JYOTI NIVAS COLLEGE AUTONOMOUS BANGALORE – 560 095
DEPARTMENT OF CHEMISTRY
B.Sc. IV SEMESTER CHEMISTRY PAPER IV SYLLABUS (2024 SEP BATCH)
INTEGRATED PRINCIPLES OF CHEMISTRY II

COURSE TITLE	**INTEGRATED PRINCIPLES OF CHEMISTRY II**
COURSE CODE	**24IVCH4T**
COURSE CREDITS	**3**
TOTAL CONTACT HOURS	**56 HOURS**
DURATION OF ESA	**3 HOURS**
FORMATIVE ASSESSMENT MARKS	**20 MARKS**
SUMMATIVE ASSESSMENT MARKS	**80 MARKS**

Course Objectives

The course aims to:

1. **Understanding Core Concepts**: Develop a thorough understanding of physical, inorganic, and organic chemistry principles such as phase equilibria, crystallography, ionic equilibria, and coordination chemistry.
2. **Analytical Skills**: Equip students with the ability to interpret phase diagrams, conductometric data, and crystallographic information.
3. **Practical Applications**: Foster skills to apply theoretical knowledge in chemical analysis, synthetic organic reactions, and real-world industrial and medical applications.
4. **Critical Thinking**: Cultivate the ability to evaluate chemical phenomena and processes using theoretical models and logical reasoning.

Course Learning Outcomes (CLOs)

1. **Understanding Core Concepts**:
   Explain fundamental concepts of phase equilibria, crystallography, coordination and organometallic chemistry, and the structure and reactivity of carbonyl and carboxylic acid compounds.
2. **Analytical Skills**:
   Solve problems related to ionic equilibria, buffer systems, conductance, and crystallographic parameters using theoretical principles and mathematical applications.
3. **Practical Applications**:
   Apply the principles of phase diagrams, electrochemistry, and organometallic chemistry in industrial, analytical, and pharmaceutical contexts.
4. **Critical Thinking**:
   - Evaluate bonding models, acid-base behaviour, stereochemistry, and reaction mechanisms to predict chemical behaviour and design organic syntheses.

- Integrate theoretical and practical knowledge to analyze experimental data, draw conclusions, and effectively communicate chemical phenomena in both written and oral forms.

Programme Outcomes (POs) for B.Sc. Programmes

The general Programme Outcomes for B.Sc. programmes with Chemistry at Jyoti Nivas College include:

1. **Core Competency**: Develop a strong foundation in the respective disciplines, enabling students to pursue higher education and research.
2. **Critical Thinking**: Enhance analytical and problem-solving skills to address scientific queries effectively.
3. **Analytical Reasoning**: Apply logical reasoning and quantitative analysis in scientific investigations.
4. **Research Skills**: Acquire the ability to design experiments, collect and interpret data, and present findings.
5. **Team Work**: Foster collaborative skills to work effectively in diverse teams.

These outcomes are designed to prepare students for advanced studies, research, and professional careers in science and related fields.

Based on the provided course objectives and learning outcomes, and aligning them with the Programme Outcomes (POs) of the B.Sc. programmes at Jyoti Nivas College Autonomous, Bangalore, here is a mapping for the B.Sc. CBZ (Chemistry, Botany, Zoology), BCZ (Biotechnology, Chemistry, Zoology), BCB (Biotechnology, Chemistry, Botany), and PCM (Physics, Chemistry, Mathematics) streams.

Mapping of Course Learning Outcomes (CLOs) with Programme Outcomes (POs)

Course Learning Outcomes (CLOs)	PO1	PO2	PO3	PO4	PO5
1. Understanding Core Concepts - Explain fundamental concepts of phase equilibria, crystallography, coordination and organometallic chemistry, and the structure and reactivity of carbonyl and carboxylic acid compounds.	✓	✓			
2. Analytical Skills - Solve problems related to ionic equilibria, buffer systems, conductance, and crystallographic parameters using theoretical principles and mathematical applications.	✓	✓	✓		
3. Practical Applications - Apply the principles of phase diagrams, electrochemistry, and organometallic chemistry in industrial, analytical, and pharmaceutical contexts.	✓		✓	✓	
4. Critical Thinking – • Evaluate bonding models, acid-base behaviour, stereochemistry, and reaction mechanisms to predict chemical behaviour and design organic syntheses. • Integrate theoretical and practical knowledge to analyze experimental data, draw conclusions, and effectively communicate chemical phenomena in both written and oral forms.	✓	✓	✓	✓	✓

This mapping ensures that the course content not only imparts essential knowledge but also aligns with the broader educational goals of the B.Sc. programmes at Jyoti Nivas College. It prepares students for higher studies, research, and professional careers in science and related fields.

Syllabus

UNIT – I **14 Hours**

Chapter 1: Phase Equilibria **10 hours**

Review: Equilibrium in systems and factors affecting equilibrium.

1.1 Introduction: Explanation of the terms with examples: phase (P), component (C) and degree of freedom (F). Phase rule - statement, significance and derivation.

1.2 Applications of phase rule to One Component Systems: Water and sulphur systems - phase diagram and explanation of the curves, areas, triple point, transition equilibria. Effect of pressure on freezing point of water, melting point of monoclinic sulphur and transition temperature of rhombic sulphur; calculation of degree of freedom.

1.3 Application of Phase rule to Two Component Systems: Types, condensed phase rule, temperature - composition phase diagrams for simple eutectic systems such as water–potassium-iodide and lead-silver systems; explanation of effect of mixing of two solids on melting point of a component, eutectic point, eutectic mixtures, effect of temperature on the solubility of KI. Desilverisation of lead by Pattinson's process. Freezing mixtures - preparation and examples. Phase diagram of $FeCl_3$ - H_2O system. Freezing mixture - definition and applications. Phase diagram of Na - K system.

1.4 Thermodynamics of Phase Transitions: Phase transitions in terms of Entropy (Fusion, vapourisation, sublimation and polymorphic changes) in terms of entropy. Limitations of the entropy concept of spontaneity. Problem on Phase transitions.

1.5 Applications of Phase rule in Metallurgy: Phase diagram of iron-carbon: explanation of the composition of austenite, ferrite, cementite and pearlite phases in the diagram.

Chapter 2: Solid state **4 hours**

Review: Crystalline and amorphous solids, anisotropy, types of crystalline solids, space lattice and unit cell.

2.1 Introduction to Crystallography: Laws of crystallography – law of rational indices, law of constancy of interfacial angles, law of constancy of symmetry elements. Symmetry elements in crystals: plane of symmetry- rectangular and diagonal planes. Axis of symmetry: two-fold, three-fold and four-fold axes. Centre of symmetry; illustration using a simple cubic crystal. Crystal systems –introduction of crystal parameters –a, b, c and α, β, γ; classification into seven systems (an example each, no diagrams required); Bravais lattices- explanation using cubic system (diagrams of primitive, face centered and body centered cubes with an example each). Weiss and Miller indices – calculation and use of h k l symbols; sketching of 100, 110, 111 planes in a cubic crystal; calculation of inter planar spacings in a simple cubic crystal, problems.

2.2 X-ray Diffraction of Crystals: Derivation of Bragg's equation and problems.

2.3 Liquid crystals: Explanation of the liquid crystalline state; types –smectic, nematic and cholesteric; examples and applications.

UNIT – II **14 Hours**

Chapter 3: Ionic equilibria **5 hours**

3.1 Hydrolysis of salts of weak acids and weak bases: Ionic product of water. Deriving the Relationship between K_h, K_w, K_a and K_b. Degree of hydrolysis and its relationship with K_h. Effect of temperature and dilution on degree of hydrolysis of salt of weak acid and weak base. pH expression for the salt of weak acid - bases. Numerical problems on the calculation of K_h, h and pH of salts of

weak acid and weak bases only.

3.2 *Self- Study:* Common ion effect: Statement and example (ammonium hydroxide - ammonium chloride and acetic acid - sodium acetate). Buffers: Types and examples. Buffer action and buffer capacity. pH of buffers- Henderson's equation and its derivation for acidic buffer. Problems in calculating the pH of buffers.

3.3 *Self-Study:* Solubility product and ionic product definitions and their applications in the precipitation of II and IV group basic radicals in the qualitative analysis of simple salt mixtures. Analytical and biological applications of buffers. Theories of Indicators: Mentioning the different theories. Acid-base theory by taking phenolphthalein as an example.

Chapter 4: Electrochemistry-I **9 hours**

Review: Electrolytes and Conductance related terms.

4.1 Conductance: Definition of molar conductance, determination of molar conductance of an electrolyte ($NaNO_3$ or KCl) using Wheatstone's bridge. Conductometric titrations: Definition and advantages over other conventional titrations. Principles involved in conductometric titrations with graph for strong acid strong base, strong acid-weak base, weak acid-strong base and weak acid-weak base titrations.

4.2 Ionic mobility: Absolute ionic mobility and transport number- definitions. Relationship between transport number and ionic mobility of an ion (no derivation). Determination of transport number of an ion (H^+ ion in HCl) by moving boundary method. Abnormal transport numbers- definition with an example like Cd^{2+} in CdI_2. Causes for abnormal transport numbers observed in certain systems. Numerical problems on (i) transport number calculation by moving boundary method (ii) relationship between transport number and ionic mobility (iii) molar conductance and specific conductance.

4.3 Kohlrausch's law: Statement and its applications (i) Evaluation of λ_∞ from λ_+ and λ_- for CH_3COOH and NH_4OH (ii) evaluation of degree of dissociation of a weak electrolyte - monochloro acetic acid (iii) evaluation of λ_∞ a weak electrolyte (iv) determination of solubility from conductance of saturated solutions of sparingly soluble salts (AgCl and $BaSO_4$). Numerical problems based on these.

4.4 : Theories of Conductance: Limitations of Arrhenius theory. Qualitative account of Debye-Huckel theory -postulates, asymmetric effect (with diagram) and electrophoretic effect. Debye-Huckel-Onsagar equation for aqueous solutions of 1:1 electrolytes. Verification of DHO equation.

UNIT – III **14 Hours**

Chapter 5: Coordination and Organometallic compounds **14 hours**

5.1Coordination Compounds: difference between double salts and complex salts with examples. Ligands - definition and their classification (mono, bi, tri, tetra, penta and hexadentate ligands and ambidentate ligands) with examples. Coordination number - definition with examples. Nomenclature of coordination compounds.

5.2 Theories of Structure and Bonding: Explanation for the formation of complexes by Werner's Theory in detail and its limitations. EAN rule - statement with illustrations. Valence bond theory: postulates, limitations of VBT. Crystal field theory: Salient features. Crystal field splitting and crystal field stabilization energies - definition and illustrations with examples. Splitting of d orbitals in octahedral, tetrahedral and square planar ligand field. Low spin and high spin complexes with examples. Limitations of CFT. Magnetic properties of $[CoF_6]^{3-}$, $[Co(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{4-}$ and $[Fe(CN)_6]^{3-}$. Spectral properties of $[Ti(H_2O)_6]^{3+}$, $[Co(H_2O)_6]^{3+}$, $[CoCl_4]^{2-}$.

5.3 Isomerism in Complexes: Structural isomerism - ionization, linkage, hydrate and coordination isomerism with examples. Stereoisomerism- geometrical and optical isomerism of coordination compounds with coordination number 4 and 6 with examples.

5.4 Organometallic compounds: Concept of hapticity, ligands classification based on hapticity. Synthesis and structure of $K[PtCl_3(\eta^2\text{-}C_2H_4)]$ and $[Fe(\eta^5\text{-}C_5H_5)_2]$. Metal carbonyls: Structures of

$Cr(CO)_6$, $Co_2(CO)_8$, $Mn_2(CO)_{10}$. Eighteen electron rule and its deviations with examples.

5.5 Applications of Coordination/Organometallic Compounds: Cis-platin in cancer therapy, chelation therapy for Pb and Hg poisoning: $Na_2CaEDTA$ in the treatment of Pb poisoning, Dimercaprol (British anti-Lewisite: BAL) in the treatment of Hg poisoning. Wilkinson's Catalyst in alkene hydrogenation, Monsanto acetic acid process.

UNIT – IV **14 Hours**

Chapter 6: Aldehydes and Ketones **5 hours**

Nomenclature. Preparation of aldehydes (i) from acid chlorides (Rosenmund reaction)-general reaction and from acetyl chloride. (ii) Gattermann-Koch aldehyde synthesis –benzaldehyde from benzene. Preparation of Ketones: from (i) nitriles (preparation of butanone), (ii) carboxylic acids with alkyl lithium, (iii) acid chlorides with metal alkyls- general reaction with one example each. General mechanism of condensation with ammonia and its derivatives (NH_2−R; R = −NH_2, −OH, −NH−CO−NH_2). Perkin condensation, Knoevenagel, condensation, benzoin condensation and acetal formation. Mechanism of aldol condensation. Mannich Reaction, Reduction: Clemmensen and Wolff-Kishner reductions (without mechanism).

Chapter 7: Carboxylic Acids and their Derivatives **6 hours**

7.1 Introduction: Nomenclature of mono, di, tri carboxylic acids. Preparation by acid hydrolysis of nitriles with mechanism. Acidic strength (pK_a values). Effect of substituents on the strength of aliphatic and aromatic carboxylic acids - (comparison of acidic strength of formic and acetic acids; acetic acid and monochloro, dichloro, trichloro acetic acids; benzoic and p-nitrobenzoic acid; benzoic acid and para-aminobenzoic acid). Reactions: Formation of esters, acid chlorides, amides and anhydrides explanation with an example for each. Hell-Vollhard-Zelinski reaction, decarboxylation and reduction (using $LiAlH_4$).

7.2 Di, tri–Carboxylic Acids and Hydroxy Acids: Action of heat on dicarboxylic acids (oxalic acid, malonic acid, succinic acid, glutaric acid and adipic acid). Reactions of tartaric acid and citric acid – (i) action of heat and (ii) reduction with HI.

7.3 Acid Derivatives: Reactions of acid chlorides (example: acetyl chloride) - hydrolysis, reaction with alcohol, ammonia and lithium dialkyl cuprates. Reactions of acid anhydrides - hydrolysis, reaction with alcohol, ammonia. Reactions of amides - hydrolysis, reduction, Hoffmann rearrangement. Reactions of esters - alkaline hydrolysis, ammonolysis and alcoholysis. Mechanism of ester hydrolysis - acid and base catalysed (acyl O-cleavage: BAC2, AAC2; alkyl O-cleavage: AAL1 mechanisms).

Chapter 8: Tautomerism and Enolates **3 hours**

8.1 Tautomerism in Carbonyl Compounds: Keto-enol tautomerism. Acidity of α-hydrogen atoms in aldehydes, ketones and active methylene compounds (example: diethyl malonate and ethyl acetoacetate).

8.2 Malonic Ester Synthesis: Preparation of diethyl malonate from acetic acid and synthetic applications of diethyl malonate (preparation of monocarboxylic acids - butanoic acid, dicarboxylic acid - adipic acid, unsaturated acids -cinnamic acid, ketones - butanone).

Recommended Books

1. Puri B.R., Sharma L.R. and Pathania M.S., Principles of Physical Chemistry, 46 th Edition, Vishal Publishing Co. 2013.
2. Barrow G.M., Physical Chemistry, 5 th Edition, Tata McGraw Hill, 2013.
3. Bahl B.S., Bahl A., Tuli G.D., Essentials of Physical Chemistry, S. Chand Publ., 2008.
4. Atkins P.W. and DePaula J., Physical Chemistry, 7 th Edition, Oxford University Press, 2008.
5. Azharoff L.V., Introduction to the Solid State. Wiley Publication. 2012.

6. Lee J.D., Concise Inorganic Chemistry, 5 th Edition, Blackwell Publishing Co. 2013.
7. Atkins P.W. and Shriver, Inorganic Chemistry, Oxford University Press, 2012.
8. Huheey J.E., Keiter E.A., Kieter R.L. and Medhi O.K., Inorganic Chemistry: Principles of Structure and Reactivity, 4 th Edition, Pearson Publication, 2009.
9. Madan R.D., Sathyaprakash's Modern Inorganic Chemistry, 3 rd Edition, S. Chand Publishing Co., 1987
10. Morrison R.T., Boyd R.N. and Bhattacharjee S.K., Organic Chemistry, 7 th Edition, Pearson Publication., 2011.
11. Solomon G. And Fryhle C.B., Organic Chemistry, 10 th Edition., Wiley Publication, 2014
12. Sanyal S.N., Reactions, Rearrangements and Reagents, Harati Bhawan Publishers and Distributors, 2013.
13. Norman R.O.C and Coxon J.M, Principles of Organic Synthesis, 3 rd Edition, CPP Publishers, 2017.
14. Bahl B.S. and Bahl A., A Textbook of Organic Chemistry., S. Chand Publication., 2008.
15. Finar I.L., Organic Chemistry – Volume 1., Pearson Publishing Co., 2013
16. Finar I.L., Organic Chemistry – Volume 2., Pearson Publishing Co., 2013
17. March J. And Smith M.B., Advanced Organic Chemistry, 6 th Edition., Wiley Publishing Co. 2009.

Jyoti Nivas College Autonomous

Bangalore 560095

IV Semester B.Sc.

Chemistry Practical Paper - IV

COURSE TITLE	**INTEGRATED PRINCIPLES OF CHEMISTRY II PRACTICAL**
COURSE CODE	**24IVCH4P**
COURSE CREDITS	**2**
TOTAL CONTACT HOURS	**48 HOURS (3 hours per week)**
DURATION OF ESA	**3 HOURS**
FORMATIVE ASSESSMENT MARKS	**10 MARKS**
SUMMATIVE ASSESSMENT MARKS	**40 MARKS**

1. To train students in the **systematic semi-micro qualitative analysis** of inorganic salt mixtures, including the identification of basic and acidic radicals.
2. To develop skills in **detecting and handling interfering radicals**, applying confirmatory tests, and understanding the underlying chemical principles.

Course Learning Outcomes (CLOs)

1. Perform systematic semi-micro qualitative analysis to identify two ions (one basic and one acidic) in a given salt mixture, including mixtures with interfering radicals.
2. Apply confirmatory tests and chemical principles to accurately detect and differentiate between interfering and non-interfering radicals.

Experiment:

Systematic semi micro qualitative analysis of a mixture of two simple salts (with interfering radicals).

Test, Repetition and Demonstration experiments.

Recommended Books

1. J Bassett, R.C.Denny,G.H.Jeffery and J.Menaham Qualitative chemical analysis. ELBS 1986.
2. V.V.Ramanujam Inorganic semimicro qualitative analysis. The National Pub.Co. 1974.
3. M.J.Sienko,R.A.Plane, S.T.Marcus Experimental Chemistry 6th edition McGraw- Hill 1985.

Jyoti Nivas College Autonomous
Bangalore 560095
IV Semester B.Sc.
Integrated Principles of Chemistry II
Scheme of Valuation

The practical paper is for a total of 50 marks of which ten marks is for internal assessment and forty marks is for the end-semester practical examination.

Part I: Continuous Internal Assessment (CIA)

The student will be assessed with viva on experiments. there will be a set of five viva of which the average marks is taken. The record of the student is also assessed a minimum of five times and the average marks is taken as the record component

Category	Marks
Viva Voce	5
Practical Record	5
Total	**10**

Part II: End-semester Practical Examination:

The examination will be for three hours duration and the student will be assigned a single step preparation along with one compound for preliminary analysis. A viva voce will be conducted on the experiments performed over the semester. The distribution of marks is as follows:

<table>
<tr><th>Category</th><th>Marks</th></tr>
<tr><td>Preliminary test</td><td>3</td></tr>
<tr><td>Analysis of acid radicals</td><td>3 x 2 = 6<table><tr><th>Category</th><th>Marks</th></tr><tr><td>Identifying the group</td><td>1</td></tr><tr><td>Confirmatory tests</td><td>2</td></tr></table></td></tr>
<tr><td>Equation for confirmatory test of acid radicals</td><td>2 x 2.5 = 5</td></tr>
<tr><td>Separation of cations into groups</td><td>6<table><tr><th>Category</th><th>Marks</th></tr><tr><td>correct recording of table</td><td>2</td></tr><tr><td>separation and mentioning the group of the cations</td><td>2 x 2 = 4</td></tr></table></td></tr>
<tr><td>Analysis of basic radicals</td><td>5 x 2 = 10</td></tr>
<tr><td>Equation for confirmatory test of basic radicals</td><td>2 x 2.5 = 5</td></tr>
<tr><td>Viva Voce</td><td>5</td></tr>
<tr><td>Total</td><td>40</td></tr>
</table>

Jyoti Nivas College Autonomous
Bangalore 560095
IV Semester B.Sc.
Skill Enhancement Paper

SKILL ENHANCEMENT PAPER	**APPLICATIONS OF CHEMISTRY IN EVERYDAY LIFE**
COURSE CODE	**24IVCH1TSKL**
COURSE CREDITS	**2**
TOTAL CONTACT HOURS	**3 HOURS/WEEK**
DURATION OF ESA	**1.5 HOURS**
FORMATIVE ASSESSMENT MARKS	**10 MARKS**
SUMMATIVE ASSESSMENT MARKS	**40 MARKS**

Course Objectives

1. To **develop practical skills** in the qualitative analysis of biomolecules and the identification of food adulterants using simple chemical tests.
2. To **introduce students to the synthesis and extraction of everyday chemical products**, emphasizing green chemistry principles and industrial relevance.

Course Learning Outcomes (CLOs)

1. Perform qualitative tests to identify carbohydrates, proteins, lipids, and food adulterants, and interpret the results accurately.
2. Apply basic synthetic techniques to prepare personal care and pharmaceutical products (e.g., soaps, sanitizers, perfumes, salol, aspirin, and acetanilide), including green chemistry approaches and natural product extraction.

Experiments:

1. Qualitative test for Carbohydrates
2. Qualitative test for proteins and lipids
3. Food Adulteration tests.
   i . Milk ii. Edible oil
4. Preparation of soaps and shampoo.
5. Preparation of Hand wash and Hand sanitisers.
6. Preparation of perfumes.
7. Extraction of essential oils.
8. reparation of salol (phenyl salicylate)
9. Field Visit – 1
10. Field Visit – 2
11. Green synthesis of Aspirin and Acetanilide. Test,

Repetition and Demonstration experiments.

Jyoti Nivas College Autonomous
Bangalore 560095
IV Semester B.Sc.
Applications of Chemistry in Everyday Life
Scheme of Valuation

The practical paper is for a total of 50 marks of which ten marks is for internal assessment and forty marks is for the end-semester practical examination.

Part I: Continuous Internal Assessment (CIA)

The student will be assessed with viva on experiments. there will be a set of five viva of which the average marks is taken. The record of the student is also assessed a minimum of five times and the average marks is taken as the record component

Category	Marks
Viva Voce	5
Practical Record	5
Total	**10**

Part II: End-semester Practical Examination:

The examination will be for three hours duration and the student will be assigned a single step preparation along with one compound for preliminary analysis. A viva voce will be conducted on the experiments performed over the semester. The distribution of marks is as follows:

Category	Marks
Qualitative tests for carbohydrates	8
Qualitative test for proteins	8
Test for food adulterants	9
Field Report	5
Viva voce on field report	5
Viva Voce on experiments	5
Total	**40**

Jyoti Nivas College Autonomous

Bangalore 560095

IV Semester B.Sc.

Discipline Elective Paper

DISCIPLINE SPECIFIC ELECTIVE PAPER	**GREEN CHEMISTRY, PHYTOCHEMISTRY AND WATER TECHNOLOGY**
COURSE CODE	**24IVCH2TDSE**
COURSE CREDITS	**2**
TOTAL CONTACT HOURS	**30 HOURS**
DURATION OF ESA	**1.5 HOURS**
FORMATIVE ASSESSMENT MARKS	**10 MARKS**
SUMMATIVE ASSESSMENT MARKS	**40 MARKS**

Course Objectives

1. **Understanding Core Concepts**:
   To introduce the principles and scope of Green Chemistry, fertilizers, dyes, and water treatment, with emphasis on sustainability and environmental impact.
2. **Analytical Skills**:
   To equip students with the ability to analyze chemical synthesis methods, environmental pollutants, and water quality parameters using scientific reasoning.
3. **Practical Applications**:
   To familiarize students with the green synthesis of industrially important compounds, fertilizer manufacturing, dye applications, and water purification techniques.
4. **Critical Thinking**:
   To encourage evaluation of traditional chemical processes and promote alternative sustainable solutions in real-world environmental and industrial contexts.

Course Learning Outcomes

1. **Understanding Core Concepts**:
   Develop foundational knowledge of Green Chemistry, fertilizers, dyes, and water technology, including their principles, processes, and environmental significance.
2. **Analytical Skills**:
   Interpret chemical properties, synthesis methods, water quality parameters, and pollution indicators (like BOD/COD), and assess environmental impact.
3. **Practical Applications**:
   Apply green chemistry techniques in the synthesis of compounds, understand fertilizer production, and evaluate water treatment and dyeing processes.
4. **Critical Thinking**:
   Evaluate the sustainability and environmental implications of chemical processes and propose eco-friendly alternatives in industrial and laboratory settings.

Syllabus

Basic Green Chemistry **10 Hours**

Introduction to Green Chemistry, Definition and scope of green chemistry, Importance and need for sustainable chemistry, Historical background and evolution, Principles of Green Chemistry - The 12 principles of green chemistry, with their explanations and examples. Relationship between green chemistry and environmental protection.

Green Chemical Synthesis using Green catalysts and biocatalysts Renewable feedstocks and atom economy, Green Solvents and Reaction Media, Ionic liquids and supercritical fluids, Water as a green solvent, Solvent-free and phase-transfer catalysis, Energy Efficiency in Chemical Processes. Energy consumption in chemical reactions. Use of renewable energy sources. Photochemical and electrochemical synthesis. Waste Prevention and Management, Concept of waste minimization, Recycling and biodegradability, Hazardous waste treatment.

Applications of green Chemistry in pharmaceuticals, agriculture, and polymers, Reactions: Green Synthesis of the following compounds: adipic acid, citral, Acetanilide, paracetamol.

Dyes **6 Hours**

Introduction to Dyes, Definition and classification of dyes, Difference between dyes and pigments, Chromophores and auxochromes, Theory of Color and Constitution, Colour and chemical constitution (Witt's theory, Modern theories), Relationship between molecular structure and color, Classification of Dyes based on application: Acid, Basic, Direct, Mordant, Vat, Disperse, Reactive dyes, etc. Preparation and uses of Methyl orange, Congo red, Malachite green, Alizarin, Indigo and Phenolphthalein. Role of mordants in dyeing process Environmental Aspects - Impact of dyes on the environment Waste management in dye industries, Biodegradable dyes.

Water Technology **6 Hours**

Wastewater characteristics (BOD, COD). Basic treatment processes: sedimentation, coagulation, filtration, disinfection, Disinfection techniques: chlorination, ozonation, UV treatment, Water softening methods: ion exchange, lime-soda process, Domestic and industrial water treatment systems, Sewage and industrial effluent treatment - Primary, secondary and tertiary treatment. Emerging and Sustainable Water Technologies - Rainwater harvesting and groundwater recharge.

Membrane technologies: reverse osmosis, ultrafiltration. Desalination techniques, Water conservation, recycling, and reuse, Role of biotechnology in water purification, Water quality testing (pH, hardness, turbidity, etc.)

Phytochemistry of Indigenous Medicinal Plants **8 Hours**

Brief account of historical use, distribution, bioactive agents, extraction and use of the following medicinal plants: *Tinospora cordifolia, Adathoda vasica, Curcuma longa, Clitoria ternatea, Withania somnifera*, *Bacopa monnieri*.

Recommended Books

1. Ahluwalia V K, Green Chemistry, 2012, Narosa Publishing House Pvt. Ltd.
2. Von Georgievics G C T, A Text-Book of Dye Chemistry: The Chemistry of Dye-Stuffs, 2018, Forgotten Books
3. Rao M N, Waste Water Treatment, 2020, Oxford and IBH Publishing,
4. Khan A R, Water Quality Analysis and Treatment, 2023, BFC Publications.