

SARVAJANIK UNIVERSITY
M.Sc. Organic Chemistry Syllabus (CBCS)

THIRD SEMESTER

Program: M.Sc. Organic Chemistry	Type: Theory
Semester: III	
Subject: DSC-V: Organic Spectroscopy	
Credit: 04(T) + 02 (P)	Total learning hours: 60
Course description: The syllabus deals with theory, principal & instrumentation of various spectroscopic techniques. This course is intended to give students a more complete picture of how spectroscopic methods are used to elucidate the structure of complex organic molecules.	
Student learning outcome: At the end of the course..... <ul style="list-style-type: none">• Students will be skilled in the interpreting NMR spectroscopy, Mass spectroscopy to derive the information regarding the structure, stereochemistry of the molecules• Students will apply the learned fundamental instrumental techniques in the physical characterization of organic molecules• Students will have a clear understanding of the subject related concepts• Students will get problem solving ability and identify organic compounds by analysis and interpretation of spectral data• Student will be able to solve structural problems based on UV-Vis, IR, ¹HNMR, ¹³CNMR and mass spectral data	

Unit 1 UV spectroscopy

(08Hrs)

- 1.1 Introduction
- 1.2 Electromagnetic radiation and spectroscopy
- 1.3 Absorption of electromagnetic radiations by organic molecules
- 1.4 Ultraviolet spectroscopy
- 1.5 Types of electronic transitions
- 1.6 Absorption laws
- 1.7 Selection Rule
- 1.8 Instrumentation
- 1.9 Applications

Unit 2 Infra-Red Spectroscopy

(08Hrs)

- 2.1 Introduction and origin of Infra-Red spectroscopy
- 2.2 Absorption in the IR region
- 2.3 Molecular Vibrations-Complexity and Simplicity of IR spectra
- 2.4 Calculation of vibrational frequencies
- 2.5 Selection Rule
- 2.6 Instrumentation
- 2.7 Sampling Techniques
- 2.8 Fingerprint region
- 2.9 Spectral features of organic compounds
- 2.10 Applications of IR- spectroscopy

Unit 3 Raman Spectroscopy

(10Hrs)

- 3.1 Introduction
- 3.2 Quantum theory of Raman effect

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- 3.3 Theory of Raman spectra
- 3.4 Equivalence of Beer-Lambert law of absorption in Raman scattering
- 3.5 Parameters of Raman lines
- 3.6 Rotational-Vibrational Raman Spectra: Diatomic and polyatomic molecules
- 3.7 Rule of mutual exclusion principle
- 3.8 Structural elucidation by Raman spectroscopy
- 3.9 Importance of Raman spectra

Unit 4 ^1H -NMR **(08Hrs)**

- 4.1 Introduction and basic principle of -NMR
- 4.2 Nuclear spin, nuclear resonance, saturation, relaxation
- 4.3 Instrumentation
- 4.4 Shielding and deshielding of magnetic nuclei
- 4.5 Chemical shift and its measurements
- 4.6 Factors influencing chemical shift
- 4.7 Spin – spin interactions and factors influencing
- 4.8 Dynamic NMR
- 4.9 Coupling constant J. and factors effecting J value

Unit 5 ^{13}C - NMR **(07Hrs)**

- 5.1 Introduction
- 5.2 Broad Band proton decoupling and Nuclear Overhauser Enhancement (NOE)
- 5.3 Off resonance decoupling, DEPT, APT
- 5.4 Chemical shift
- 5.5 Calculations of chemical shifts of aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbons
- 5.6 ^{13}C - ^{13}C coupling constant
- 5.7 ^{13}C - ^1H coupling constant

Unit 6 2D NMR **(06Hrs)**

- 6.1 Introduction
- 6.2. Homo-nuclear COSY
- 6.3 Hetero-nuclear HETCOR
- 6.4 Hetero-nuclear Single Quantum Coherence (HSQC)
- 6.5 NOESY and ROESY techniques
- 6.6 Comparison of ^1D NMR and ^2D NMR

Unit 7 Mass Spectroscopy **(08Hrs)**

- 7.1 Basic Principle
- 7.2 Instrumentation
- 7.3 Various methods of ionisation (EI, CI, FD, ESI, APCI, MALDI and FAB)
- 7.4 Mass analysers
 - 7.4.1 Time of flight mass analyser
 - 7.4.2 Quadrupole mass analyser
 - 7.4.3 Ion trap mass analysers

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- 7.4.4 Magnetic sector mass analyser
- 7.4.5 Electrostatic sector mass analyser
- 7.4.6 Ion cyclotron resonance
- 7.5 Fragmentation rules
- 7.6 Factors controlling fragmentation

Unit 8: Problems based on joint applications of UV, IR, NMR, MASS (05Hrs)

References:

1. Understanding NMR Spectroscopy, James Keeler, 2nd Edition, 2013, India Pvt Ltd.
2. Organic Spectroscopy through Solved Problems, Kali Shankar Mukherjee Bodhisattwa Mukhopadhyay, 1st Edition, 2013.
3. Elementary Organic Spectroscopy, Principles and Chemical Applications, Y.R. Sharma, 5th Revised Edition, 2013, S. Chand and Company.
4. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR, D. N. Sathyanarayana, 2nd Edition, 2013, I K International Publishing House Pvt. Ltd.;
5. Spectroscopy of Organic Compounds, P. S. Kalsi, 17th edition, 2016, New Age international Publishers.
6. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, 8th Edition, 2015, Wiley.
Principles of NMR Spectroscopy, David Goldenberg, 4th Edition, 2016, University Science Books.
7. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James A. Vyvyan, 4th Edition, Brooks Cole.
8. Spectroscopic Methods in Organic Chemistry, D.H Williams, I. Fleming, 6th Edition, Tata Mc Graw Hill Education.
9. Spectroscopy of Organic Compounds, P S Kalsi, 6th Edition, New Age International Publisher.
10. Organic Spectroscopy: Principles and Applications, Jag Mohan, 2nd Edition, Published by Alpha Science International Ltd.
11. Organic Spectroscopy (NMR, IR, Mass and UV), Dewan S.K., 1st Edition, CBS Publisher & Distributors Pvt Ltd.
12. Basic Principles of Spectroscopy, Raymond Chang, McGraw-Hill Inc.
13. Elementary Organic Spectroscopy, Y R Sharma, S. Chand & Company Pvt. Ltd.
14. Organic Spectroscopy, William Kemp, Palgrave Macmillan.
15. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce, 8th Edition, Wiley.

M.Sc. Organic Chemistry Syllabus (CBCS)

THIRD SEMESTER

Program: M.Sc. Organic Chemistry	Type: Theory
Semester: III	
Subject: DSC-VI- Designing Organic Synthesis	
Credit: 04(T) + 02 (P)	Total learning hours: 60
Course description: The course will cover different concepts regarding retrosynthetic analysis and synthetic planning, designing organic synthesis, principles and applications of asymmetric synthesis, general treatment of reaction mechanism, tautomerism.	
Student learning outcome: At the end of the course.....students will learn about <ul style="list-style-type: none">• Synthetic planning and designing in various organic synthesis.• To understand the methodology, basics and applications of electro-organic chemistry.• To study applications of organometallic compounds in organic synthesis.• To obtain knowledge regarding asymmetric synthesis.	

Unit 1 Retrosynthetic Analysis

(08 Hours)

- 1.1 Protecting Groups in Organic Synthesis:
Protection and deprotection of the Hydroxyl, Carbonyl, Amino and Carboxyl functional groups and its applications.
- 1.2 Concept of Umpolung (Reversal of Polarity):
Generation of acyl anion equivalent using 1,3-dithianes, methyl thio methyl sulfoxides, cyanide ions, cyanohydrins ethers, nitro compounds & vinylated ethers.
- 1.3 Introduction to Retrosynthetic analysis and Synthetic Planning:
Linear and convergent synthesis, Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group inter conversions, functional group addition (FGA), functional group of Removal (FGR), importance of order of events in Organic Synthesis. One and two group C-X disconnections (1,1; 1,2; 1,3 difunctionalized compounds) selective organic transformations. Chemo selectivity, Regio selectivity, Stereoselectivity, enantio selectivity.

Unit 2 Designing Organic Synthesis

(06 Hours)

- 2.1 General Strategy: Choosing a disconnection-simplification Symmetry, high yielding steps, and recognisable starting material.
- 2.2 One group C-C Disconnections: Alcohols (including Stereo selectivity), Carbonyls (including regio selectivity), Alkane Synthesis, use of acetylenes and aliphatic nitro compounds in Organic Synthesis.
- 2.3 Two group C-C Disconnections: 1,2; 1,3; 1,4; 1,5 and 1,6 – difunctionalized compounds, Diels-Alder reactions, α , β – unsaturated compounds, control in carbonyl condensations, Michael addition and Robinson annelation.

Unit 3 Electro-Organic Chemistry and Selected Methods of Organic Synthesis (08 Hours)

- 3.1 Introduction: Electrode Potential, Cell Parameters, Electrolyte, working electrode choice of Solvents, Supporting Electrolytes.
- 3.2 Cathodic reduction: Reduction of alkyl halides, aldehydes, ketones, nitro compounds, olefins, arenes, electro-dimerization.
- 3.3 Anodic Oxidation: Oxidation of alkyl benzene, Kolbe reaction, Non-Kolbe oxidation, sono oxidation.

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Unit 4 Selected Methods of Organic Synthesis (06 Hours)

- Application of the following in Organic Synthesis.
- 4.1 Crown ethers, Cryptands, Micelles, Cyclodextrins, Catechols.
 - 4.2 Organo catalysts: Proline, Imidazolidinone
 - 4.3 Catalysed cycloaddition reactions, Stille reaction, Saegusa-1 to oxidation to enones, Negishi coupling.

Unit 5 Transition and rare earth metals in Organic Synthesis (12Hours)

- 5.1 Introduction to basic concepts: 18 electron rule, Bonding in transition metal complexes, C-H activation, Oxidative addition, Reductive elimination, Migratory insertion.
- 5.2 Palladium in Organic Synthesis: π – bonding of Pd with olefin, applications in C-C bond formation, Carbonylation, Alkane isomerisation, Cross-coupling of organometallics and halides, Representative examples. Heck reaction, Suzuki-Miyaura coupling, Sonogashira reaction and Wacker Oxidation. Heteroatom coupling for bond formation between aryl/vinyl groups and N, S or P – atoms.
- 5.3 Olefin metathesis using Grubbs's Catalyst.
- 5.4 Application of Ni, Co, Fe, Rh and Cr carbonyls in Organic Synthesis
- 5.5 Application of samarium iodide including reduction of Organic halides, aldehydes and ketones, α -functionalised carbonyl and nitro compounds.
- 5.6 Application of Ce (IV) in synthesis of hetero cyclic quinoxaline derivatives and its role as a deprotecting agent.

Unit 6 Principles and applications of asymmetric synthesis: (08 Hours)

- 6.1 Stereoselectivity in cyclic compounds, enantio-selectivity, diastereoselectivity,
- 6.2 Enantiomeric and diastereomeric excess, stereo selective aldol reactions.
- 6.3 Cram's rule, Felkin-Anh rule, Cram's chelate model,
- 6.4 Asymmetric synthesis, chiral pool strategy, use of chiral auxiliaries, chiral reagents and catalysts
- 6.5 Asymmetric hydrogenation, asymmetric epoxidation and asymmetric hydroxylation
- 6.6 Baker Yeast as chiral catalyst.

Unit 7 General Treatment of Reaction Mechanism (04 Hours)

- 7.1 Intermolecular & intramolecular reactions.
- 7.2 Concept of organic acids and bases: effect of structure, substituent and solvent on acidity and basicity; proton sponge
- 7.3 Comparison between nucleophilicity and basicity;
- 7.4 Application of thermodynamic principles in acid-base equilibria.

Unit 8 Tautomerism (08 Hours)

- 8.1 Prototropy (keto-enol, nitro- aci-nitro, nitroso-oxyimino, diazo-amino and enamine-imine systems); valence tautomerism and ring-chain tautomerism;
- 8.2 Composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3- di carbonyl systems, phenols and related systems)
- 8.3 Factors affecting keto-enol tautomerism;
- 8.4 Application of thermodynamic principles in tautomeric equilibria.

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- 8.5 Rate constant and free energy of activation; free energy profiles for one-step, two-step and three- step reactions;
- 8.6 Catalysed reactions: electrophilic and nucleophilic catalysis;
- 8.7 Kinetic control and thermodynamic control of reactions;
- 8.8 Isotope effect: primary and β -secondary kinetic isotopic effect (kH /kD)
- 8.9 Principle of microscopic reversibility; Hammond's postulate

References:

1. Advanced Organic Chemistry Part A and Part B: Reaction and Synthesis, Francis A Carey, Richard J Sundberg, 5th Edition, Springer Verlag.
2. Modern methods of Organic Synthesis, Synthesis 4th Edition, 2004, W. Carruthers and Iain Coldham, Cambridge University Press.
3. Modern Organic Synthesis: An Introduction, G.S. Zweifel and M.H.Nantz , W.H. Freeman , 2007.
4. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon, 3rd Edition, Nelson Thornes.
5. Advanced Organic Chemistry: Reactions & Mechanisms, B. Miller and R. Prasad, 2nd Edition, Pearson.
6. Organic reactions & their mechanisms, 3rd Revised Edition, P. S. Kalsi, New Age International Publishers.
7. Organic electrochemistry, H. Lund and M. Baizer, 3rd Edition, Marcel Dekker.

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THIRD SEMESTER

Program: M.Sc. Organic Chemistry	Type: Theory
Semester: III	
Subject: SEC-III- Analytical Techniques in Applied Chemistry	
Credit: 04(T) + 02 (P)	Total learning hours: 60
Course description: This course paper deals about sampling and analysis methods to determine various quality parameters of soil and fertilizer, water-wastewater, industrial solid waste and stack gas, ore and alloy, polymer, petroleum and fuel, pharmaceutical and clinical analysis.	
Student learning outcome: At the end students will be able to learn about Sampling techniques, principle, chemical reaction and analysis methods of various quality parameters of <ul style="list-style-type: none"> • Soil and fertilizer • Water-wastewater • industrial solid waste and stack gas • ore and alloy • polymer • petroleum and fuel • pharmaceutical • Clinical analysis 	

Unit 1 Soil and Fertilizer Analysis

(06 Hours)

- 1.1 Sampling
- 1.2 Principle, Chemical Reaction and Methods of Analysis:
 - 1.2.1 pH & Moisture
 - 1.2.2 Kjeldahl and Total Nitrogen
 - 1.2.3 Organic Carbon
 - 1.2.4 Total P and Phosphate
 - 1.2.5 Na and K, Ion Exchange Capacity
 - 1.2.6 Pesticides and Insecticides
- 1.3 Soil Health Standards

Unit 2 Industrial Wastewater Analysis

(08 Hours)

- 2.1 Sampling
- 2.2 Principle, Chemical Reaction and Methods of Analysis:
 - 2.2.1 D.O., BOD and COD
 - 2.2.2 Phenol and TOC
 - 2.2.3 Metals and Heavy Metals
- 2.3 Disposal Standards

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Unit 3 Industrial Solid Waste & Stack Gas Analysis **(06 Hours)**

- 3.1 Sampling
- 3.2 Principle, Chemical Reaction and Methods of Analysis:
 - 3.2.1 Proximate Analysis of Solid Waste
 - 3.2.2 Ultimate Analysis of Solid Waste
 - 3.2.3 Particulate Matter
 - 3.2.4 CO, SO_x, NO_x
- 3.3 Quality Standards

Unit 4 Petroleum & Fuel Analysis **(06 Hours)**

- 4.1 Sampling and Determination
 - 4.1.1 Moisture, Volatiles, Ash and Fixed carbon
 - 4.1.2 Calorific value
 - 4.1.3 Flash and Fire Point
 - 4.1.4 Aniline point
 - 4.1.5 Octane Number and Cetane Number

Unit 5 Clinical Analysis **(08 Hours)**

- 5.1 Sampling
- 5.2 Estimation of
 - 5.2.1 Blood Chloride, Na and K
 - 5.2.3 Blood Glucose
 - 5.2.4 Blood Urea and BUN
 - 5.2.5 Creatinine and Billirubin
 - 5.2.6 Cholesterol and Haemoglobin

Unit 6: Ore & Alloy Analysis **(06 Hours)**

- 6.1 Determination of % Purity of
 - 6.1.1 Pyrolusite Ore (Available O₂ and MnO₂, Mn⁺²)
 - 6.1.2 Dolomite Ore or Lime Stone (Calcium)
 - 6.1.2 Stainless Steel Alloy (Iron and Nickle)
 - 6.1.3 Brass Alloy (Copper and Zinc)
 - 6.1.4 Chromite Ore (Chromium)

Unit 7 Pharmaceutical analysis **(12 Hours)**

- 7.1 Determination of Diclofenac (non-aqueous titration)
- 7.2 Calcium in Vitamin D and Calcium formulations (Complexometry)
- 7.3 Sulphanilamide (potentiometry)
- 7.4 Pethidine hydrochloride (UV-Vis), Frusemide (UV-Vis)
- 7.5 Aspirin, paracetamol and codein in APC tablets (NMR)
- 7.6 Phenobarbitone in tablets (IR)
- 7.7 Pivolic acid in dipivefrin eye drops (GC)
- 7.8 Assay of hydrocortisone cream. (HPLC)

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7.9 Impurity profiling of Propranolol (GC-MS), famotidine (LC-MS).

Unit 8: Polymer Analysis

(08 Hours)

- 8.1 Chemical analysis of polymers: X-ray diffraction analysis, thermal analysis, TGA, DTA.
- 8.2 Physical testing of polymers: Mechanical properties, Fatigue testing, impact testing, tear resistance, hardness, abrasion resistance
- 8.3 Thermal properties: Softening temperature, flammability
- 8.4 Optical properties: transmittance, color, gloss, haze and transparency.
- 8.5 Electrical properties: dielectric constant and loss factor, resistivity, dielectric strength, electronic properties.
- 8.6 Chemical properties: resistance to solvents, vapor permeability, weathering.
- 8.7 Measurement of molecular weight and size: (4 L) End group analysis, colligative properties measurements, solution viscosity and molecular size.

References:

1. Chemistry for Environmental Engineering and Science, C. N. Sawyer and P. L. McCarty, G.F. Parkin, 5th Edition, 21st Reprint, 2015, McGraw Hill Education (India) Private Limited.
2. Analytical Chemistry, H. Kaur, 1st Edition, 2013, Pragati Prakashan.
3. Quantitative Analysis, R.A Day, A. L. Underwood, 6th Edition, 1991, Prentice-Hall.
4. Standard Methods for Examination of Water & Wastewater – Andrew D. Eaton, Lenore S. Clesceri, Eugene W. Rice, Arnold Greenberg, 23rd Edition, 2017, published by APHA, AWWA, WEF.
5. Environmental Chemistry - A. K. De, 7th Edition, 2015, New Age international (P) Ltd.
6. Official Methods of Analysis – Dr. William Harwitz, Dr. George W Latimer, 18th Edition, 2005, published by Association of Officiating Analytical Chemists (AOAC).
7. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West, F.J. Holler and S.R. Crouch, 9th Edition, Reprint 2014, Cengage Learning.
8. Analytical Instrumentation, Bela G. Liptak, 1st Edition, 1994, 1st Indian Reprint, 2012, Chilton Book Company.
9. Analytical Techniques in Agriculture, Biotechnology and Environmental Engineering, A. Nag, 1st Edition, 2006, Prentice Hall of India Pvt. Ltd.
10. Laboratory Manual on Engineering Chemistry, S.K. Bhasin and Sudha Rani, 3rd Edition, Reprint 2011, Dhanpat Rai Publishing Company (P) Ltd.

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THIRD SEMESTER

Program: M.Sc. Organic Chemistry	Type: Theory
Semester: III	
Subject: DSE- III - Application of Green Chemistry	
Credit: 04(T) + 02 (P)	Total learning hours: 60
Course description: Students shall be able to understand: <ul style="list-style-type: none"> • A functional concept of the field of green chemistry. • The 12 principles of green chemistry. • Several realworld examples where organizations used green chemistry to improve the sustainability performance of their products. How the practice of green chemistry enhances competitiveness, innovation and faster time to market.	
Student learning outcome: At the end of the course students will be able to...understand about <ul style="list-style-type: none"> • Green Chemistry is the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances. • This course will present the fundamentals of the 12 principles of green chemistry, and explore relevant examples of their practical use in commercial applications. • To understand the environmental consequences of chemical manufacturing and illustrate how these may be minimized. 	

Unit 1 Application of green chemistry in daily life (06 Hours)

- 1.1 Green Dry cleaning of clothes, Green Bleaching Agents, green detergents, green dyes
- 1.2 Eco Friendly paints & Waxes
- 1.3 Putting out Fires in a green way
- 1.4 Turning turbid water clear in a Green way
- 1.5 Biodegradable plastics
- 1.6 Computer chips
- 1.7 Green drugs
- 1.8 Solar cell, Solar water heater
- 1.9 Green building and construction Materials
- 1.10 Bleaching of paper
- 1.11 Reusable water Bottle
- 1.12 Bio Material & Green fuel
- 1.13 Anti foulants and other green chemicals

Unit 2 Application of green chemistry in pharmaceutical Industry. (12Hours)

- 2.1 Green Pharmacy: Principle
- 2.2 Green Catalyst & Biocatalyst used in pharmaceutical industry.
- 2.3 Green Solvents and it's categories:
Water, Ionic liquids & Supercritical CO₂, Other Green Solvents
- 2.4 Solvent free processes,
- 2.5 Green processes in Pharmaceutical development
- 2.6 Minimum Pharmacy Waste
- 2.7 Design pharmaceutical products for degradation
- 2.8 Green Resources for Drug development through Ethan botany
- 2.9 Eco friendly Medicinal plants & Ayurvedic preparation

Unit 3 Application of Green chemistry in Agriculture. (10Hours)

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- 3.1 Natural product in plant protection:
- 3.2 Development of green chemicals for the Agriculture-Minimum Risk Pesticides
- 3.3 Eco friendly Pesticides & Insecticides
- 3.4 Renewable Feedstock from Agriculture (Biomass)
- 3.5 A new Role of Neem Tree in greening the Environment
- 3.6 Vesicular Arbuscular Mycorrhizae in green chemistry.

Unit 4 Application of Green chemistry in Industry (12Hours)

- 4.1 Food and flavour Industry
- 4.2 Paper and pulp Industry
- 4.3 Polymer Industry
- 4.4 Textile Industry
- 4.5 Paint Industry: Water Based paints, High solids Paints, low TiO₂ paint
- 4.6 Tannery Industry
- 4.7 Rubber Industry

Unit 5 Application of Green chemistry for achieving sustainable development (06 Hours)

- 5.1 Green chemistry skills
- 5.2 Environmentally Friendly Technologies
- 5.3 Renewable feedstock and raw materials,
- 5.4 Oleochemistry, photochemistry, bio catalysis & biotransformation, sequestration of CO₂, waste biomass as chemical feed stock,
- 5.5 Biodegradation of biomass to biogas & biodiesels

Unit 6 Application of Green chemistry in analytical chemistry (04Hours)

- 6.1 Green analytical chemistry
- 6.2 Electrophoresis
- 6.3 Micronization in separation Methods
- 6.4 Greener solvent for separation

Unit 7 Eco friendly technologies for clean world (06Hours)

- 7.1 Waste: production, problems & prevention
- 7.2 Environmentally Benign Technologies using green chemistry
- 7.3 Application of non conventional energy sources
- 7.4 Microwave induced & Ultrasound assisted green synthesis

Unit 8 Other Applications Of Green Chemistry (04 Hours)

- 8.1 Chemicals from glucose:
- 8.2 Polysaccharide Polymers
- 8.3 Application of green chemistry in organic synthesis
- 8.4 Greener nanoscience

References:

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1. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, 2005, Anamalaya Publishers.
2. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, 1988, University Press.
3. A.S. Matlack: Introduction to Green Chemistry, 2001, Marcel Dekker.
4. M.C. Cann & M.E. Connely: Real-World Cases in Green Chemistry, 2000, American Chemical Society, Washington.
5. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, 2002, American Chemical Society, Washington.

Laboratory Practical

1. Determination of Organic Carbon in soil sample.
2. Determination of Nitrogen in soil sample.
3. Determination of Phosphorous in soil sample.
4. Determination of BOD in industrial wastewater sample.
5. Determination of NO_x in Air sample.
6. Determination of SO_x in Air sample.
7. Nitration of Salysilic Acid using Ca(NO₃)₂ and Acetic Acid.
8. Bromination of Acetanilide using KBrO₃ and (NH₄)₂Ce(NO₃)₆.
9. Preparation of Schiff Base by Microwave Technique.
10. Determination of Blood Sugar by Folin-Wu method.
11. Determination of Blood Urea by DAM method.
12. Determination of % Purity of Brass Alloy (Copper and Zinc).

References:

1. Standard Methods for Examination of Water & Wastewater, Andrew D. Eaton, Lenore S. Clesceri, Eugene W. Rice, Arnold Greenberg, 23rd Edition, 2017, published by APHA, AWWA, WEF.
2. Official Methods of Analysis, Dr. William Harwitz, Dr. George W Latimer, 18th Edition, 2005, published by Association of Officiating Analytical Chemists (AOAC).
3. Analytical Techniques in Agriculture, Biotechnology and Environmental Engineering, A. Nag, 1st Edition, 2006, Prentice Hall of India Pvt. Ltd.
4. Laboratory Manual on Engineering Chemistry, S.K. Bhasin and Sudha Rani, 3rd Edition, Reprint 2011, Dhanpat Rai Publishing Company (P) Ltd.