, hydrocarbons, olefins using sample spectra.<br>Estimation: Amines, phenols, aldehydes, ketones, Ester, amide, Carboxylic compounds. | 8 hours/week     |

| <b>SEMESTER IV</b>                                                                                                                                                                                                                                                                                                                                     |                                              |                   |
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| <b>Code: 4001</b>                                                                                                                                                                                                                                                                                                                                      | <b>Title: Advanced Analytical Techniques</b> | <b>Credits: 4</b> |
| <p><b>Objectives:</b> i) To understand basic concepts of advanced analytical techniques.<br/>ii) To comprehend principle and instrumentation of advanced analytical techniques.<br/>iii) To understand role of computers in analytical chemistry.<br/>iv) To apply the concepts of green chemistry to analytical chemistry for better environment.</p> |                                              |                   |
| <b>Paper I</b>                                                                                                                                                                                                                                                                                                                                         |                                              | <b>60 Hours</b>   |

|          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |             |
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| Unit I   | <p>Advanced Electro-analytical methods</p> <p>a) Amperometric Titrations: Principle, Instrumentation, titration curves.<br/>         Biamperometric Titrations: Principle, instrumentation, titration curves.</p> <p>b) Modified Polarographic Methods: Differential Pulsed polarography, Square Wave Polarography, Cyclic voltammetry.</p>                                                                                                                                                                                                                                                                                                                                                                                                           | 15 Lectures |
| Unit II  | <p>Thermal &amp; Radioactive methods of analysis</p> <p>a) Thermal methods:<br/>         TGA :- Principles, Instrumentation, Application<br/>         DTA :- Principles, Instrumentation, Application<br/>         DSC :- Principles, Instrumentation, Application<br/>         Thermometric Titrations</p> <p>b) Radio analytical Methods:<br/>         Radioactive decay products and processes, Radioactive decay rates, Instrumentation.<br/>         Neutron activation method:-<br/>         Destructive, non-destructive. Applications of Neutron Activation.</p> <p>c) Isotope dilution method: Principle, Applications.<br/>         Photo Acoustic Spectroscopy (PAS): Photo acoustic effect, theory of PAS, Instruments, Applications.</p> | 15 Lectures |
| Unit III | <p>Surface Analytical Techniques</p> <p>a) Surface spectroscopic methods: Electron Spectroscopy for Chemical Analysis (ESCA) - Principles, Instrumentations, Applications.</p> <p>b) Auger electron spectroscopy:<br/>         Principles, Instrumentations, Applications.</p> <p>c) Scanning Electron Microscopy: Principles, Instrumentation, Applications.</p> <p>d) Computers in Analytical chemistry: Computer terminology, Components of computer, Computer software-Scientific packages, Applications of computers- Passive and Active, Computers networks, Lab Information Management System (LIMS).</p>                                                                                                                                      | 15 Lectures |
| Unit IV  | <p>Green Analytical Methods: Principle &amp; concept, Atom economy, and trends in Green Analytical chemistry, Greening sample treatment, Green Instrumental Analysis.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 15 Lectures |

### **PRACTICAL ADVANCED ANALYTICAL TECHNIQUES**

**Objectives:** i) To develop skill in conductometry, pHmetry and thermometry for analysis of acids and bases.

ii) Able to analyze different parameters for water analysis.

iii) To analyze cosmetic raw materials.

| Code: 4002                                          | PRACTICAL                                                                                                                                                                                                                                      | 4 Credits    |
|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Conductometry<br>pHmetry<br>Thermometric titrations | Conductometric titration of acids, bases, mixture of acids.<br>pH metric titration of mixture of acids and selection of indicators for volumetric titration, pH metric titration of polybasic acids.<br>Thermometric titrations of acids/bases | 8 hours/week |
| Water analysis<br>Cosmetic analysis                 | Water Analysis of samples for hardness, dissolved oxygen, residual chlorine content,<br>Analysis of Cosmetics intermediates.                                                                                                                   |              |

**Reference Books:**

1. Skoog D.A., West D.M., Holler and Crouch, Fundamentals of Analytical Chemistry, Cengage Learning, Wiley-VCH Weinheim, 2011.
2. J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, Vogel's Quantitative Chemical Analysis, Pearson Education, ELBS, 6<sup>th</sup> Edition, 2009.
3. Fifeild F. W. and Kealey D, Principle & Practice of Analytical Chemistry, Blackwell Science, 5<sup>th</sup> Edition, 2000.
4. Gary D. Christian, Purnendu Dasgupta, Kevin Schug, Analytical Chemistry, John Wiley, 7<sup>th</sup> Edition, 2013.
5. Douglas A. Skoog, F. James Holler and Stanley R. Crouch, Principles of Instrumental Analysis, Cengage Learning, 6<sup>th</sup> Edition, 2006.
6. Ahuja & Jespersen, Modern Instrumental Analysis, Elsevier Science, 1<sup>st</sup> Edition, 2006.
7. D.C. Harris, Exploring Chemical Analysis, W.H. Freeman, 3<sup>rd</sup> Edition, 2005.
8. Edited by Pradyot Patnaik, Dean's Analytical Chemistry Handbook, McGraw Hill, 2<sup>nd</sup> Edition, 2004.
9. Klaus Danzer, Analytical Chemistry, Springer-BBH, 2007.
10. A. L. Underwood, Quantitative Analysis, Prentice-Hall of India Pvt Ltd., 1999.
11. M. Koel & M. Kaljurand, Green Analytical Chemistry, RSC Publishing, 2012.
12. M. L. Guardia, S. Carrigues, A Handbook of Green Analytical Chemistry, Wiley Interscience, 2012.

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| <b>Code: 4003</b> | <b>RESEARCH PROJECT</b> | <b>8 Credits (9 wks)</b> |
|-------------------|-------------------------|--------------------------|

- Objectives:** i) Able to collect data and literature survey.  
ii) Able to use statistical aids for data processing.  
iii) Acquire knowledge and skills for higher level research work.

**Research Project & Evaluation:**

Students will be given guidance on basic research approaches, methodology and tools; and expected to collect data (primary, secondary), conduct literature survey and complete a small research project in the institution or industries.

After completion of research study, each student will submit the report of 50-60 pages (12,000 to 15,000 words). The chapter wise indexing and typing rules will be the same as of thesis writing.

Each report will be evaluated by the guide and external referee. Evaluation of research project will be conducted internally and externally.

|                   |                          |                          |
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| <b>Code: 4004</b> | <b>IN-PLANT TRAINING</b> | <b>8 Credits (6 wks)</b> |
|-------------------|--------------------------|--------------------------|

- Objectives:** i) The intern will develop skills in the analytical techniques in practical work situation.  
ii) Intern will develop and strengthen their professional skills and interpersonal relationship in work environment of the industry.  
iii) It will provide opportunity to find out their interest in a particular carrier.  
iv) Experiential learning will have broader perspective for employment.

**In-plant Training & Evaluation:**

Internship placement will be in research institutes, industries like pharma, food and cosmetic or Government organization (BARC or Haffkine Institute), subject to approval of the internship coordinator. Student will prepare a detailed plan with the approval of external mentor which will be submitted to the internship coordinator within 7 days of the joining. At the end of internship, student will prepare a write up (2000 to 3000 words) based on their daily work activities in the organization. Evaluation of the internship assignment will be done internally and externally.

## First to Fourth Semester

### Question Paper Pattern for Theory

Time: 3 Hrs

Marks: 100 (Converted to 50 Marks)

Note: All Questions are Compulsory

Q.1 Attempt any TEN of the following Objective Ques. --- 20 Marks

15 questions from Unit I, II, III & IV.

Q.2 Attempt any TWO of the following --- 20 Marks

Four questions from Unit I.

Q.3 Attempt any TWO of the following --- 20 Marks

Four questions from Unit II.

Q.4 Attempt any TWO of the following --- 20 Marks

Four questions from Unit III.

Q.5 Attempt any TWO of the following --- 20 Marks

Four questions from Unit IV.

## First to Fourth Semester

### Question Paper Pattern for Practical(internal/external)

**Lab Course**

**Time: 4 Hrs.**

Marks: 50

Q.1 Synopsis of Experiment --- 05Marks

Q.2 Experiment --- 30 Marks

Q.3 Viva --- 10 Marks

Q.4 Record Book --- 05 Marks