Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus For

B. Sc. (Chemistry)

Choice Based Credit System (CBCS) Syllabus
Under National Education Policy (NEP)
To be implemented from Academic Year 2024-2025

Level:- 4.5 (First Year) Sem:I

Course Type	Course Code	Course Title	Credits		Teaching Scheme Hr/Week		Evaluation Scheme and Max Marks		
			TH	PR	TH	PR	CE	ESE	Total
Subject 1 T(2)+ (T/P) (2) or T(4)	24ScCheU1101	Physical & Inorganic Chemistry	2		2		20	30	50
	24ScCheU1102	Lab Course on 24ScCheU1101		2		4	20	30	50
Subject 2 T(2)+ (T/P) (2) or T(4)	24ScCheU1201	<<Subject 2 Theory>>	2		2		20	30	50
	24ScCheU1202	<<Subject 2 Practical>>		2		4	20	30	50
Subject 3 T(2)+ (T/P)(2) or T(4)	24ScCheU1301	<<Subject 3 Theory>>	2		2		20	30	50
	24ScCheU1302	<<Subject 3 Practical>>		2		4	20	30	50
IKS T(2)	24CpCopU1901	Generic IKS	2		2		20	30	50
GE/OE (T/P) (2)	24ScCheU1401	General Chemistry -I	2		2		20	30	50
SEC (P) (2)	24ScCheU1601	Lab Course on Basic Analytical Skills-I		2		4	20	30	50
AEC T(2)	24CpCopU1701 / 24CpCopU1702	MIL-I (Hindi) / MIL-I (Marathi)	2		2		20	30	50
VEC T (2)	24CpCopU1801	Environmental Science	2		2		20	30	50
Total			14	08	14	16			550

Level:- 4.5 (First Year) Sem:II

Course Type	Course Code	Course Title	Credits		Teaching Scheme Hr/Week		Evaluation Scheme and Max Marks		
			TH	PR	TH	PR	CE	ESE	Total
Subject 1 T(2)+ T/P(2) or T(4)	24ScCheU2101	Physical & Organic Chemistry	2		2		20	30	50
	24ScCheU2102	Lab Course on 24ScCheU2101		2		4	20	30	50
Subject 2 T(2)+ T/P(2) or T(4)	24Sc***U2201	<<Subject 2 Theory>>	2		2		20	30	50
	24Sc***U2302	<<Subject 2 Practical>>		2		4	20	30	50
Subject 3 T(2)+ T/P(2) or T(4)	24Sc***U2301	<<Subject 3 Theory>>	2		2		20	30	50
	24Sc***U2302	<<Subject 3 Practical>>		2		4	20	30	50
GE/OE (T/P)(2)	24ScCheU2401	General Chemistry- II	2		2		20	30	50
SEC P(2)	24ScCheU2601	Lab Course on Basic Instrumentation Skills		2		4	20	30	50
AEC T(2)	24CpCopU2703	English Communication Skills I	2		2		20	30	50

VEC T(2)	24CpCopU2801	Democracy, Election and Governance	2		2		20	30	50
CC(2)	24CpCopU2001/ 24CpCopU2011 / 24CpCopU2021 / 24CpCopU2031 / 24CpCopU2041 / 24CpCopU2051 / 24CpCopU2061 / 24CpCopU2071	Physical Education / Cultural Activities / NSS / NCC / Fine Arts / Applied Arts / Visual Arts / Performing Arts	2		2		20	30	50
Total			14	08	14	16			550

Level:- 5.0 (Second Year) Sem:III

Course Type	**Course Code**	**Course Title**	**Credits**		**Teaching Scheme Hr/Week**		**Evaluation Scheme and Max Marks**		
			TH	PR	TH	PR	CE	EE	Total
Major Core T(2+2 or 4), (T/P)(2)	24ScCheU3101	Physical, Inorganic & Organic Chemistry	4		4		40	60	100
	24ScCheU3102	Lab Course on 24ScCheU3101		2		4	20	30	50
VSC P(2)	24ScCheU3501	Lab Course on Chemistry of Cosmetic Ingredients		2		4	20	30	50
IKS (T/P)(2)	24ScCheU3901	Ancient Metallurgy in India	2		2		20	30	50
FP P(2)	24ScCheU3002	Field Project I		2		4	20	30	50
Minor (T/P) (2+2 or 4)	24ScCheU3301	Fundamentals of Biochemistry	2		2		20	30	50
	24ScCheU3302	Lab Course on 24ScCheU3301		2		4	20	30	50
GE/OE (T/P) (2)	24ScCheU3401	General Chemistry -III	2		2		20	30	50
AEC T(2)	24CpCopU3703	English Communication Skills II	2		2		20	30	50
CC T(2)	24CpCopU3001	Online Course on Yoga	2		2		20	30	50
Total			14	08	14	16			550

Level:- 5.0 (Second Year) Sem:IV

Course Type	**Course Code**	**Course Title**	**Credits**		**Teaching Scheme Hr/Week**		**Evaluation Scheme and Max Marks**		
			TH	PR	TH	PR	CE	EE	Total
Major Core T(2+2 or 4), (T/P)(2)	24ScCheU4101	Physical, Inorganic & Organic Chemistry	4		4		40	60	100
	24ScCheU4102	Lab Course on 24ScCheU4101		2		4	20	30	50
VSC P(2)	24ScCheU4501	Lab Course on Drug Analysis		2		4	20	30	50
CEP P(2)	24CpCopU4003	Community Engagement Project		2		4	20	30	50
Minor (T/P)(2+2 or 4)	24ScCheU4301	Fundamentals of Bioinorganic Chemistry	2		2		20	30	50
	24ScCheU4302	Lab Course on 24ScCheU4301		2		4	20	30	50

GE/OE (T/P) (2)	24ScCheU4401	General Chemistry -IV	2		2		20	30	50
SEC P(2)	24ScCheU4601	Lab Course on Computer Applications in Chemistry		2		4	20	30	50
AEC T(2)	24CpCopU4701 / 24CpCopU4702	MIL-II (Hindi) / MIL-II (Marathi)	2		2		20	30	50
CC T(2)	24CpCopU4001	Health and Wellness	2		2		20	30	50
Total			12	10	12	20			550

Level:- 5.5 (Third Year) **Sem:-V**

Course Type	**Course Code**	**Course Title**	**Credits**		**Teaching Scheme Hr/Week**		**Evaluation Scheme and Max Marks**		
			TH	PR	TH	PR	CE	EE	Total
Major Core T(2+2+2+2 or 4 + 2+2 or 4 + 4) P(2+2 or 4)	24ScCheU5101	Organic Chemistry	2		2		20	30	50
	24ScCheU5102	Physical Chemistry	4		4		40	60	100
	24ScCheU5103	Introduction to Nanochemistry and Applications	2		2		20	30	50
	24ScCheU5104	Lab Course on 24ScCheU5101		2		4	20	30	50
	24ScCheU5105	Lab Course on 24ScCheU5102		2		4	20	30	50
Major Elective (T/P) (2+2 or 4)	24ScCheU5201	Advanced Analytical Techniques	2		2		20	30	50
	24ScCheU5202	Lab Course on 24ScCheU5201		2		4	20	30	50
	24ScCheU5203	Instrumental Methods of Analysis	2		2		20	30	50
	24ScCheU5204	Lab Course on 24ScCheU5203		2		4	20	30	50
VSC P(2)	24ScCheU5501	Lab Course on Raw material Analytical Methods		2		4	20	30	50
FP (2)	24ScCheU5001	Field Project II		2		4	20	30	50
Minor (T/P) (2)	24ScCheU5302	Fundamentals of Chromatographic Separations	2		2		20	30	50
Total			12	10	12	20			550

Level:- 5.5 (Third Year) **Sem:-VI**

Course Type	**Course Code**	**Course Title**	**Credits**		**Teaching Scheme Hr/Week**		**Evaluation Scheme and Max Marks**		
			TH	PR	TH	PR	CE	EE	Total
Major Core T(2+2+2+2 or 4+2+2 or 4+4) P(2+2 or 4)	24ScCheU6101	Organic Chemistry	2		2		20	30	50
	24ScCheU6102	Inorganic Chemistry	4		4		40	60	100
	24ScCheU6103	Organic Spectroscopy	2		2		20	30	50
	24ScCheU6104	Lab Course on 24ScCheU6101		2		4	20	30	50
	24ScCheU6105	Lab Course on 24ScCheU6102		2		4	20	30	50
Major Elective (T/P) (2+2 or 4)	24ScCheU6201	Environmental and Green Chemistry	2		2		20	30	50
	24ScCheU6202	Lab Course on 24ScCheU6201		2		4	20	30	50

	24ScCheU6203	Industrial Chemicals and Environment	2		2		20	30	50
	24ScCheU6204	Lab Course on 24ScCheU6203		2		4	20	30	50
VSC P(2)	24ScCheU6501	Lab Course in Paint and dyes		2		4	20	30	50
OJT (2)	24ScCheU6004	On Job Training		4		8	40	60	100
Total			10	12	10	24			550

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Third Year of B. Sc. NEP II (Chemistry) 2026-27

Semester – V

Course Type	Course Code	Course Name	No. of Credits
Major Mandatory	24ScCheU5101	Organic Chemistry (T)	02 Credits (30L)
	24ScCheU5102	Physical Chemistry (T)	04 Credits (60L)
	24ScCheU5103	Introduction to Nano chemistry and Applications (T)	02 Credits (30L)
	24ScCheU5104	Lab Course on 24ScCheU5101	02 Credits (15P)
	24ScCheU5105	Lab Course on 24ScCheU5102	02 Credits (15P)
Major Electives	Elective I 24ScCheU5201	Advanced Analytical Techniques (T)	02 Credits (30L)
	24ScCheU5202	Lab Course on 24ScCheU5201	02 Credits (15P)
	Elective II 24ScCheU5203	Instrumental Methods of Analysis (T)	02 Credits (30L)
	24ScCheU5204	Lab Course on 24ScCheU5203	02 Credits (15P)

Minor	24ScCheU5302	Fundamentals of Chromatographic Separations (T)	02 Credits (30L)
VSC (P)	24ScCheU5501	Lab Course on Raw material Analytical Methods (P)	02 Credits (15P)
FP (P)	24ScCheU5001	Field Project II	02 Credits
Total Credits			22 Credits

OE: Open Elective,
AEC: Ability Enhancement Course,
VEC: Value Education Courses, CC: Co-Curricular Courses,
T: Theory

OJT: On Job Training, FP: Field Project,
VSC: Vocational Skill Courses,
CEP: Community Engagement Project P: Practical

Credits	Total Marks	CIE	ESE
4	100	40	60
2	50	20	30

23ScCheU5101: Organic Chemistry (T)

Course Outcomes:

CO1: Understand and compare the strength of organic acids and bases, including effects of structure, solvent, pKa/pKb, and Hammett equation.

CO2: Explain the mechanisms and stereochemistry of reactions of alkenes, including electrophilic additions, rearrangements, and oxidation–reduction reactions.

CO3: Describe the reactivity and reactions of alkynes, including addition reactions and formation of metal acetylides.

CO4: Analyze elimination reactions (E1, E2, E1cB) and predict products based on structure and reaction conditions.

CO5: Understand conformational analysis and stability of decalin systems and represent them using projections.

24ScCheU5101: Organic Chemistry (T)		**(30 Lectures, 2 Credits)**
Chapter 1	**Strength of organic acids and base**	**(08 Lectures)**
	• Origin of acidity, influence of solvent • Simple aliphatic saturated and unsaturated acids • Substituted aliphatic acid, phenols, aromatic carboxylic acids • pka and temperature • pkb, aliphatic and aromatic bases, heterocyclic bases, acid base catalysis • Introduction to the Hamette equation. Introduction to σ and ϱ	
Chapter 2	**Chemistry of unsaturated hydrocarbons**	**(08 Lectures)**

	Reaction of Carbon-Carbon double bond: • Introduction, Mechanism of electrophilic addition to C=C bond • Orientation & reactivity, Rearrangements, (Support for formation of carbocation) • Addition of hydrohalogen, Anti Markownikoff's addition (peroxide effect) with mechanism • Addition of halogens (dl pairs and meso isomers), hypohalous acids (HOX) • Hydroxylation (Mechanism of cis and trans 1,2-diols). • Hydroboration-Oxidation (Formation of alcohol), Hydrogenation (Formation of alkane) **Reactions of Carbon–Carbon triple bond:** • Addition of hydrogen, halogens, halogen acids, water and formation of metal acetylides and its application
Chapter 3	**Elimination Reactions (08 Lectures)**
	• Introduction; • 1,1 ; 1,2 elimination • E1, E2 and E1cB mechanism with evidences • Hoffmann and Saytzeff's elimination • Reactivity effect of structure, attacking and leaving groups • Pyrolytic elimination reactions • Elimination reactions in cyclohexane
Chapter 4	**Introduction to Decalin stereochemistry (06 Lectures)**
	• Introduction • Different conformations Decalin, Conformational Locking in Decalin • Ring flipping in trans-decalins, Conformations of Cis-Decalin, Stability of Decalins • Conformations and Stability of Mono substituted Decalins • Newman projection of decalin system

References:

1. Organic Chemistry by Jonathan Clayden, Nick Greeves, Stuart Warren
2. Advanced Organic Chemistry by Francis A. Carey and Richard J. Sundberg
3. Organic Chemistry by T. W. Graham Solomons, Craig Fryhle and Scott Snyder

4. A Guidebook to Mechanism in Organic Chemistry by Peter Sykes
5. Modern Physical Organic Chemistry by Eric V. Anslyn and Dennis A. Dougherty
6. Organic Chemistry by Paula Yurkanis Bruice
7. Organic Chemistry by Jagdamba Singh and L. D. S. Yadav
8. Advanced Organic Chemistry by B. S. Bahl and Arun Bahl
9. Stereochemistry of Organic Compounds by D. Nasipuri
10. Stereochemistry: Conformation and Mechanism by P.S. Kalsi
11. Basic Concepts in Organic Stereochemistry by Sunil Kumar Talapatra & Bani Talapatra

24ScCheU5104: Organic Chemistry (P)

Course Outcomes

CO1: Perform preparation of organic derivatives (2,4-DNP, oxime, semicarbazone, benzoyl, acetyl)

CO2: Carry out organic syntheses such as nitration, hydrolysis, Diels–Alder reaction, bromination, and imide formation.

CO3: Separate and purify binary organic mixtures using solvent extraction (ether) and appropriate techniques.

CO4: Conduct qualitative analysis of organic compounds and identify unknowns using systematic procedures.

24ScCheU5104: Organic Chemistry (P)	**(Any 12 P, 2 Credits)**
1.	**Derivative Preparations**
	1) 2, 4- DNP derivative 2) Oxime derivative 3) Semicarbazide derivative 4) Benzoyl derivative 5) Acetyl derivative
2.	**Organic Preparations**
	1) To prepare dinitrobenzene from nitrobenzene. 2) To prepare benzoic acid from ethyl benzoate. 3) Diels Alder reaction (Anthracene with Diethyl Malonate) 4) To prepare p-bromo benzanilide from benzanilide. 5) To prepare phthalimide from phthalic anhydride.
3.	**Binary Mixture Separations using Ether and Perform Organic Qualitative**

	Analysis
	(Minimum 5 mixtures), Separations using ether, Full analysis, Purification, Physical constant, TLC

References:

1. Practical of Organic Chemistry by Vogel
2. Comprehensive practical organic chemistry V.K Ahluwalia, Renu Agarwal

24ScCheU5102: Physical Chemistry

Course Outcomes:

CO1: To learn basic concepts of quantum chemistry and the difference between classical and quantum mechanics.

CO2: Application Schrödinger equation for simple one-dimensional systems.

CO3: Understanding the different types of spectroscopies and their applications.

CO4: Study of vibrating diatomic molecules, energy levels of a diatomic molecule, simple oscillator, Scattering of light and Raman Spectrum. rotational and vibrational spectrum.

CO5: Understanding the concept of EMF and Electrode Potential

CO6: Understanding Nernst Equation and its Applications

CO7: Understanding the potentiometric titrations

24ScCheU5102: Physical Chemistry	**(60 L, 4 Credits)**
Chapter 1	**Quantum Chemistry (20 Lectures)**
	• Introduction to black-body radiation and distribution of energy • Photo-electric effect. • Concept of quantization • The uncertainty principle • Basic idea about wave function • Operators, Eigen function and values • Schrodinger equation and application to free-particle and particle in a box.
Chapter 2	**Molecular Spectroscopy (20 Lectures)**

	• Introduction • Electromagnetic spectrum: Interaction of electromagnetic radiation with molecules and various types of spectra. • Rotation spectroscopy: The rotation of molecules, Rotational spectra of diatomic molecules, selection rule, intensities of the spectral lines and Numericals. • Vibrational spectroscopy: Vibration of diatomic molecule-, Numericals • Raman spectroscopy: Introduction, Explanation of Rayleigh's line, stokes and anti-stokes lines,
Chapter 3	**Electrochemistry (20 Lectures)**
	• Introduction: Electrochemical Cell, Daniel Cell, Salt Bridge, Net Cell Reaction and its Representation, Electrode Potential and its types • Quantitative aspects of Faraday's laws of electrolysis, • Determination of EMF of a cell. • Nernst equation and its Applications • Application of EMF measurements in determining (i) pH values, using hydrogen, quinone-hydroquinone and glass and electrodes. • Concentration Cells: Types of Cells with examples • Potentiometric titrations (acid-base, redox, precipitation) • Hydrogen generation by electrolysis, hydrogen as fuel, hydrogen storage.

Reference Books:

1. Laideler K. J. and Meiser J. M. *Physical Chemistry* Third Edition (International)1999
2. Levine I. N., *Physical Chemistry*, Fourth Edition, McGraw-Hill (International), 1995.
3. McQuarrie D. A. and Simon J. D. *Physical Chemistry- A Molecular Approach*, University Science Books, 1998.
4. Chandra, A. K. *Introductory Quantum Chemistry* Tata McGraw-Hill (2001).
5. House, J. E. *Fundamentals of Quantum Chemistry* 2nd Ed. Elsevier: USA (2004).
6. Kakkar, R. *Atomic & Molecular Spectroscopy: Concepts & Applications*, Cambridge University Press (2015).
7. Lowe, J. P. & Peterson, K. *Quantum Chemistry*, Academic Press (2005).

8. Banwell, C. N. & McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi (2006).
9. Atkins, P.W & Paula, J.D. Physical Chemistry, 10th Ed., Oxford University Press (2014)
10. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005)
11. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012)
12. R. L. Madan Physical Chemistry
13. K. L. Kapur A Textbook of Physical Chemistry (Volume III) 3rd Ed.
14. Puri; Sharma; Pathania Principles of Physical Chemistry

24ScCheU5105: Lab Course on 24ScCheU5102

Course Outcomes:

CO1: Students will grasp the basic principles of how light interacts with matter leading to the production of spectra.

CO2: Students will gain knowledge about the instrumentation involved in spectroscopy, including spectrometers, sample preparation, and data acquisition. Students will learn how to use spectroscopy for quantitative analysis, such as determining the concentration of a specific compound in a mixture.

CO3: Students will be able to measure and interpret electrode potentials using suitable electrodes, and relate them to oxidation–reduction reactions.

CO4: Students will be able to understand the basics of machine learning in computational chemistry.

CO5: Students will learn to accurately determine the pH of solutions using indicators or a pH meter, and understand its importance in controlling chemical reactions and electrochemical processes.

CO6: Students will learn to write and run various programs in computer languages for applications in chemistry

24ScCheU5105: Lab Course on 24ScCheU5102	**(Any 12 P, 2 Credits)**
	1. To verify additives of absorbances of a mixture of coloured substances in solution using potassium permanganate and potassium dichromate solutions. 2. To titrate copper (II) ion with EDTA (ethylenediaminetetraacetic acid-sodium salt) photometrically.

	3. To determine the pH of a given solution spectrophotometry/colorimetry using methyl red indicator. 4. To determine the indicator constant of methyl red spectrophotometrically 5. To determine the molecular composition of Ferric-salicylate complex by Job's method. 6. Simultaneous determination of Co(II) and Cr(III) spectrophotometrically. 7. To determine the amount of HCl by Potentiometric titration using quinhydrone electrode 8. Potentiometric titration of weak acid (e.g. acetic acid) with caustic soda solution and determination of the dissociation constant of acid using quinhydrone electrode at room temperature. 9. To determine the strengths of hydrochloric acid and acetic acid in their mixture with the help of pH meter 10. To determine ionic product of water with the help of pH meter 11. To determine the pka values of dibasic acids pH-metrically 12. Write and run a program for basic operations (Addition, Subtraction, LCM and HCF of two numbers. etc.) using Q-BASIC/PYTHON/FORTRAN programming languages. 13. Write and run a program for finding the roots of equations (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid, etc.) using Q- BASIC/PYTHON/FORTRAN programming languages. 14. Write and run a program to plot/draw (e.g. isotherm curves, van Der Waal gas curves, Maxwell distribution, pH titrations, potentiometric titrations, etc.) using Q- BASIC/PYTHON/FORTRAN programming languages. 15. Write and run a program for addition and subtraction of matrices using Q-BASIC/PYTHON/FORTRAN programming languages.

References:

1. R. Kumari. *Computers and their Applications to Chemistry* Narosa Publishing House (2002)
2. McQuarrie, D. A. *Mathematics for Physical Chemistry* University Science Books (2008).
3. Mortimer, R. *Mathematics for Physical Chemistry*. 3rd Ed. Elsevier (2005).
4. Steiner, E. *The Chemical Maths* Book Oxford University Press (1996).
5. Yates, P. *Chemical Calculations*. 2nd Ed. CRC Press (2007).
6. Harris, D. C. *Quantitative Chemical Analysis.* 6th Ed., Freeman (2007) Chapters 3-5.

7. Levie, R. de, *How to use Excel in analytical chemistry and in general scientific data analysis*, Cambridge Univ. Press (2001) 487 pages.
8. Noggle, J. H. *Physical Chemistry on a Microcomputer*. Little Brown & Co. (1985).
9. Venit, S.M. *Programming in BASIC: Problem-solving with structure and style*. Jaico Publishing House: Delhi (1996).
10. P. S. Sindhu, *Practicals in physical chemistry – a modern approach,* Macmillan. 2005.
11. J. M. Wilson, R. J. Newcomb, A. R. Denaro *Experiments in Physical Chemistry*,2nd Edn., Elsevier.
12. Saroj Kr Maity, Naba Kr Ghosh, *Physical Chemistry Practical*-2012
13. Dr. J. B. Yadav,*Advanced Practical Physical Chemistry*- 4th Ed 2023
14. Dr. J.N. Gurtu , Amit Gurtu *Advanced Physical Chemistry Experiments* Pragati Publications-2008

24ScCheU5103: Introduction to Nanochemistry and Applications (T) (30 Lectures, 02 Credits)

Course Outcomes:

CO1: Understanding the basic knowledge of nanoscience and nanotechnology.

CO2: To learn different types of nanomaterials, such as nanoparticles, nanotubes, and nanolayers. Also, through a general understanding of Nanoscale Phenomena,

CO3: Understanding of the unique physical, chemical, and biological properties that emerge at the nanoscale.

CO4: To learn how these properties differ from those at the macroscopic scale and how they can be harnessed for various applications.

CO5: To emphasize the interdisciplinary nature of nanoscience and nanotechnology, encouraging students to integrate knowledge from various fields, such as physics, chemistry, biology, and engineering.

24ScCheU5103: Introduction to Nanochemistry and Applications (30 Lectures, 02 Credits)	
Chapter 1	**Introduction to nanoscience, nanostructure and nanotechnology (6 Lectures)**
	• Overview of nanostructures and nano-materials • Classification of nano material as 1D, 2D, 3D by dimensions (cluster, colloid, nanoparticles, and nanostructures -Spheroid, Wire, Rod, Tube, and Quantum Dot) • Calculation of percentage of surface atom and surface to volume ratio of spherical, wire, rod, and disc shapes nanoparticles.

Chapter 2	**Size dependent properties of nanomaterials (6 Lectures)**
	• Quantum confinement, Electrical, Optical (Surface Plasmon resonance), • Variation in colors (Blue shift & Red shift), • Magnetic, thermal and catalytic properties.
Chapter 3	**Synthesis of Nanomaterials (8 Lectures)**
	• Brief introduction about Top-down and Bottom-up approaches & self-assembly techniques of nanoparticles synthesis and Solvothermal process, • Examples of preparation of gold and silver metallic nanoparticles, self-assembled nanostructures control of nanoarchitecture-one dimensional control. • Carbon nanotubes and inorganic nanowires.
Chapter 4	**Material characterization techniques (10 Lectures)**
	• Uv-Vis spectroscopy • Introduction to Electron microscopic technique, XRD Diffraction technique, X-ray Photoelectron spectroscopy • Zeta-potential measurement; Examples of use of nanomaterials in environmental remediation and biology (few practical examples of use of materials can be discussed)

References:

1. Nanomaterials for sustainable development, by Dr. Rajaram Mane (Springer Nature)
2. C. N. R. Rao, A Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH Verlag Germany 2005
3. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications,Imperial College Press, London, 2004
4. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley and Sons, England 2005
5. Charles P. Poole and Frank J Owens, Introduction to Nanotechnology, Wiley Interscience, 2003.

24ScCheU5201: Advanced Analytical Techniques

Course Outcomes:

CO1: Understand the fundamental principle, theory and applications of advanced analytical techniques.

CO2: Explain working principle of thermal method, AAS, Fluorometry, Nephelometry and Turbidimetry, spectrophotometry

CO3: Design an experiment for analysis of various elements, food and pharmaceutical samples.

CO4: Determine the concentration of unknown compound using AAS, Fluorometry,

CO5: Nephelometry and Turbidimetry, spectrophotometry.

CO6: Understand the instrumentation of various analytical techniques.

CO7: To develop the skill of instrument handling.

24ScCheU5201: Advanced Analytical Techniques (T)	**(30L, 02 Credits)**
Chapter 1	**Thermal Methods of Analysis (10 Lectures)**
	• Principle of Thermal Analysis, Classification of Thermal Techniques • Thermogravimetry - Principle, Instrumentation of TGA • Thermogravimetric curves, thermal equation of TGA • Factors affecting TG curve, Applications • Differential Thermal Analysis - Principle, Instrumentation Applications of DTA • Numerical Problems
Chapter 2	**Spectrophotometry and Colorimetry (10 Lectures)**
	• Introduction • Electromagnetic radiation (Wavelength, Wave number, Frequency) and interaction of radiation with matter • Terminology used in absorption measurements (Radiant energy, radiant power, transmittance, absorbance, absorptivity, molar absorptivity and path length) • Fundamental laws of photometry (Lambert's Law, beer's Law, Lambert's - Beer's Law), Deviation from Beer's law • Instrumentation of single beam colorimeter, single and double beam spectrophotometer, additivity of absorbances, Simultaneous spectrophotometric determinations

	• Applications and numerical problems.
Chapter 3	**Nephelometry and Turbidimetry (5 Lectures)**
	• Introduction • Principle of Nephelometry and Turbidimetry, Choice between Nephelometry and Turbidimetry, theory (Reflection Vs Scattering, Particle dimension smaller than wavelength and nephelometry, particle dimension larger than wavelength and turbidimetry) • Factors affecting measurements • Instrumentation (turbidimeter and Nephelometer) • Applications of turbidimetry and Nephelometry, numerical Problems
Chapter 5	**Fluorimetry (5 Lectures)**
	• Introduction • Comparison of absorption and fluorescence methods, theory • Instrumentation, applications.

References:

1. Instrumental Methods of Analysis (5th Edition) by Gurdeep R. Chatwal and Sham K. Anand
2. Vogel's Textbook of Qualitative Chemical Analysis (6th Edition) by J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar
3. Principles of Instrumental Analysis (5th Edition) Douglas A. Skoog, F. James Holler, Timothy A. Nieman
4. Instrumental Methods of Analysis (6th edition) Willard Merritt, Dean, Settlec
5. Analytical Chemistry by Gary D. Christian (6th edition)
6. Introduction to Instrumental Analysis by Robert D. Braun.

24ScCheU5202: Lab Course on 24ScCheU5201 (P)	(Any 12 P, 2 Credits)
	1. Determination of fluorides in a water sample by using a spectrophotometer. 2. Determination of sulfate ions in a water sample by using a turbidimeter. 3. To determine the turbidity of the given sample of water by using the Nephelometer. 4. Determination of λmax and concentration of unknown solution of $KMnO_4$ in 2N H_2SO_4. 5. Estimation of carbohydrate by spectrophotometric method. 6. Determination of Aspirin in AIP tablet using spectrophotometer. 7. Analysis of Aspirin by Conductometric titration. 8. Fluorometric determination of riboflavin (Vitamin B_2) 9. Spectrophotometric determination of Iron from Iron syrup. 10. Estimation of amino acid by using spectrophotometric method. 11. Estimation of Vitamin C by using spectrophotometric method. 12. To determine the amount of copper present in the given solution of copper sulphate by colorimetric titration method using standard EDTA solution. 13. Determination of indicator constant of methyl red colorimetrically. 14. Estimation of proteins by Biuret method 15. Estimation of Curcumin from turmeric sample. 16. Estimation of Cholesterol by kit method. 17. Estimation of Urea by Kit Method.

References:

1. Analytical Chemistry by Gary D. Christian (6th edition)
2. Advanced Practical Chemistry by Jagdamba Singh (Pragati Prakashan)
3. Analytical Chemistry by Dr. Alka L. Gupta (Fourth Edition)
4. Textbook on Practical Chemistry by K. S. Mukherjee
5. Biochemical methods by S. Sadasivam (third edition)

24ScCheU5203: Instrumental Methods of Analysis (T+P)

Course Outcomes:

CO1: To understand the fundamental principle, theory and applications of instrumental Methods

CO2: To design an experiment based on instruments and for analysis of various elements.

CO3: To Learn basics of instrumental techniques and its application.

CO4: Understanding basics of electroanalytical methods and techniques in analytical chemistry which studies an analyte by measuring the potential (volts) and/or current (amperes) in an electrochemical cell containing the analyte and their applications.

CO5: To apply fundamental Analytical techniques and interpret the experimental data qualitatively and quantitatively

CO6: To apply concepts of electrochemistry in experiments

24ScCheU5203: Instrumental Methods of Analysis (T)	**(30 L, 2 Credits)**
Chapter 1	**pH metry** **(4 L)**
	● Introduction, Determination of pH, Ion-selective Electrode, Instrumentation, Application of pH Measurement
Chapter 2	**Potentiometry** **(5 L)**
	● Introduction, Reference Electrodes (The Hydrogen Electrode, The calomel electrode), Indicator Electrode, Ion Selective Electrode (Ion exchange electrode, Gas sensing electrode), Principles of potentiometric titration.
Chapter 3	**Conductometry**
	● General considerations, The measurement of conductivity, The basis of conductometric titrations, Apparatus and measurement, Applications of conductometric titrations.
Chapter 4	**Electrophoresis** **(4 L)**
	● Introduction, Principle, Types of Electrophoretic system (Moving Boundary Electrophoresis, Zone Electrophoresis, Steady state electrophoresis, Disc electrophoresis), Applications
Chapter 5	**Polarography** **(5 L)**
	● Introduction, principle of polarography, electrodes used in polarography, Dropping mercury electrode, polarographic cell, polarograph, working of polarograph, polarogram, factors affecting polarographic wave, half wave potential, oxygen interference, applications of polarography, ● numerical.
Chapter 6	**Flame Emission Spectroscopy** **(5 L)**
	● Introduction, principle, advantages and disadvantages of FES, Instrumentation of flame photometer, interferences in flame photometry,

	applications, numerical Problems.
Chapter 7	**Cyclic Voltammetry (3 L)**
	• Introduction, • Instrumentation • Experimental parameters • Current potential relation for linear sweep voltammetry (LSV) and Cyclic Voltammetry (CV) • Application and Interpretation of CV

References:

1. Instrumental Methods of Analysis (5th Edition) by Gurdeep R. Chatwal and Sham K. Anand
2. Vogel's Textbook of Qualitative Chemical Analysis (6th Edition) by J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar
3. Principles of Instrumental Analysis (5th Edition) Douglas A. Skoog, F. James Holler, Timothy A. Nieman
4. Instrumental Methods of Analysis (6th edition) Willard Merritt, Dean, Settle
5. Analytical Chemistry by Gary D. Christian (6th edition)
6. Vogel' Quantitative Chemical Analysis (5th edition)
7. Introduction to Instrumental Analysis by Robert D. Braun.

24ScCheU5204: Lab Course on 24ScCheU5203	(Any 12 P, 2 Credits)
	1. Determination of pH of buffer solution by colour matching of the indicator. 2. Potentiometric titration of anthranilic acid and glycine with NaOH. 3. Simultaneous determination of silver halides by potentiometric titration. 4. Determination of water hardness with EDTA. 5. Determination of the pH of hair shampoos. 6. Determination of pH of soil sample by using pH meter method. 7. Estimation of sodium by Flame emission spectrometer. 8. Estimation of potassium by Flame emission spectrometer. 9. Estimate the amount of lead present in a solution of lead nitrate by conductometric titration with sodium sulphate. 10. To determine the solubility of given sparingly soluble salt by conductance measurements. 11. Titration of a mixture of HCl and CH_3COOH potentiometrically. 12. To determine the concentration of strong acid and weak acid present in the mixture by titrating with a strong base. 13. To determine the dissociation constant of oxalic acid by pH-metric titration with a strong base. 14. Potentiometric titration of a standard solution of KCl against AgNO3 Solution. 15. Determination of Cu(II) by using spectrophotometric titration with EDTA.

References:

1) Analytical Chemistry by Gary D. Christian (6th edition)
2) Practical Chemistry for T. Y. B. Sc
3) Analytical Chemistry by Dr. Alka L. Gupta (Fourth Edition)
4) Textbook on Practical Chemistry by K. S. Mukherjee
5) Advanced Practical Chemistry by Jagdamba Singh (Pragati Prakashan)
6) Experiments in Chemistry D. V. by Jahagirdar (Himalaya Publishing House)

24ScCheU5302: Fundamentals of Chromatographic Separations (T)

Course Outcomes:

CO1: Identify the role of stationary and mobile phases in separation

CO2: To Differentiate between various chromatographic techniques

CO3: Perform sample preparation and analyze samples using different chromatographic methods.

CO4: Understand and apply method development and optimization strategies in chromatography.

CO5: Calculate retention factor (Rf values)

CO6: Understand the fundamentals of TLC, including plate preparation, sample spotting, and solvent development.

24ScCheU5302 : Fundamentals of Chromatographic Separations (T)	**(30 L, 02 Credits)**
Chapter 1	**Introductions to Chromatography (4 Lectures)**
	• Introduction: Brief history of chromatography, theory of chromatography • Types of chromatography • Classification of chromatography • Principle of chromatographic analysis with a matchbox model, • Applications of chromatography.
Chapter 2	**Paper chromatography (7 Lectures)**
	• Principle, papers as a chromatographic medium, modified papers • Solvent systems, mechanism of paper chromatography • Experimental technique, • Different development methods-ascending, descending, horizontal, circular spreading, multiple development, two-dimensional development, • Reverse phase paper chromatographic • Technique-visualization and evaluation of chromatogram • Applications: separation of amino acids, separation of plant pigment
Chapter 3	**Thin layer chromatography (7 Lectures)**
	• Principle, chromatographic media-coating materials, • Applications, activation of adsorbent, sample development, and solvent • systems, development of chromatoplate • Types of development • Visualization methods, documentation, Applications in the separation.
Chapter 4	**Column chromatography (adsorption chromatography) (6 Lectures)**

	• Principle, general aspects, adsorption isotherms, • Chromatographic media, nature of forces between adsorbent and solutes, eluents (mobile phase) • Column chromatography without detectors, liquid chromatography with detectors and applications
Chapter 5	**Ion exchange chromatography (6 Lectures)**
	• Principle, resins, action of resins, • Experimental techniques, • Separation of metal ions • Separation of chloride and Bromide ions - removal of interfering radicals. • Applications.

References:

1. Jagdamba Singh, R.K.P singh , jaya singh Advanced practical chemistry
2. R.P.W Scott, Techniques and Practice of Chromatography,Marel Dekker Inc,New York
3. M.N. Sastri , Separation Methods, Himalaya Publishing Company, Mumbai
4. E. Helfman, Chromatography, Van Nostrand, Reinhold, New York
5. E. Lederer and M. Lederer, Chromatography, Elsevier, Amsterdam.
6. Chemical separation methods, John A Dean, Von Nostrand Reinhold, New York

24ScCheU5501: Lab Course on Raw material Analytical Methods (P) Course Outcomes:

- This subject deals with the various aspects of impurity, impurities in residual solvents, elemental impurities.
- The students will expertise in raw material analysis.
- This subject deals with different methods involved in quality controls.
- The subject emphasizes on different tests for determination of purity.

23ScCheU5301: Raw Material Analytical Methods (Any 12 Expts, 2 Credits)	
	Practicals
	1. Determination of % purity of nitro amines by diazotization method. 2. Determination of % purity of raw material hydrochloric acid (weighing method and not dilution method). 3. Determination of % purity of raw material sulphuric acid (weighing method and not dilution method). 4. Determination of % purity of raw material nitric acid (weighing method and not dilution method). 5. Chloride (Cl^-) estimation by precipitation titration method. 6. Determination of % purity of oleum. 7. Determination of % purity of potassium carbonate. 8. Determination of % purity of raw caustic material. 9. Determination of % purity of sodium bicarbonate ($NaHCO_3$). 10. Estimation of Cu from dye material volumetrically (Complexometric) by digestion of the dye. 11. Estimation of degree of unsaturation of fatty acid by wiji's solution or by bromination method. 12. Estimation of Ni / Cr from dye material using volumetric methods. 13. Estimation of Fe content from $FeCl_3.6H_2O$ raw material gravimetrically. 14. Estimation of Cu from dye material (Biodegradable dye/ Food grade dye) volumetrically (using thiosulphate) by digestion of the dye.

References:

1.Vogel's textbook of quantitative chemical analysis 5th ed - G H Jeffery, J Bassett, J Mendham, R C Denney

Field project II

Course outcomes:

1. To enable the students for scientific literature reading and analyzing the literature data.
2. To link the basic chemistry concepts with current research advancements.
3. To enable the students to identify thrust areas in specific fields of chemistry and plan a research hypothesis.
4. To develop new experimental skills, interpreting a research outcome and enhancing the scientific writing abilities.

24ScCheU5001: Field Project II (2 Credits)	
	Project: By Individual student

Semester - VI

Course Type	Course Code	Course Name	No. of Credits
Major Mandatory	24ScCheU6101	Organic Chemistry	02 Credits (30L)
	24ScCheU6102	Inorganic Chemistry	04 Credits (60 L)
	24ScCheU6103	Organic Spectroscopy	02 Credits (30L)
	24ScCheU6104	Lab Course on 24ScCheU6101	02 Credits (15P)
	24ScCheU6105	Lab Course on 24ScCheU6102	02 Credits (15P)
Major Electives	Elective III 24ScCheU6201	Environmental and Green Chemistry (T)	02 Credits (30L)
	24ScCheU6202	Lab Course on 24ScCheU6201	02 Credits (15P)
	Elective IV 24ScCheU6203	Industrial Chemicals and Environment (T)	02 Credits (30L)
	24ScCheU6204	Lab Course on 24ScCheU6203	02 Credits (15P)
VSC	24ScCheU6501	Lab Course in Paint and dyes (P)	02 Credits (15P)
OJT	24ScCheU6004	On Job Training	04 Credits
Total Credits			22 Credits

24ScCheU6101: Organic Chemistry (T) (30L, 02 Credits)

Course Outcomes:

CO1: Understand the fundamental concepts and mechanism of Aromatic Electrophilic Substitution (AES) including the formation and stability of the arenium ion intermediate.

CO2: Explain the effect of substituents on aromatic rings, including orientation (ortho/para/meta directing) and classify substituents as activating or deactivating groups.

CO3: Describe and illustrate mechanisms of key electrophilic substitution reactions such as halogenation, nitration, sulfonation, Friedel–Crafts alkylation/acylation, Vilsmeier, Gattermann–Koch, diazo coupling, and ipso-substitution.

CO4: Understand the principles and mechanisms of Aromatic Nucleophilic Substitution (ANS) including SNAr (addition–elimination), SN1, benzyne (elimination–addition), and SNR1 pathways.

CO5: Analyze factors affecting nucleophilic substitution reactions such as electron-withdrawing groups (EWGs), leaving group ability, and reaction conditions.

CO6: Explain the formation, stability, and reactivity of carbanions and apply this knowledge to important reactions like Aldol, Claisen, Dieckmann, and Perkin condensations.

CO7: Demonstrate synthetic applications of active methylene compounds such as malonic ester and acetoacetic ester, and understand the preparation and applications of the Wittig reagent.

CO8: Apply the concept of retrosynthetic analysis including disconnection approach, synthons, synthetic equivalents, functional group interconversion (FGI), and transform methods (TM).

CO9: Design synthetic routes for simple organic molecules such as alkanes, alkenes, alkynes, alcohols, aldehydes, ketones, and esters using retrosynthetic strategies.

CO10: Develop problem-solving skills to plan and execute organic synthesis pathways relevant to academic and industrial applications.

24ScCheU6 6101: Organic Chemistry (T)	(30L, 02 Credits)
Chapter 1	**Aromantic Electrophilic Substitution (08 Lectures)**
	• Introduction • Arenium ion mechanism • Effect of substituent group (Orientation, o/p directing and m directing groups) • Classification of substituent groups (activating and deactivating groups) • Mechanism of –Halogenation, nitration, sulfonation, Friedel-Crafts alkylation/acylation, Vilsmeier reaction, and Gatterman-Koch reaction, Diazo Coupling reactions, Ipso-substitution.
Chapter 2	**Aromantic Nucleophilic Substitution (06 Lectures)**
	• Introduction, • Ipso-substitution. • Addition-elimination (SNAr), SN1, • Elimination-addition (Benzyne) SNR1 reactions, • reactivity factors, Effect of Electron Withdrawing Groups (EWGs) • Leaving Group Ability
Chapter 3	**Carbanions and their reactions (08 Lectures)**
	• Introduction, Formation and stability of Carbanion. • Reactions involving carbanions and their mechanisms: Aldol, Claisen, Dieckmann and Perkin condensations. • Synthesis and Synthetic applications of Malonicester, Acetoacetic ester Wittig reagent, Application of Wittig in Natural Products like flavone, coumarin, isoflavone etc.
Chapter 4	**Retro synthetic analysis and applications (08 Lectures)**
	• Introduction • Different terms used - Disconnection, Synthons, Synthetic

	equivalence, FGI, TM ● One group disconnection Retro synthesis and synthesis of target molecules: alkanes, alkene, alkynes, ketone, aldehyde, ester, alcohol.

References:

1. Organic Chemistry by Morrison and Boyd 6th Edn
2. Organic Chemistry by Cram and Hammond
3. Organic Chemistry by John McMurry 6th Edn.1999
4. Organic Chemistry by Graham Solomans
5. Organic Chemistry by I. L. Finar Vol.2 5th Edn.
6. Organic Chemistry by Clayden, Greeves, Warren and Wothers (Oxford Press)
7. A guide book to reaction Mechanism by Peter Sykes 6th Edn

24ScCheU6104: Lab Course on 24ScCheU6101 (Any 12, 2 Credits)

Course Outcomes:

CO1: Perform volumetric estimations accurately for organic compounds such as monobasic and dibasic acids using appropriate titration techniques.

CO2: Estimate organic compounds like glucose, aniline/phenol, paracetamol/aspirin, and vitamin C using standard analytical methods (Fehling's, iodometric, etc.) with proper calculations.

CO3: Demonstrate proper laboratory skills including preparation, standardization of solutions, handling of reagents, and use of glassware.

CO4: Carry out organic synthesis reactions such as methyl salicylate, coumarin derivatives, resacetophenone, and related compounds with understanding of reaction principles.

CO5: Purify synthesized organic compounds using techniques like recrystallization and distillation, and determine their physical constants.

CO6: Understand reaction mechanisms and practical aspects involved in functional group transformations and organic preparations.

CO7: Perform qualitative analysis of ternary organic mixtures, including type determination, systematic separation, purification, and identification of components.

CO8: Determine physical constants (melting point, boiling point) and use them for

confirmation of identity and purity of compounds.

CO9: Develop skills in observation, recording experimental data, and error analysis to ensure reliability of results.

CO10: Apply laboratory safety practices, proper waste disposal, and maintain good laboratory ethics and documentation skills.

24ScCheU6104: Lab Course on 24ScChe U6101	**(Any12 Expts, 2 Credits)**
	Volumetric Estimations
	1. Monobasic and Dibasic acid 2. Glucose estimation by Fehling's Solution 3. Aniline / Phenol estimation Iodometrically 4. Estimation of Paracetamol / Aspirin from APC / Aspirin tablet 5. Estimation of Vitamin C from Celin Tablet
	Organic Preparations
	1. Synthesis of methyl salicylate (IODEX content) 2. Preparation of Yara Yara Compound from methoxy naphthalene 3. Preparation of 7-hydroxy coumarin from resorcinol 4. Preparation of Resacetophenone from Resorcinol. 5. Preparation of 2-phenyl ethanol from acetophenone.
	Ternary Mixture Separations (Minimum 5 mixtures)
	Perform only Solid- Solid-Solid Ternary organic mixture: Type determination, Separation, Purification and Physical constant

References:

1. Practical of Organic Chemistry by Vogel
2. Comprehensive practical organic chemistry V.K Ahluwalia, Renu Agarwal

24ScCheU6103: Organic Spectroscopy (T)
Course Outcomes:

CO1: Introduction to concepts of UV, IR and NMR spectroscopy.

CO2: Understanding the UV, IR and NMR theory concepts.

CO3: Applying the UV-VIS spectra and calculation of λmax of different chromophores and the effect of auxochromes on the λmax.

CO4: Analyzing the IR spectra for different functional groups of organic compounds.

CO5: Understanding the concepts of Chemical shift, spin-spin splitting, coupling constant, shielding and deshielding effect.

CO6: Applying all the concepts in the elucidation of the organic compounds.

CO7: Analyzing the unknown samples and estimation of the unknown compounds.

CO8: Synthesis of the various pharmaceutical ingredients and their analysis.

CO9: Separation and analysis of the mixture of three organic compounds.

CO10: Application of separation principles in organic preparations.

24ScCheU6103: Organic Spectroscopy (T)	**(30L, 02 Credits)**
Chapter 1	**Ultra-Violet Spectroscopy & Infra-red Spectroscopy (08 Lectures)**
	Ultra-Violet Spectroscopy ● Introduction, nature of UV, Beer's law, absorption of UV radiation by organic molecules leading to different excitations. ● Terms used in UV Spectroscopy-Chromophore, Auxochrome Bathochromic shift (Redshift), hypsochromic shift (Blueshift) hyperchromic and hypochromic effect. ● Effect of conjugation on position of UV band. ● Calculation of max by Woodward and Fisher rules for dienes and enone systems, Colour and visible spectrum, ● Applications of UV Spectroscopy-Determination of structure Determination of stereochemistry (Cis and Trans)

	Infra-red Spectroscopy ● Introduction, Principle of IR Spectroscopy ● Fundamental modes of vibrations (3N-6, 3N-5), Types of vibrations (Stretching and bending), Hooke's Law ● Condition for absorption of IR radiations, vibration of diatomic molecules. ● Regions of IR Spectrum: Fundamental group region, fingerprint region aromatic region, Characteristic of IR absorption of functional groups: Alkanes, alkenes, alkynes, alcohol, ethers, alkyl-halides, carbonyl compounds (-CHO, C=O, -COOR, -COOH), amines, amides and Aromatic Compounds and their substitution Patterns. ● Factors affecting IR absorption: Inductive effect, Resonance effect, Hydrogen bonding and its application of IR spectroscopy in determination of structure, chemical reaction and hydrogen bonding.
Chapter 2	**^{1}H-NMR Spectroscopy (08 Lectures)**
	● Introduction, principles of PMR spectroscopy, magnetic and nonmagnetic nuclei. ● Precessional motion of nuclei without mathematical details. ● Nuclear resonance, chemical shift, shielding & deshielding effect. ● Measurement of chemical shift, delta and Tau-scales. ● TMS as a reference and its advantages, peak area, integration, spin-spin coupling, coupling constants, J-value (only first ordered coupling be discussed)
Chapter 3	**Combined problems (08 Lectures)**
	● Combined problems of Ultra-Violet Spectroscopy & Infra-red Spectroscopy and ^{1}H NMR Spectroscopy
Chapter 2	**Natural Products (6 Lectures)**
	● Terpenoids: Introduction, isolation, classification. Citral-structure

	determination using chemical and spectral methods, Synthesis of Citral by Barbier and Bouveault Synthesis. ● Alkaloids: Introduction, extraction, purification, some examples of alkaloids and their natural resources. Ephedrine - structure determination using chemical methods. Synthesis of Ephedrine by Nagi.

References:

1. Spectroscopy of Organic Compounds by P. S. Kalsi
2. Spectroscopic techniques by Silverstein
3. Introduction to Spectroscopy by Pavia
4. Medicinal Natural Products - A Biosynthetic approach by Paul M. Dewick 3rd Ed.(Wiley)
5. Secondary metabolism - J. Mann, 2nd edition
6. Chemical aspects of Biosynthesis – J. Mann (1994).

24ScCheU6102: Inorganic Chemistry (T)

Course Outcomes:

CO1: Identify & classify fundamental aspects of Molecular orbital theory

CO2: Be able to construct molecular orbital diagrams & predict molecular geometry for homonuclear diatomic, heteronuclear diatomic, homonuclear triatomic, and heteronuclear triatomic molecules.

CO3: Have a background to apply organometallics to other fields: organic synthesis, polymerization, bioinorganic chemistry, etc.

CO4: Widely used in research and industrial chemical reactions, as well as in the role of catalysts to increase the rate of reactions.

CO5: Explain the stability of organometallic compounds and hence the requirements of the special experimental conditions for their synthesis.

CO6: To explain the concepts of geometry of molecules & understand how to determine the point group of the molecules.

CO7: Develop advanced laboratory skills used in inorganic synthesis including

spectroscopic and analytical techniques for identification and characterization of inorganic molecules.

CO8: Ability to treat and evaluate the results of analysis.

24ScCheU6102: Inorganic Chemistry (T)	**(60 L, 4 Credits)**
Chapter 1	**Molecular Orbital Theory (12 Lectures)**
	• Features of MOT, Formation of Molecular Orbitals (MO's) by LCAO principle rules of LCAO combination. • Different types of combination atomic orbital (AO's): S-S, S-P, P-P and d-d, non-bonding combination orbitals (formation of NBMO) • M.O. energy level diagram for homonuclear diatomic molecules, bond order and existence of molecules from bond order, energy (β) and magnetic behavior for following molecules or ions:H_2, H_2^+, He, Li_2, Be_2, B_2, C_2, N_2, O_2, O_2^+, O_2^-, O_2 , F_2, Ne_2,etc. • M.O. Energy level diagram for heteronuclear diatomic molecules like CO, NO, HCl, HF. • M.O. Energy level diagram for heteronuclear triatomic molecules like CO_2, NO_2
Chapter 2	**Molecular Orbital Theory Of Coordination Complex (6 Lectures)**
	• Introduction. • Assumptions of MOT of coordination complex and MO energy level diagrams • Formation of MO's from metal orbitals and composite ligand- $[Co(NH_3)_6]^{3+}$, $[Ni(CN)_6]^{4-}$, $[Co(CN)_6]^{3-}$, $[Ni(H_2O]^{2+}$ • MO correlation diagram for octahedral complexes with sigma bonding, effect of π bonding. • Charge transfer spectra
Chapter 3	**Organometallic Chemistry (16 Lectures)**

	• Definition, brief history, classification of organometallic compounds on the basis of bond type. common notation used in organometallic chemistry, concept of hapticity of organic ligands, importance of organometallic chemistry, organometallic compounds as reagents, additives, and catalysts. • General principles of catalysis properties of catalysts. • Homogeneous and heterogeneous catalysis. • Metal Carbonyls:18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series and finding metal-metal bonds • Structure of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co, and Ni using VBT. -acceptor behavior of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain the extent of back bonding. • Role of triethylaluminium in polymerization of ethene (Ziegler- Natta • Catalyst). Species present in ether solution of Grignard reagent and their structure
Chapter 4	**Catalysis by Organometallic Compounds (20 Lectures)**
	• Study of the following industrial processes and their mechanism: • Alkene hydrogenation (Wilkinsons Catalyst) • Hydroformylation (Co salts) • Wacker Process • Synthetic gasoline (Fischer Tropsch reaction) • Synthesis of gas by metal carbonyl complexes • Suzuki & Negishi Coupling Reactions
Chapter 5	**Introduction to Group Theory (6 Lectures)**

	• Introduction and importance of symmetry in chemistry • Symmetry elements and symmetry operations • Concept of a point group with illustrations using the following point groups: (i) C∞v (HCl), (ii) D∞h (H_2), (iii) C_2v (H_2O), (iv) C_3v (NH_3), (v) C_2h (trans-dichloroethylene) and (vi) D_3h (BCl_3).

References:

1. Cotton, F.A.G.; Wilkinson & Gaus, P.L.
2. Basics Organometallic Chemistry by B. D. Gupta
3. Huheey, J. E.; Keiter, E.A. & Keiter, R. L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
4. Sharpe, A.G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
5. Greenwood, N.N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
6. Shriver, D.D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.
7. Miessler, G. L. & Tarr, D.A. Inorganic Chemistry 4th Ed., Pearson, 2010.
8. Collman, J. P. et al. Principles and Applications of Organotransition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
9. Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. j New York, NY: John Wiley, 2000.
10. Spessard, G. O. & Miessler, G.L. Organometallic Chemistry. Upper Saddle River, NJ: Prentice-Hall, 1996.
11. Symmetry and Spectroscopy of Molecules by K. Veera Reddy
12. Group Theory and its Applications by P. K. Bhattacharya
13. Inorganic Chemistry: Catherine Housecrof
14. Symmetry and Group Theory – Vijayalaxmi

24ScCheU6105: Lab Course on 24ScCheU6102 (P)

24ScCheU6105: Lab Course on 24ScCheU6102 (P)	**(Any 12 Expts, 2 Credits)**
	1. Inorganic Qualitative semi micro analysis of ternary mixtures (Identification of three groups and complete detection of any two groups for basic radical) Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested. **(6 Mixtures)** 2. Measurement of 10Dq by spectrophotometric method 3. Synthesis of Nitro penta-ammine cobalt (III) chloride. 4. Synthesis of Nitrito penta-ammine cobalt (III) chloride. 5. Gravimetric Analysis of Barium as barium sulphate. 6. Gravimetric Analysis of iron as iron oxide. 7. Gravimetric Analysis of Nickel as Ni-DMG. 8. To determine the amount of copper from brass Iodometrically. 9. To determine the concentration of Fe(III) of unknown concentration using ammonium thiocyanate at 540 nm by spectrophotometric method. 10. To determine the concentration of cobalt of unknown concentration using R-Nitroso salt at 520 nm by spectrophotometric method.

References:

1. Vogel's Qualitative Inorganic Analysis, Revised by G. Svelha. Pearson Education,2002.
2. Marr & Rockett Practical Inorganic Chemistry. John Wiley & Sons 1972.
3. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood Publishing, Chichester) 1999.
4. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House.
5. Practical Chemistry,for TYBSc course Manali Publication Pune-30
6. Synthesis and Technique in Inorganic Chemistry G. S. Girolami, T. B. Rauchfuss, R. J. Angelici

24ScCheU6201: Environmental and Green Chemistry (T) Course Outcomes:

CO1: To understand how to design chemical reactions/chemical synthesis using green chemistry principles.

CO2: To understand the use of green chemistry principles and processes in laboratory reactions.

CO3: To understand Atom economy and design of chemical reactions using the principle.

CO4: Use of green chemistry in combinatorial chemistry and biomimetic catalyst.

CO5: Identification of greener solvents and recycling of these including catalysts.

CO6: Learn various green alternatives of energy such as Microwave, ultrasound for chemical reactions.

CO7: Composition of atmosphere, Atmospheric chemical phenomenon and environmental pollution.

24ScCheU6201 Environmental and Green Chemistry (T)		**(30 L, 2 Credit)**
Chapter 1	**Introduction to Green Chemistry**	**(04 Lectures)**
	● Basic introduction and explaining goals of Green Chemistry. ● Limitations/Obstacles in the pursuit of the goals of Green Chemistry	
Chapter 2	**Principles of Green Chemistry**	**(05 Lectures)**
	● Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: ● Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products, Atom Economy, calculation of atom economy of the rearrangement, addition substitution and elimination reactions.	
Chapter 3	**Green Synthesis / Reactions**	**(06 Lectures)**

	• Green Synthesis of the following compounds: adipic acid, catechol (alternative to Strecker synthesis) • Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid. • Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine) • Surfactants for carbon dioxide • Solvents with CO_2 for precision cleaning and dry cleaning of garments. • An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.
Chapter 4	**Environment** **(5 Lectures)**
	• Introduction, Terminologies, Segments of environment • Type of Pollution: Air, Soil, Water, Noise • Composition of atmosphere • Temperature variation of earth atmospheric system (temperature vs. altitude curve) • Biogeochemical cycles of C, N, P, S and O systems. • **Case study:** The evolution of the environment
Chapter 5	**Atmosphere** **(10 Lectures)**
	• Chemical composition of atmosphere - particle, ions, and radicals in their formation • Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, and O (SOx, NOx, COx) and their effect, PAH • Pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control. • **Case study**: Bhopal Gas Disaster, Taj mahal as a sink for acid rain.

References:

1. Environmental Chemistry - A. K. De, 5th Edition (New age international publishers)
2. Environmental Chemistry - J. W. Moore and E. A. Moor (Academic Press, New York)
3. Environmental Chemistry - A. K. Bhagi and C. R. Chantal (Himalaya Publishing House
4. Environmental Chemistry - H. Kaur 2nd Edition 2007, Pragati Prakashan, Meerut, India
5. Environmental Chemistry with Green Chemistry A. K Das, Books and Allied (P) Ltd.
6. Environmental chemistry, Sharma and Kaur, 2016, Krishna publishers
7. Environmental Pollution, Monitoring and control, S. M. Khopker, 2007, New Age International.
8. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W. H. Freeman publication.
9. G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa (2009).

24ScCheU6202: Lab Course on 24ScCheU6201 (P)

Course Outcomes:

CO1: Demonstrate safe laboratory practices while performing experiments related to environmental and green chemistry.

CO2: Determine important environmental parameters including hardness, dissolved oxygen, alkalinity, and chemical oxygen demand (COD).

CO3: Apply principles of Green Chemistry to design and perform eco-friendly chemical experiments that minimize hazardous waste.

CO4: Use greener reagents, solvents, and energy-efficient methods in laboratory experiments.

CO5: Interpret experimental data and prepare laboratory reports related to environmental monitoring and sustainable chemistry.

CO6: Develop awareness of environmental protection and sustainable development through practical chemical analysis.

24ScCheU6202: Lab Course on 24ScCheU6201 (P)	(Any 12 Expts, 2 Credit)
Practicals	
	1. Preparation of biodiesel from vegetable/ waste cooking oil. 2. Benzoin condensation using Thiamine Hydrochloride as a catalyst. (Instead of cyanide) 3. Clay catalysed solid state synthesis of 7-hydroxy-4-methyl coumarin using K10 Montmorillonite. 4. Bromination of acetanilide by using ceric ammonium nitrate. 5. Preparation of 1,1-bis-2-naphthol by $FeCl_3$ 6. Synthesis of dihydropyrimidone (Multicomponent coupling). 7. Acetylation of primary amine using Zinc dust. 8. Determination of Biological Oxygen Demand (BOD). 9. Determination of Chemical Oxygen Demand (COD). 10. Find out the percentage of available chlorine in bleaching powder. 11. Estimation of chloride in different water samples. 12. Estimation of sulphate in different water samples. 13. Estimation of salinity of water in different samples. 14. Estimation of phosphate in different water samples. 15. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titration method. 16. To calculate Environmental (E) factor, Process Mass Intensity (PMI), atom economy/efficiency, Reaction Mass Efficiency (RME), Carbon Efficiency of given organic transformation

Reference Books:

1. Ahluwalia, V.K. & Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. Practical Green Chemistry: Strategies, Tools & Experiments (Paperback, Dr. Sanjay Kumar Batra, Dr. Shefali Shukla, Dr. Shikha Gulati) Shree Kala Prakashan

3. A. I. Vogel, Textbook of Practical Organic Chemistry, Fifth Edition, 1989.
4. Environmental chemistry, Sharma and Kaur, 2016, Krishna publishers.
5. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W. H. Freeman publication.
6. G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition)
7. R. M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, John Wiley & Sons, Inc. Publishers, New Delhi. (2005 edition).
8. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.

24ScCheU6203: Industrial Chemicals and Environment (T)

Course Outcomes:

CO1: Explain the production, uses, and hazards associated with key industrial gases

CO2: Understand and apply green chemistry principles to minimize hazardous waste and promote sustainable industrial practices.

CO3: To understand the production and applications of industrial chemicals

CO4: To analyze industrial gases and their uses

CO5: To evaluate the environmental impact of chemical industries

CO6: To know pollution control strategies

CO7: Comply with safety and regulatory standards

CO8: Examine case studies on industrial accidents & safety

CO9: To define and classify polymers based on their structure, source, and polymerization process.

CO10: Analyze the total alkalinity of water samples by volumetry

24ScCheU6203: Industrial Chemicals and Environment (T)	**(30 L, 2 Credits)**
Chapter 1	**Industrial Gases and Inorganic Chemicals (8 Lectures)**
	• Industrial gases: large-scale production, uses, storage, and hazards in handling gases: oxygen, nitrogen, helium, hydrogen, acetylene, carbon monoxide, sulfur dioxide, and phosgene. • Inorganic Chemicals: 1. Ammonia: Manufacture of ammonia by modified Haber Bosch process, its uses. 2. Sulphuric acid: manufacture of sulphuric acid by contact process, its uses. 3. Nitric acid: Manufacture of nitric acid by Ostwald's process, and its uses

Chapter 2	**Polymer Industries** **(8 Lectures)**
	• Classification of Polymers: Organic and Inorganic polymers • Basic concepts, nomenclature, degree of polymerization, classification of polymerization reactions, thermodynamics, and transport properties of polymers. • Commercial polymers and their importance: Nylon, polyesters (terylene and Dacron), rubber, vulcanization of rubber, synthetic rubber, Bun 2-N rubber, copolymers of butadiene, PVC, acrylic, Teflon, polyethylene and acrylonitrile • Silicone polymers: silicone oils, rubber, grease and resin • Resins: phenol-formaldehyde resins, urea-formaldehyde resins, epoxy resins, melamine-formaldehyde resins. • Biodegradable Polymer.
Chapter 3	**Agrochemicals** **(8 Lectures)**
	• General introduction and scope of agrochemicals • Meaning and examples of: Insecticides, Herbicides, Fungicides, Rodenticides, Pesticides, Plant growth regulators. Pesticide formulation, slow-release pesticide formulations, storage stability test, and Industrial entomology. • Advantages and disadvantages of agrochemicals. • Synthesis and application: BHC and Endosulphan. • Biopesticides like Neem oil and Karanja oil. • Importance of Biofertilizer, Types, examples

Chapter 4	Energy & Environment (6 Lectures)
	• Sources of energy: coal, petrol, and natural gas. Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. • Nuclear Energy and Nuclear Pollution: Disposal of nuclear waste, nuclear disaster, and its management.

References:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. Polymeric Materials, C.C.Winding & G. D. Hiatt McGraw Hill Book Co
3. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
4. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
5. K. De, Environmental Chemistry: New Age International Pvt. Ltd, New Delhi.
6. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi.
7. S.E. Manahan, Environmental Chemistry, CRC Press (2005).
8. G.T. Miller, Environmental Science 11th edition. Brooks/ Cole (2006).
9. A. Mishra, Environmental Studies. Selective and Scientific Books, New Delhi (2005).
10. Polymer Science by Gowarikar

24ScCheU6204: Lab Course on 24ScCheU6203 (P)	(Any12 Expts, 2 Credits)
Practicals	
	1. Determination of phosphorus as phosphate from the given fertilizer sample. 2. Determination of sulfur as sulphate from the given fertilizer sample. 3. To determine the molecular weight of a polymer by a viscometer. 4. Preparation of Nylon-6,6 polymer 5. Estimation of total hardness of water by the EDTA method. 6. Estimation of total alkalinity of water samples (CO^{3-}, HCO^{3-}) volumetrically. 7. Determination of dissolved oxygen in water. 8. Determination of Chemical Oxygen Demand (COD) 9. Determination of Biological Oxygen Demand (BOD) 10. To determine the percentage of available chlorine in bleaching powder. 11. Estimation of Fe (II) and oxalic acid using standardized KMnO4 solution 12. Measurement of dissolved CO2. 13. Study of some of the common bio-indicators of pollution. 14. Analytical essay of SPM in air samples.

References:

1. Comprehensive practical organic chemistry V.K Ahluwalia, Renu Agarwal
2. E. Stocchi: Industrial Chemistry, Vol. I, Ellis Horwood Ltd. UK.
3. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. S.S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.

6. K. De, Environmental Chemistry: New Age International Pvt. Ltd, New Delhi.
7. S. M. Khopkar, Environmental Pollution Analysis: Wiley Eastern Ltd, New Delhi

24ScCheU6501: Lab Course in Paint and dyes (P)

Course Outcomes:

CO1: To Understand the fundamental difference between Pigments and Dyes.

CO2:o Understand the basic concept of Pigments.

CO3: To Understand the basic concept of Dyes.

CO4: To Understand the synthesis methods of Pigments.

CO5: To Understand the synthesis methods Dyes.

CO6: To Understand the application of Pigment and Dyes

24ScCheU6501: Lab Course in Paint and dyes (P)	**(Any 12 Expts, 2 Credits)**
Practicals	
	1. Synthesis of Prussian blue (Ferric ferrocyanide) 2. Synthesis of an Azo Dye-of Benzenediazonium Ion with Naphthalen-2-ol. 3. Synthesis of Indigo dye. 4. Synthesis of Methyl orange dye. 5. Synthesis of Chrome Yellow Paint Pigments. 6. Synthesis of Malachite Paint Pigments. 7. Synthesis of White Paint Pigments. 8. Extraction and Gravimetric Analysis of Pelargonidin Dye from Onion Peel. 9. Extraction and Spectrophotometric Analysis of Pelargonidin Dye from Onion Peel.

	10. Aqueous Extraction of natural dye (Carotenoid, Lutein from marigold flower). 11. Extraction of indigo dye. 12. Photocatalytic degradation of methyl orange dye by using Catalytical material. 13. Photocatalytic degradation of rhodamine b dye by using Catalytical material. 14. Chromatographic identification of Pigments (Cartoenoid, Chlorophylls) 15. To investigate the effect of pH on various pigments and dyes.

References:

1. Paints, Pigments, Varnishes & Enamels Technology Handbook (with Process & Formulations) 2nd Revised Edition-NIIR Board of Consultants and Engineers.
2. Christopher R. Vyhnal, Elizabeth H. R. Mahoney, Yuan Lin, Roxanne Radpour, Henry Wadsworth, Cite this: J. Chem. Educ. 2020, 97, 5, 1272–1282.
3. Inorganic Pigment Synthesis - R. M. Jones -Austin Peay State University.
4. Pigments, Paint and Painting: A practical book for practical men by George Terry.
5. Comprehensive Practical Organic Chemistry -V. K. Ahluwalia and Renu Aggarwal.

24ScCheU6004: On-Job Training

Course Outcomes:

CO1: Demonstrate the ability to apply theoretical knowledge learned in the classroom to real-world work scenarios effectively.

CO2: Acquire and enhance technical and practical skills specific to the industry or field of training.

CO3: Identify, analyze, and solve work-related challenges using critical thinking and creativity.

CO4: Develop effective verbal and written communication skills appropriate for the workplace, including the ability to collaborate with team members and interact with

clients or customers.

CO5: Exhibit professional behavior, responsibility, and a strong work ethic while adhering to organizational policies and standards.

CO6: Manage time effectively to meet deadlines, balance multiple tasks, and prioritize responsibilities in a work environment.

CO7: Work effectively as part of a team, respecting diversity and contributing positively to team objectives.

CO8: Adapt to changing work conditions, roles, and responsibilities while maintaining productivity and focus.

CO9: Gain insights into industry practices, work culture, and current trends that enhance career readiness and employability.

CO10: Reflect on personal performance, identify areas for growth, and seek opportunities for continuous learning and self-improvement.

24ScCheU6004: On-Job Training	**(4 Credits)**
	Project: By Individual student

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