

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

M.Sc. Organic Chemistry Syllabus				
	Semester-1	Semester-2	Semester-3	Semester-4
Core-1 (DSC)	Theoretical organic chemistry (DSC I)	Organic synthesis and mechanism (DSC III)	Organic Spectroscopy (DSC V)	Dissertation (SEC Component)
Core-2 (DSC)	Industrial Processes, Waste Management & Quality Control (DSC II)	Chemistry of Natural Products (DSC IV)	Designing organic synthesis (DSC VI)	
Skill Enhancement Course (SEC)	Advance analytical chemistry (SEC I)	Instrumentation and analytical techniques (SEC II)	Analytical Techniques in Applied Chemistry (SEC III)	Physical Organic Chemistry (DSC- VII)
Discipline Centric Electives (DSE)	Food Chemistry (DSE I)	Forensic Chemistry & Toxicology (DSE II)	Applications of Green Chemistry (DSE III)	Medicinal Chemistry/Dyes (DSE-IV)

Semester	Discipline Specific Elective Courses
1	1. Food Chemistry 2. Energy and Environment 3. Laboratory safety and management 4. Bioethics
2	1. Forensic Chemistry & Toxicology 2. Bioinformatics 3. IPR 4. Biostatistics.
3	1. Forensic biology and DNA typing 2. Research Methodology 3. Bio-entrepreneurship 4. Application of Green Chemistry
4.	1. Medicinal Chemistry 2. Dyes



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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..... • 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 ^1H -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 • 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 region 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, Shono 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, Catecholates.
- 4.2 Organo catalysts: Proline, Imidazolidinone
- 4.3 Catalysed cycloaddition reactions, Stille reaction, Negishi cross-coupling to oxidation to enones, Negishi coupling.

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

- 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 • 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: • 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 • 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.



SARVAJANIK UNIVERSITY
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FOURTH SEMESTER

Program: M.Sc.	Type: Theory
Subject: DSC- VII: Physical Organic Chemistry	
Credit: 04(T) + 02 (P)	Total learning hours: 60
Course description: This course paper covers thermodynamic and kinetic requirements of organic reaction – reactivity, reaction mechanism, study of acidity and basicity of organic compounds, mechanisms of surface reactions, application of chemical kinetics in pharmaceuticals, molecular dynamics in biological macromolecules.	
Student learning outcome: At the end students will be able to learn about.... • Thermodynamic and Kinetic requirements of organic reaction • Reactivity and selectivity principles • Determination of Reaction Mechanism • Linear free energy relationships (LFER) • Factors affecting acidity and basicity, Acid and base catalysis • Kinetic effects of surface heterogeneity & interactions • Calculation of elimination rate constant & metabolism constant • Supramolecular reactivity and catalysis • Molecular channels, devices and transport processes	

Unit 1 Thermodynamic and Kinetic Necessities of a Reaction (06 Hours)

- 1.1 Chemical equilibrium: rate and equilibrium constants
- 1.2 Mechanistic significance of entropy, enthalpy and Gibb's free energy
- 1.3 Arrhenius equation, transition state theory, uses of activation parameters
- 1.4 Transition state model- potential energy surface for substitution and elimination reactions

Unit 2 Principle of Reactivity (06 Hours)

- 2.1 Hammond's postulate, Marcus theory of electron transfer
- 2.2 Reactivity and selectivity principles,
- 2.3 Curtin-Hammett Principle, Microscopic reversibility
- 2.4 Kinetic vs thermodynamic control of organic reactions

Unit 3 Determination of Reaction Mechanism (08 Hours)

- 3.1 Product analysis, Kinetic studies
- 3.2 Theory of isotope effect: primary and secondary kinetic isotope effects
- 3.3 Heavy atom isotope effects, Tunnelling effect, Solvent effect
- 3.4 Detection and trapping of intermediates
- 3.5 Crossover experiments and stereochemical evidence

Unit 4 Structural Effects on Reactivity (10 Hours)

- 4.1 Linear free energy relationships (LFER)
- 4.2 The Hammett equation, substituent, constants
- 4.3 Theories of substituent effects, interpretation of σ values, reaction constant ρ



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- 4.4 Deviations from Hammett equation, dual-parameter corrections, inductive substituent constant
- 4.5 The Taft model σ_I - and σ_R - scales, Swain-Scott & Edward equations, Winstein Grunwald relationship
- 4.6 Isokinetic relationship

Unit 5 Acids and Bases (06 Hours)

- 5.1 Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity and solvation.
- 5.2 Comparative study of acidity and basicity of organic compounds on the basis of pKa values
- 5.3 Levelling effect and non-aqueous solvents
- 5.4 Acid and base catalysis - general and specific catalysis with examples

Unit 6 Reactions at Surfaces (06 Hours)

- 6.1 Mechanisms of surface reactions- kinetic effects of surface heterogeneity & interactions
- 6.2 Surface inhibition and activation energies - Surface exchange reactions- TST of surface reactions
- 6.3 Unimolecular & bimolecular reactions
- 6.4 Micelles: Surface active agents-micellization, CMC, micellar catalysis

Unit 7 Application of Chemical Kinetics in Pharmaceuticals (06 Hours)

- 7.1 Pharma concentration time curve
- 7.2 Protein binding and drugs, drug dissolution rate
- 7.3 Pharmacokinetics applied to one-component open model
- 7.4 Calculation of elimination rate constant & metabolism constant

Unit 8 Molecular Dynamics (12 Hours)

- 8.1 Principle of molecular association and organization in biological macromolecules:
 - 8.1.1 Enzymes, nucleic acids, membranes
 - 8.1.2 Model systems like micelles and vesicles
- 8.2 Molecular receptors and design principle
 - 8.2.1 Cryptands, cyclophanes, calixerenes, cyclodextrines
- 8.3 Supramolecular reactivity and catalysis
- 8.4 Molecular channels and transport processes
- 8.5 Molecular devices and nanotechnology



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M.Sc. Organic Chemistry Syllabus (CBCS)
FOURTH SEMESTER

References:

1. Molecular Mechanics, U. Burkert and N.L. Allinger, ACS Monograph 177, 1982
2. Physical Organic Chemistry, N.S. Isaacs, ELBS/Longman, 1990.
3. Supramolecular Chemistry; Concepts and Perspectives, J.M. Lehn, 1995, VCH, Weinheim.
4. Physical Chemistry, Peter Atkins and Julio de Paula, 5th Edition, 2006, W. H. Freeman and Company New York.
5. Chemical Kinetics, Keith J. Laidler, 3rd Edition, 1987, Pearson Education.
6. The Physical Basis of Organic Chemistry, H. Maskill, 1985, Oxford University Press.
7. Catalysis, J.C. Kuriacose, 1991, Macmillan India Ltd.
8. Micelles, Theoretical and applied aspects, V. Moroi, 1992, Plenum.
9. Mechanism and Theory in Organic Chemistry, T.H. Lorry and K.S. Richardson, 2nd Edition, 1981, Harper & Row, New York.
10. A Guidebook to Mechanism in Organic Chemistry, P. Sykes, 5th Edition, 1981, Longman, London,.
11. L.P. Hammett, Physical Organic Chemistry, 2nd Edition, 1970, McGraw Hill, New York.
12. P. Deslongchamps, Stereoelectronic Effects in Organic Chemistry, 1983, Pergamon, London.



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

Program: M.Sc.	Type: Theory
Subject: DSC-VIII: Industrial Chemistry	
Credit: 04(T)	Total learning hours: 60
Course description: This course paper includes the concept of material and energy balance, design of equipment, various instruments useful in industry, flow chemistry, industrial polymers, developments of process in chemical industries, strategies for organic reaction and processes and phase transfer catalysis.	
Student learning outcome: At the end the students will be able to learn about.. • Material and energy balance and calculations • Material and design of chemical reactor, pressure vessel • Instruments for measuring temperature, pressure and water flow of process stream • Principles and types of flow chemistry • Principle, working and applications of polymer processing techniques • Objectives and approaches of process development in chemical industries • Choice of reagents and solvents for organic reaction and processes • Nature and factors of phase transfer catalysis reactions	

Unit 1 Material and Energy Balance

(06 Hours)

- 1.1 Material balance: Process classification
- 1.2 Choice of system and basis of molecular processes with chemical reactions
- 1.3 Material balance calculations
- 1.4 Multiple unit processes, Recycle and bypass
- 1.5 Energy balance: Forms of energy, Energy balance
- 1.6 Energy changes in physical processes
- 1.7 Energy changes in reactions
- 1.8 Energy balance Calculations

Unit 2 Equipment Design

(06 Hours)

- 2.1 Material of constructions: Mechanical properties, Corrosion resistance
- 2.2 Plastics, Ceramics, Metals and alloys, Stainless steel
- 2.3 Special material for food and pharmaceutical equipment
- 2.4 Protective coatings, Surface treatment to metals for corrosion resistance
- 2.5 Classification of chemical reactors, Design of chemical reactors
- 2.6 Pressure vessels for internal or external pressure

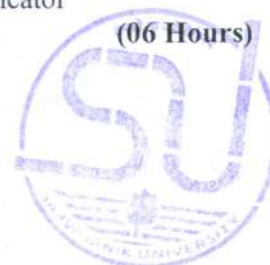
Unit 3 Industrial Instrumentation

(06 Hours)

- 3.1 Measurement of temperature, Thermo couples and pyrometers, High temperature thermometers
- 3.2 Optical pyrometers, Measurement of pressure and vacuum, Manometric and Bourdon gauges, Vacuum gauges, Ionization and pirani gauges
- 3.3 Flow measurement, Pitot tube, Rotameters, Liquid level indicators, Hook Type, Sight glass, Float type, Capacitance level indicator, Radiation level indicator

Unit 4 Flow Chemistry

(06 Hours)



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M.Sc. Organic Chemistry Syllabus (CBCS)
FOURTH SEMESTER

- 4.1 Introduction
- 4.2 Flow chemistry versus batch chemistry
- 4.3 Key principles of flow chemistry: residence time, mixing, pressure and temperature
- 4.4 Types of flow chemistry

Unit 5 Industrial Polymers (08 Hours)

- 5.1 Introduction
- 5.2 Principle, Working and applications of following polymer processing techniques:
Injection moulding, extrusion, blow moulding, compression moulding, film casting, thermoforming and vacuum forming

Unit 6 Process Development in Chemical Industries (12 Hours)

- 6.1 Introduction to process research & development
- 6.2 Goals & Objectives of Process development
- 6.3 Stages in process development
- 6.4 Scope and Limitations of Process development
- 6.5 Exploratory (Investigative) approach in Process development
- 6.6 Survey of Some organic reactions in relation to process development

Unit 7 Strategies for simplification of organic reaction and processes (06 Hours)

- 7.1 Choosing a reagent, Modifying reagents
- 7.2 Solvents: choosing a solvent, impurities in solvent, effect of solvents in organic reactions, mixed solvents,
- 7.3 Aqueous mediums for organic reactions, liquid products as solvents, new solvents

Unit 8 Phase transfer catalysis (10 Hours)

- 8.1 Nature of phase transfer catalysis reactions
- 8.2 Factors effecting phase transfer catalysis reactions
- 8.3 Choosing a phase transfer catalyst
- 8.4 Important phase transfer catalysts

References:

1. Industrial chemistry, H.K. L. Vaid, 1st Edition, 2007, Anmol publication.
2. Fundamentals of Industrial Chemistry: Pharmaceuticals, Polymers, and Business, John A. Tyrell, 2014.
3. Outlines of industrial chemistry, Frank Hall Thorp and Warren Kendall Lewis, 2018, Palala Press.
4. Industrial Chemistry, Dr. Darshan V. Chaudhary, 1st Edition, 2015, Create space publisher.
5. Industrial Inorganic Chemistry, Mark Anthony Benvenuto, de Gruyter, 2013.
6. Organic Chemistry Principles and Industrial Practice, Mark M. Green, Harold A. Wittcoff, 1st Edition, Wiley-VCH GmbH & Co, KGaA.
7. Toma Glasnov, Continuous-Flow Chemistry in Research Laboratory, Springer International Publisher.
8. Polymer Technology, D.C. Miles & J. H. Briston, Enlarged edition, 1996, Chemical Publishing company, Inc, New York



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9. Plastics Materials and Processes, Seymour S. Schwartz S.H. Goodman, 1982, Van Nostrand Reinhold, New York
10. Plastics Technology, R. V. Milbey, 1st Edition, 1973, McGraw Hill, Book Company New York
11. The chemistry of process development in fine chemicals and pharmaceutical industry, C. Someshwara Rao, 2nd Edition, 2004, Asian books Pvt. Ltd. New Delhi
12. Developing an Industrial chemical process, Joseph Mizrahi, 2003, CRC press
13. Practical process research and development, N. G. Anderson, 2000, American Press
14. Designing and operating safe chemical reaction process, Health and Safety Executive (HSE), 2000, HSE publishers



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

Program: M.Sc. Organic Chemistry	Department: Chemistry
Semester: IV	Type: Theory
Subject: DSE-V-Principles of Medicinal Chemistry	
Credit: 04(T)	Total learning hours: 60
Course description: This course explores the role of organic chemistry in the discovery and synthesis of important compounds widely used as medicines. It includes drug discovery process, QSAR concept, and role of computer in drug design. This syllabus also covers pharmacokinetics and pharmacodynamics which is very important for the students of medicinal chemistry. Apart from these some important drugs are also discussed in this paper.	
Student learning outcome: At the end of the course..... • Students will gain a comprehensive understanding of the fundamental concepts related to the actions and clinical uses of major classes of drugs from their chemical structures • They will be familiar with history of drugs, new invention in Medicinal chemistry • Students will get an overview of the applications of these concepts in applied field • Students will be aware about the basic ideas of medicines & their working mechanism • Students will have knowledge of synthesis of some drugs	

Unit-1 Introduction to Drug Discovery

(10 Hrs)

- 1.1 Introduction
- 1.2 Stereochemistry and drug design
 - 1.2.1 Structurally rigid groups
 - 1.2.2 Conformation
 - 1.2.3 Configuration
- 1.3 Solubility and drug design
- 1.4 Solubility and drug structure
- 1.5 Salt formation
- 1.6 The incorporation of water solubilizing groups in a structure
 - 1.6.1 The type of group
 - 1.6.2 Reversibly and irreversibly attached groups
 - 1.6.3 The position of the water solubilizing group
 - 1.6.4 Methods of introduction

Unit-2 Quantitative Structure–Activity Relationship

(08 Hrs)

- 2.1 Introduction to quantitative structure activity relationship studies
- 2.2 Lipophilicity
 - 2.2.1 Partition coefficients (P)
 - 2.2.2 Lipophilic substitution constants
- 2.3 Electronic effects: The Hammett constant (s)
- 2.4 Steric effects
 - 2.4.1 Taft steric parameter (Es)
 - 2.4.2 Molar refractivity (MR)
 - 2.4.3 Other parameters
- 2.5 Hansch analysis
- 2.6 Craig plots
- 2.7 Topliss decision tree



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FOURTH SEMESTER

Unit-3 Computer Aided Drug Design

(07 Hrs)

- 3.1 Introduction
 - 3.1.1 Molecular modelling methods
 - 3.1.2 Computer graphics
- 3.2 Molecular mechanics
 - 3.2.1 Creating a molecular model using molecular mechanics
- 3.3 Molecular dynamics
 - 3.3.1 Conformational analysis
- 3.4 Quantum mechanics
- 3.5 Docking

Unit-4 Pharmacokinetic

(07 Hrs)

- 4.1 Basic principles of pharmacokinetics
 - 4.1.1 Absorption
 - 4.1.2 Distribution
 - 4.1.3 Metabolism
 - 4.1.4 Excretion
- 4.2 Pharmacokinetic models
- 4.3 Pharmacokinetic parameters in defining drug deposition and in therapeutics
- 4.4 Uses of pharmacokinetics in drug development process
- 4.5 Concept of pro drug and soft drug

Unit-5 Pharmacodynamics

(08 Hrs)

- 5.1 Introduction
- 5.2 Principles of drug action
- 5.3 Mechanisms of drug action
- 5.4 Introduction to the concept of receptors and drug receptor interactions
- 5.5 Biotransformation
- 5.6 Dose-response relationships
- 5.7 Drug potency and efficacy
- 5.8 Combined effect of drugs

Unit-6 Antibiotics

(07 Hrs)

- 6.1 Introduction and classification
- 6.2 Antibiotics that interfere with the biosynthesis of bacterial cell wall
 - 6.2.1 The β -lactum antibiotics: Penicillin and Cephalosporin (Synthesis and uses)
 - 6.2.2 Non lactum antibiotics
 - 6.2.3 Bacitracin, Vancomycin and Cycloserine (Synthesis and therapeutic uses)
- 6.3 Antibiotics that interfere with the protein biosynthesis in microorganisms
 - 6.3.1 Non lactum antibiotics: Tetracycline, Chloroamphenicol
- 6.4 Non classifiable antibiotics

Unit-7 Drugs Acting at Synaptic and Neuro-Effector Junction Sites

(07 Hrs)

- 7.1 Cholinergics and Anticholinesterases
- 7.2 Adrenergic drugs



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FOURTH SEMESTER

- 7.3 Antispasmodic and antiulcer drugs
- 7.4 Neuromuscular blocking agents

Unit-8 Miscellaneous

(06 Hrs)

- 8.1 Antifungal – polyenes
- 8.2 Antiviral – Acyclovir
- 8.3 Antimalarials : : Modern chemotherapy of malaria, 4-amino and 8-amino quinolins, 9- amino acridine
- 8.4 Mode of action of antimalarial agents
- 8.5 SAR of antimalarial agents
- 8.6 Synthesis of mefloquine, chloroquine, primaquine and daraprim

Reference:

1. Burger's medicinal chemistry and drug design, 1997, vol I to 5 edited by Manfred E. Woltt John Wiley and sons Mc. New York
2. Foye's Principles of medicinal chemistry, Thomas Lemke, 2012, Lippincott Williams and Wilkins
3. Principles of medicinal chemistry vol I & II (5/e), F.S.kadam, K.R. Mahadik and K.G.Bohra, 2019, Nirali publication
4. Medicinal chemistry, Ashutosh kar, 2018, New Age International Publishers
5. The organic chemistry of drug synthesis vol I, II and III Daniel Lednicer (Editor), Lester A. Mitscher (Editor), 1980, Wiley
6. An introduction to Medicinal chemistry, G. L. Patrick, 2018, Oxford University Press
7. The Organic Chemistry of Drug Design and Drug Action, Richard B. Silvermann, 2014, Academic Press
8. Essentials of Medical Pharmacology, K. D. Tripathi, 2019, Jaypee Brothers Medical Publishers (P) Ltd.
9. A textbook of medicinal chemistry, P. Primoo, 2019, CBS Publishers & Distributors
10. Text book of pharmaceutical organic chemistry, Md. Ali, 2020, CBS Publishers



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

Program: M.Sc.	Type: Theory
Semester-4	
Subject: DSE – IV Dyes	
Credit: 04(T)	Total learning hours: 60
Course description: This course will give an introduction to dyes and pigments. The primary goal of this course is to make students aware of how dyes can be classified and the basic chemistry applied in dyeing process. This subject provides fundamental knowledge of various types of dyes and how to carry out dyeing process in textile industries. This course also includes applications of dyes in the field other than textile fibres.	
Student learning outcome: Upon completion of this course, students will be able to learn about: • To explain the and define the classes of dyes, substrates • To understand the variety and chemistry of dyes and their application • To distinguish the various dye class and their application to different fibres types • To understand the uses of dyes in non-textile field.	

Unit 1 Colour and constitutions

(06 Hours)

- 1.1 Colour, chromophore and Auxochromes.
- 1.2 Classification of dyes based on chemical nature.
- 1.3 Relation between colour and constitution
 - 1.3.1 Witt's theory
 - 1.3.2 Armstrong theory
 - 1.3.3 Modern theory
 - (a)Valence bond theory
 - (b)Molecular orbital theory

Unit2 Dyes

(08 Hours)

- 2.1 Definition, Classification Based on Application
- 2.2 Fastness properties & applicability on substrates
- 2.3 Examples with structures (a) Acid Dyes- Orange II, (b) Basic Dyes-methyl violet, Victoria Blue B (c) Direct cotton Dyes- Benzofast Yellow 5GL (d) Azoic Dyes-Diazo components; Fast yellow G, Fast Orange R. Coupling components. Naphthol AS, Naphthol ASG (e) Mordant Dyes-Erichrome Black A, Alizarin. (f) Vat Dyes- Indanthrene brown RRD, Indanthrene Red 5GK. (g) Sulphur Dyes- Sulphur Black T (no structure) (h) Disperse Dyes-Celliton Fast brown 3R, perlon fastblue FFR (i) Reactive Dye scibacron Brilliant Red B, procion brilliant Blue HB.

Unit 3 Considerations in Dye Design

(06 Hours)



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M.Sc. Organic Chemistry Syllabus (CBCS)
FOURTH SEMESTER

- 3.1 Dye -substrate affinity
- 3.2 Dyes for polyesters
- 3.3 Dyes for polyamides and proteins
- 3.4 Dyes for cationic polymers
- 3.5 Dyes for cellulosic polymers
- 3.6 Toxicological consideration
- 3.7 Structure -Property Relationship.

Unit 4 General Theory of Dyeing

(06 Hours)

- 4.1 Introduction of Dyeing
- 4.2 Role of water
- 4.3 Role of electrolytes
- 4.4 High temperature the Dye Liquor
- 4.5 High temperature Dyeing
- 4.6 Dye auxiliaries compounds
- 4.6.1 Swelling agents
- 4.6.2 Levelling agents
- 4.7 Scouring after dyeing

Unit 5 Basic Operations in Dyeing Process

(08 Hours)

- 5.1 Preparation of the fibres
- 5.2 Preparation of the dyebath, Application of the dyebath and finishing
- 5.3 Various methods of dyeing: Direct dyeing, Vat dyeing, Mordant dyeing, Disperse dyeing and Formation of dye on the fibre
- 5.4 Dyeing of wool with the acid dyes
- 5.5 Dyeing with the reactive dyes

Unit 6 Non Textile Uses of Dyes

(06 Hours)

- 6.1 Biological staining agents Methylene blue, Crystal violet
- 6.2 Dyes as therapeutics: Mercurochrome, Acriflavine, Crystal violet, Prontosil
- 6.3 Dyes used in food and cosmetics
- 6.4 Paper and Leather Dyes
- 6.7 Miscellaneous Dyes: Hair dyes, Laser dyes, Indicators, Security inks

Unit 7 Pigments

(10 Hours)

- 7.1 Introduction
- 7.2 Difference between Dyes and Pigments
- 7.3 Classification of pigments
- 7.4 Application of pigments
- 7.5 Raw materials for organic pigments
- 7.6 General methods of processing and synthesis of inorganic pigments: Crushing and grinding, vaporization, co precipitation, filtration, drying, flushing, calcinations/roasting, vapour phase oxidation etc.

Unit 8 Smart Dyes

(10 Hours)



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M.Sc. Organic Chemistry Syllabus (CBCS)
FOURTH SEMESTER

- 8.1 Introduction and types of Chromism
- 8.2 Application of smart and functional Dyes in Textiles
 - 8.2.1 Electrochromic dyes
 - 8.2.2 Thermochromic dyes
 - 8.2.3 Photochromic dyes
 - 8.2.4 Chemochromic dyes
 - 8.2.5 Solvatochromic dyes
 - 8.2.6 Mechano chromic dyes

Reference Books

1. Color Chemistry, 3rd Edition, Heinrich Zollinger, Wiley – VCH, 2003.
2. Organic Chemistry and Application Properties, John Shore, Society of Dyers & Colourists; 2nd Edition, 2002.
3. The Chemistry of Synthetic dyes, K. Venkataraman, 1971, Academic Press.
4. Industrial Inorganic Pigments, Gunter Buxbaum, 1st Edition, 2005, Wiley-VCH.
5. Industrial Organic Pigments: Production, Properties, Applications, 3rd Edition, 2006.
6. Application Properties of Pigments, A. Karnik, 1st Edition, 1999.
7. Chemistry of Synthetic Dyes and Pigments, Lubs H. A., Robert E. Krieger Publishing Company, New York, 1977.
8. Chemistry of Synthetic Dyes – Vol I, Venkataraman, K., 1952, Academic Press.
9. Chemistry of Synthetic Dyes – Vol III, Venkataraman, K., 1972, Academic Press.
10. Colour and Chemical Constitution of Organic Dyes, Griffiths J., 1976, Academic Press.
11. Quantum Chemistry, Chandra A. K., 1979, Tata McGraw Hill.
12. Color Chemistry – Synthesis, Properties and Applications of Dyes and Pigments, Zollinger H., 2nd Edition, 1991, Weinheim – VCH.

