

Progressive Education Society's
Modern College of Arts, Science and Commerce (*Autonomous*),

Shivajinagar, Pune- 5

Third Year of B. Sc. NEP (Chemistry)

2025-26

Semester – V

Course Type	Course Code	Course Name	No. of Credits
Major Mandatory	23ScCheU5101	Organic Chemistry (T + P)	04 Credits (30L+15P)
	23ScCheU5102	Physical Chemistry (T)	04 Credits (60L)
	23ScCheU5103	Lab Course on 23ScCheU5102 (P)	02 Credits (15P)
Major Electives	Elective I 23ScCheU5201	Green Chemistry (T + P)	04 Credits (30L+15P)
	Elective II 23ScCheU5202	Instrumental Methods of Analysis (T + P)	04 Credits (30L+15P)
Minor	23ScCheU5301	Fundamentals of Chromatographic Separations (T+P)	04 Credits (30L+15P)
VSC (P)	23ScCheU5501	Lab Course in Paint and dyes (P)	02 Credits (15P)
FP (P)	23ScCheU5001	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:

1. Recalling the various organic reactions involving carbanion as intermediate. Explaining the carbanion reaction intermediates. Its stability and applications
2. Understanding the concept of elimination reaction and its different types.
3. Applying the stereochemistry to the various addition reactions of alkene and alkynes.
4. Utilizing the knowledge of organic chemistry and applying in the disconnection approach and to understand the term FGI, synthons, synthetic equivalents.
5. To understand and the different concepts like stereochemistry, retrosynthesis, intermediates in designing the target molecules.
6. Preparations of various derivatives of different functional groups in organic compounds.
7. Synthesis of the various pharmaceutical ingredients and its analysis
8. Ether based separation and analysis of mixture of binary organic compounds
9. Application of separation principles in organic preparations.

23ScCheU5101: Organic Chemistry (T)		(30 L, 2 Credits)
Chapter 1	Retrosynthesis	(08 Lectures)
	• Introduction • Different terms used–Disconnection, Synthons, Synthetic equivalence, FGI, TM. • One group disconnection. • Retrosynthesis and Synthesis Alkanes, Alkene, Alkynes, Ketone, Aldehyde, Alcohol • Target molecules: Alkanes, Alkene, Ester, Alcohol etc.	

Chapter 2	Carbanion (08 Lectures)
	• Introduction, Formation and stability of Carbanion. • Reactions involving carbanions and their mechanisms: Aldol Claisen, Dieckmann and Perkin reactions. • Synthesis and Synthetic applications of Malonic ester, Acetoacetic ester. • Wittig reagent, Application of Wittig in Natural Products like flavone, coumarin, isoflavones.
Chapter 3	Eliminations reactions (08 Lectures)
	• Introduction: 1,1 and 1,2 eliminations. • 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	Stereochemistry of C=C addition reactions and triple bond (06 Lectures)
	• Syn and Anti addition of halogen to C=C • Ozonolysis reaction to C=C • Addition to conjugated dienes

23ScCheU5101: Organic Chemistry (P)

23ScCheU5101: Organic Chemistry (P) (Expts 15, 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), Full analysis

Reference:

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

23ScCheU5102: Physical Chemistry

Course Outcomes:

1. To learn basic concepts of quantum chemistry and the difference between classical and quantum mechanics.
2. Application Schrödinger equation for simple one-dimensional systems.
3. Understanding the different types of spectroscopies and their applications.
4. Study of Vibrating diatomic molecules, energy levels of a diatomic molecule, simple oscillator, Scattering of light and Raman Spectrum. rotational and vibrational spectrum.
5. Understand the concepts of Radioactivity.
6. Study the kinetics of nuclear reactions and its applications.

23ScCheU5102: Physical Chemistry		(4 Credits, 60 Lectures)
Chapter 1	Quantum Chemistry	(20 Lecture)
	● Introduction to black-body radiation and distribution of energy. ● Photo-electric effect. ● Concept of quantization. ● Wave particle duality (de-Broglie's hypothesis). ● 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 Lecture)
	● 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-harmonic, Numericals. ● Rotational-Vibrational spectra of Diatomic molecules :P and R branch. ● Raman spectroscopy: Introduction, Explanation of Rayleigh's line, stokes and anti-stokes lines, Pure Rotational-Raman spectra for diatomic molecules.	
Chapter 3	Nuclear Chemistry	(20 Lecture)
	● The atom, nucleus and outer sphere and its classification. ● Nuclear forces, nuclear stability, binding energy, Numericals.	

	● Radioactive decay (Radioactive elements, general characteristics of radioactive decay, decay kinetics - decay constant, half-life, mean life period), units of radioactivity. ● Types of radioactive decay- alpha, beta, gamma. ● Decay kinetics. ● Measurement of radioactivity: 1) Ionisation chamber 2) Proportional counter 3) G.M. counter ● Applications of Radioactivity.
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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. Arnikar H. J., *Essentials of Nuclear Chemistry*, Wiley Eastern, Second Edition.
10. Friendlander G, Kennedy G and Miller J. M. *Nuclear and Radiochemistry*, Wiley Interscience.
11. Overman R. T, *Basic concept of Nuclear Chemistry*, Chapman & Hall.

23ScCheU5103: Lab Course on 23ScCheU5102

Course Outcomes:

1. Students will grasp the basic principles of how light interacts with matter, leading to the

- production of spectra.
2. 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.
 3. Students should be able to collect, analyze, and interpret data from nuclear chemistry experiments, including plotting graphs, calculating uncertainties, and drawing conclusions.
 4. Students should be able to identify, use, and calibrate various nuclear instrumentation, such as the Geiger-Müller counter.
 5. Students will be able to understand the basics of machine learning in computational chemistry.
 6. Students will learn to write and run various programs in computer languages for applications in chemistry.

23ScCheU5103: Lab Course on 23ScCheU5102

(15 Expts, 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 by 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 plateau voltage of the given G. M counter.
8. To determine the $E_{\max}$ of the β particles.
9. To illustrate that for the number of counts recorded being high, Poisson distribution follows closely normal or Gaussian distribution.
10. Estimation of efficiency for a Gamma Source.

11. Estimation of efficiency for a Beta Source.
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.

Reference Books:

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. J. N. Reddy, M.S.R. Murty, *Experiments with G.M Counter*, Nucleonix systems Pvt. Ltd.

13. R.C. Das, B. Behera, *Experimental Physical Chemistry*, Tata McGraw-Hill Publishing company limited.

14. D.V. Jahagirdar, *Experiments in Chemistry*, Himalaya Publishing house, 2003

23ScCheU5201: Green Chemistry (T + P)

Course Outcomes:

1. To understand how to design chemical reactions/chemical synthesis using green chemistry principles.
2. To understand the use of green chemistry principles and processes in laboratory reactions.
3. To understand Atom economy and design of chemical reactions using the principle.
4. Use of green chemistry in combinatorial chemistry and biomimetic catalyst
5. Identification of greener solvents and recycling of these including catalysts.
6. Learn various green alternatives of energy such as Microwave, ultrasound for chemical reactions.

23ScCheU5201: Green Chemistry (T)		(4 Credits)
Chapter 1	Introduction to Green Chemistry	(4 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 and Designing a Chemical Synthesis	(20 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. ● Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk = (function) hazard × exposure; waste or pollution prevention hierarchy.	

	● Green solvents-supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents. ● Energy requirements for reactions-alternative sources of energy: use of microwaves and ultrasonic energy. ● Selection of starting materials; avoidance of unnecessary derivatization – careful use of blocking/protecting groups. ● Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis. ● Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD “What you don’t have cannot harm you”, greener alternative to Bhopal Gas Tragedy (safer route to carbaryl) and Flixborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation. ● Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes
Chapter 3	Green Synthesis / Reactions (06 Lectures)
	● Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis) ● Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents, Diels-Alder reaction and Decarboxylation reaction ● Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine) ● Surfactants for carbon dioxide – replacing smog producing and ozone depleting solvents with CO₂ for precision cleaning and dry cleaning of garments. ● An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.

Reference Books:

1. Ahluwalia, V.K. & Kidwai, M.R. New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. Anastas, P.T. & Warner, J.K.: Green Chemistry - Theory and Practical, Oxford University Press (1998)
3. Matlack, A.S. Introduction to Green Chemistry, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
5. Ryan, M.A. & Tinnesand, M. Introduction to Green Chemistry, American Chemical Society, Washington (2002).
6. Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition 2010.

23ScCheU5201: Green Chemistry (P)	(2 Credit)
1. Preparation and characterization of ZnO nanoparticles using tea leaves. (Ref 2) 2. Preparation of biodiesel from vegetable/ waste cooking oil. (Ref. 1) 3. To calculate Environmental (E) factor, Process Mass Intensity (PMI), atom economy/efficiency, Reaction Mass Efficiency (RME), Carbon Efficiency of given organic transformation that illustrates Green Chemistry a. Rearrangement Reaction b. Substitution Reaction c. Addition Reaction d. Elimination Reaction 4. Benzoin condensation using Thiamine Hydrochloride as a catalyst (instead of cyanide). (Ref. 1 and Ref. 3) 5. Benzil-Benzilic acid Rearrangement (Ref. 12) 6. Mechanochemical solvent free synthesis of azomethines (Ref. 1) 7. Solvent free, microwave assisted one pot synthesis of phthalocyanine Cu(II) complex. (Ref.1) 8. Photoreduction of benzophenone to benzopinacol in presence of sunlight. (Ref. 1 and Ref. 4)	

9. Clay catalysed solid state synthesis of 7-hydroxy-4-methyl coumarin using K10 Montmorillonite. (Ref. 5)
10. Bromination of acetanilide by using ceric ammonium nitrate. (Ref. 6)
11. Preparation of 1,1-bis-2-naphthol by FeCl_3 (Ref. 7)
12. Synthesis of dihydropyrimidone (Multicomponent coupling). (Ref. 8)
13. Preparation of Manganese (III) acetylacetonate. (Ref. 9)
14. Acetylation of primary amine using Zinc dust. (Ref. 10)
15. Preparation of benzopinacolone by glacial acetic acid containing trace amount of Iodine. (Ref. 11)

Reference Books:

1. Ahluwalia, V. K. & Kidwai, M. R. New Trends in Green Chemistry, Anamalaya Publishers (2005).
2. Prasanta Sutradha and Mitali Sahar, Bull. Mater. Sci., Vol. 38, No. 3, June 2015, pp. 1-5.
3. P., D. L. Lampman, G. M. Chriz, Introduction to organic lab technique; College Publishing, New York, 1982 experiment no 40
4. P., D. L. Lampman and G. M. Chriz, Introduction to Organic Lab Technique; College Publishing, New York, 1982 exp. 47
5. Greener approach to undergraduate chemistry experiments, ACS publications, 2002, p 25.
6. P. F. Schatz, Journal of Chemical Education. 1996, 173, 267.
7. A. I. Vogel, Textbook of Practical Organic Chemistry, Fifth Edition, 1989.

23ScCheU5202: Instrumental Methods of Analysis (T+P)

Course Outcomes:

1. To understand the fundamental principle, theory and applications of instrumental Methods
2. To design an experiment based on instruments and for analysis of various elements.
3. To Learn basics of instrumental techniques and its application.
4. 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.

5. To apply fundamental Analytical techniques and interpret the experimental data qualitatively and quantitatively
6. To apply concepts of electrochemistry in experiments

23ScCheU5202: Instrumental Methods of Analysis (T+P) (2 Credits, 30 Lectures)	
Chapter 1	pH metry (05 Lectures)
	• Introduction, Determination of pH, Ion-selective Electrode, Instrumentation, Application of pH Measurement
Chapter 2	Potentiometry (06 Lectures)
	• 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 (04 Lectures)
	• General considerations, The measurement of conductivity, The basis of conductometric titrations, Apparatus and measurement, Applications of conductometric titrations.
Chapter 4	Electrophoresis (05 Lectures)
	• Introduction, Principle, Types of Electrophoretic system (Moving Boundary Electrophoresis, Zone Electrophoresis, Steady state electrophoresis, Disc electrophoresis), Applications
Chapter 5	Polarography (05 Lectures)
	• 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 (05 Lectures)
	• Introduction, principle, advantages and disadvantages of FES, Instrumentation of flame photometer, interferences in flame

	photometry, applications, numerical Problems.
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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.

23ScCheU5202: Instrumental Methods of Analysis	(15 Experiment, 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 CH₃COOH 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)

23ScCheU5301: Fundamentals of Chromatographic Separations (T+P)

Course Outcomes:

1. Identify the role of stationary and mobile phases in separation
2. To Differentiate between various chromatographic techniques
3. Perform sample preparation and analyze samples using different chromatographic methods.
4. Understand and apply method development and optimization strategies in chromatography.
5. Calculate retention factor (R_f values)
6. Understand the fundamentals of TLC, including plate preparation, sample spotting, and solvent development.

23ScCheU5301: Fundamentals of Chromatographic Separations (T)		(2 Credit)
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 matchbox model, and 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 chromatograms, applications.
Chapter 3	Thin layer chromatography (7 Lectures)
	● Principle, chromatographic media-coating materials, ● Applications, activation of adsorbent, sample development, solvent systems, development of chromatoplate ● Types of development ● Visualization methods, documentation, and applications in the separation.
Chapter 4	Column chromatography (6 Lectures)
	● Principle, general aspects, adsorption isotherms, ● Chromatographic media, nature of forces between adsorbent and solutes, eluents (mobile phase) ● Column chromatography without detectors, and liquid chromatography with detectors and applications.
Chapter 5	Ion exchange chromatography (6 Lectures)
	● Principle, resins, action of resins, ● Experimental techniques, applications, ● Separation of metal ions ● Separation of chloride and Bromide ions - removal of interfering radicals.

Reference Books:

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

Practicals	23ScCheU5301: Fundamentals of Chromatographic Separations (P) (2 Credits)
	● Paper Chromatography: 1. Paper chromatographic separation of Ni^{2+} and Co^{2+} OR Mn^{2+} and Zn^{2+} (<i>Two metal ions</i>) 2. Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+} (<i>Three metals ions</i>) 3. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values. 4. Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography ● Thin Layer Chromatography 5. Separation of nitro phenol isomers by Thin layer chromatography 6. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them based on their R_f values. 7. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC Chromatography. ● Column Chromatography Separation of binary mixture of cations by Column Chromatography (any two mixtures) 8. Fe + Al, 9. Cu + Mg 10. Co+ Ni 11. Separation of mixture of $\text{K}_2\text{Cr}_2\text{O}_7$ and KMnO_4 by column Chromatography, ● Ion exchange: 12. Determination of exchange capacity of cation exchange resins and anion exchange resins. 13. Separation of metal ions from their binary mixture.

Reference Book:

1. Jagdamba Singh, R.K.P Singh, Jaya Singh Advanced practical chemistry
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis, 6th Ed., Pearson, 2009.
3. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd., London.
4. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
5. Ditts, R.V. Analytical Chemistry: Methods of Separation. Van Nostrand, New York, 1974.
6. Skoog, D. A. Holler, F. J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition
7. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.

23ScCheU5501: Lab Course in Paint and dyes (P)**Course Outcomes:**

1. To Understand the fundamental difference between Pigments and Dyes.
2. To Understand the basic concept of Pigments.
3. To Understand the basic concept of Dyes.
4. To Understand the synthesis methods of Pigments.
5. To Understand the synthesis methods Dyes.
6. To Understand the application of Pigment and Dyes

23ScCheU5501: Lab Course in Paint and dyes**(15 Expts, 2 Credit)**

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 yellow dye.
5. Synthesis of Methyl orange dye.
6. Synthesis of Alizarin dye.
7. Synthesis of Chrome Yellow Paint Pigments.
8. Synthesis of Malachite Paint Pigments.
9. Synthesis of White Paint Pigments.
10. Extraction and Gravimetric Analysis of Pelargonidin Dye from Onion Peel.
11. Extraction and Spectrophotometric Analysis of Pelargonidin Dye from Onion Peel.
12. Aqueous Extraction of natural dye (Cartoenoid, Lutein from marigold flower).
13. Extraction of indigo dye.
14. Photocatalytic degradation of methyl orange dye by using Catalytical material.
15. Photocatalytic degradation of rhodamine b dye by using Catalytical material.
16. Chromatographic identification of Pigments (Cartoenoid, Chlorophylls).
17. To investigate the effect of pH on various Pigments and Dyes

Reference Books:

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.

FP-II 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.

23ScCheU5001: Field Project II		(2 Credits)
	Project: By Individual student	

Semester - VI

Course Type	Course Code	Course Name	No. of Credits
Major Mandatory	23ScCheU6101	Inorganic Chemistry (T)	04 Credits (60L)
	23ScCheU6102	Organic Chemistry (T+P)	04 Credits (30L+15P)
	23ScCheU6103	Lab Course on 23ScCheU6101 (P)	02 Credits (15P)
Major Electives	Elective III 23ScCheU6201	Environmental Chemistry (T + P)	04 Credits (30L+15P)
	Elective IV 23ScCheU6202	Industrial Chemicals and Environment (T + P)	04 Credits (30L+15P)
Minor	23ScCheU6301	Advanced Analytical Techniques (T+P)	04 Credits (30L+15P)
OJT	23ScCheU6004	On Job Training	04 Credits (30L+15P)
Total Credits			22 Credits

23ScCheU6101: Inorganic Chemistry (T)

Course Outcomes:

1. Identify & classify fundamental aspects of Molecular orbital theory
2. Be able to construct molecular orbital diagrams & predict molecular geometry for homonuclear diatomic, heteronuclear diatomic, homonuclear triatomic, and heteronuclear triatomic molecules.
3. Have a background to apply organometallics to other fields: organic synthesis, polymerization, bioinorganic chemistry, etc.
4. Widely used in research and industrial chemical reactions, as well as in the role of catalysts to increase the rate of reactions.
5. Explain the stability of organometallic compounds and hence the requirements of the special experimental conditions for their synthesis.
6. To explain the concepts of geometry of molecules & understand how to determine the point group of the molecules.
7. Develop advanced laboratory skills used in inorganic synthesis including spectroscopic and analytical techniques for identification and characterization of inorganic molecules.
8. Ability to treat and evaluate the results of analysis

23ScCheU6101: Inorganic Chemistry (T)		(60 Lectures, 4 Credits)
Chapter1	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^{2-}, F_2, Ne_2, M.O. Energy level diagram for heteronuclear diatomic molecules like CO, NO, HCl, HF. • M.O. Energy level diagram for Heteronuclear Triatomic Molecule like CO_2, NO_2
Chapter 2	Molecular Orbital Theory Of Coordination Complex (6 Lectures)
	• Introduction. Assumptions of MOT MO treatment to octahedral complexes with sigma bonding. 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. π-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 3	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 4	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) $C_{\infty v}$ (HCl), (ii) $D_{\infty h}$ (H_2), (iii) C_{2v} (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans-dichloroethylene) and (vi) D_{3h} (BCl_3).

Reference Books:

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 Housecroft.
14. Symmetry and Group Theory – Vijayalaxmi.

23ScCheU6103: Lab Course on 23ScCheU6101	(Expts 15, 2 Credits)
Practicals	
1. Qualitative semi micro analysis of mixtures containing 3 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested. (6 Mixtures) 7. Measurement of 10Dq by spectrophotometric method 8. Synthesis of Nitro penta-ammine cobalt (III) chloride. 9. Synthesis of Nitrito penta-ammine cobalt (III) chloride. 10. Gravimetric Analysis of Barium as barium sulphate. 11. Gravimetric Analysis of iron as iron oxide. 12. Gravimetric Analysis of Nickel as Ni-DMG. 13. To determine the amount of copper from brass Iodometrically. 14. To determine the concentration of cobalt of unknown concentration using ammonium thiocyanate at 480 nm by spectrophotometric method. 15. To determine the concentration of cobalt of unknown concentration using R-Nitroso salt at 520 nm by spectrophotometric method.	

Reference books:

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.

23ScCheU6102: Organic Chemistry (T+P)

Course Outcomes:

1. Introduction to concepts of UV, IR and NMR spectroscopy
2. Understanding the UV, IR and NMR theory concepts
3. Applying the UV-VIS spectra and calculation of λ_{max} of different chromophores and the effect of auxochromes on the λ_{max}
4. Analyzing the IR spectra for different functional groups of organic compounds
5. Understanding the concepts of Chemical shift, spin-spin splitting, coupling constant, shielding and deshielding effect
6. Applying all the concepts in the elucidation of the organic compounds.
7. Analyzing the unknown samples and estimation of the unknown compounds.
8. Synthesis of the various pharmaceutical ingredients and their analysis.
9. Separation and analysis of the mixture of three organic compounds.
10. Application of separation principles in organic preparations

23ScCheU6102: Organic Chemistry (T) (30 Lectures, 4 Credits)	
Chapter 1	Spectroscopic methods in structure determination of organic compounds (24 Lectures)
	• Introduction, the meaning of spectroscopy, nature of electromagnetic radiation, wavelength, frequency, energy, amplitude, wavenumber and their relationship • Different units of measurement of wavelength frequency, and different regions of electromagnetic radiations. Interaction of radiation with matter. • Excitation of molecules with different energy levels, such as rotational, vibrational and electronic levels. Type of Spectroscopy And advantages of spectroscopic methods. I) 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 the 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) II) 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. III) ¹H-NMR Spectroscopy • 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
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	coupling, coupling constants, J-value (only first ordered coupling be discussed) Problems based on $^1\text{H-NMR}$
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.

Reference Books:

1. Spectroscopy of Organic Compounds by P. S. Kalsi
2. Spectroscopic techniques by Silverstein
3. Introduction to Spectroscopy by Pavia

23ScCheU6102: Organic Chemistry (P)

Organic Chemistry Practicals (Expts 15, 2 Credits)	
1.	Volumetric Estimations
	- Monobasic and Dibasic acid - Glucose estimation by Fehling's Solution - Aniline / Phenol estimation Iodometrically - Estimation of Paracetamol / Aspirin from APC / Aspirin tablet - Estimation of Vitamin C from Celin Tablet
2.	Organic Preparations
	- Synthesis of methyl salicylate (IODEX content) - Preparation of Yara Yara Compound from methoxy naphthalene - Preparation of 7-hydroxy coumarin from resorcinol

	• Preparation of Resacetophenone from Resorcinol. • Preparation of 2-phenyl ethanol from acetophenone.
3	Ternary Mixture Separations (Minimum 5 mixtures)
	Perform only Solid- Solid-Solid Ternary organic mixture: Type determination, Separation, Purification and Physical constant.

Reference:

1. Practical of Organic Chemistry by Vogel

23ScCheU6201: Environmental Chemistry (T+P)

Course Outcomes:

1. Composition of atmosphere
2. Biogeochemical cycles
3. Hydrological cycle
4. Water quality parameters
5. Atmospheric chemical phenomenon and environmental pollution
6. Water pollution, parameters of water pollution, treatment of polluted water.

23ScCheU6201: Environmental Chemistry (T)		(30 Lecture, 2 Credit)
Chapter 1	Environment	(4 Lectures)
	• Composition of atmosphere • Temperature variation of earth atmospheric system (temperature vs. altitude curve) • Biogeochemical cycles of C, N, P, S and O system. • Case study: The evolution of the environment	
Chapter 2	Hydrosphere	(8 Lectures)

	- Hydrological cycle, aquatic pollution and water quality parameters – Dissolve oxygen, biochemical oxygen demand, chemical oxygen demand - Analytical methods for the determination of fluoride, chromium and arsenic, residual chlorine and chlorine demand - Purification and treatment of municipal water and waste water. - Case study: Lake Nyos disaster
Chapter 3	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 and their effect - Pollution by chemicals, CFC, Green House effect, acid rain, air pollution and control. - Case study: Bhopal Gas Disaster, Tajmahal as a sink for acid rain.
Chapter 4	Aquatic chemistry (10 Lectures)
	- Water and its necessities, various water quality parameters (DO, BOD, COD, - Conductivity, pH, alkalinity, hardness and its determination, - Industrial, municipal water treatment processes - Waste water treatment procedure (primary, secondary and tertiary) - Solid waste treatment. - Soil pollution and Noise pollution. - Case study: Ganga River pollution, Minamata disaster, Fukushima disaster

Reference Books:

1. De. A. K. Environmental Chemistry, Wiley Eastern Ltd, 1990.
2. Miller T. G. Jr., Environmental Science, Wadsworth publishing House, Meerut Odum.E.P.1971.
3. Odum, E.P. (1971) Fundamentals of Ecology. Third Edition, W.B. Saunders Co.,

Philadelphia

4. S. E. Manahan, Environmental chemistry, 1993, Boca Raton, Lewis publisher
5. Environmental chemistry, Sharma and Kaur, 2016, Krishna publishers
6. Environmental Pollution, Monitoring and control, S.M. Khopker, 2007, New Age International.
7. Environmental chemistry, C. Baird, M. Cann, 5th Edn, 2012, W. H. Freeman publication.
8. G. S. Sodhi Fundamental Concepts of Environmental Chemistry (Third Edition) Narosa (2009).
9. Principles of instrumental analysis: D. A. Skoog, Fifth Edition, Sauns College Publishing (London)
10. Basic concepts of analytical chemistry: S. M. Khopkar, Wiley Eastern (1995)

23ScCheU6201: Environmental Chemistry (P)	
Practical	(15 Expts, 2 Credit)
	1. Determination of dissolved oxygen in given water (chemical method) 2. Determination of dissolved oxygen in given water (Instrumentation method). 3. Determination of Biological Oxygen Demand (BOD). 4. Determination of Chemical Oxygen Demand (COD). 5. Find out the percentage of available chlorine in bleaching powder. 6. Estimation of chloride in different water samples. 7. Estimation of sulphate in different water samples. 8. Estimation of salinity of water in different samples. 9. Estimation of phosphate in different water samples. 10. Estimation of total alkalinity of water samples (carbonate, bicarbonate) by titration method. 11. Determination of nitrate-nitrogen in water. 12. Photocatalytic Dye Fragmentation.

Reference Books:

1. R.M. Felder, R.W. Rousseau: Elementary Principles of Chemical Processes, John Wiley & Sons, Inc. Publishers, New Delhi. (2005 edition).
2. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
3. S. S. Dara: A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
4. A. K. De, Environmental Chemistry: New Age International Pvt., Ltd, New Delhi.
5. S. M. Khopkar, Environmental Pollution Analysis: New Age Int. Publisher, New Delhi.

243cCheU6202: Industrial Chemicals and Environment (T + P)**Course Outcomes:**

1. To understand the production and applications of industrial chemicals
2. To analyze industrial gases and their uses
3. To evaluate the environmental impact of chemical industries
4. To know pollution control strategies
5. Comply with safety and regulatory standards
6. Examine case studies on industrial accidents & safety
7. To define and classify polymers based on their structure, source, and polymerization process.
8. Analyze the total alkalinity of water samples volumetrically

243cCheU6202: Industrial Chemicals and Environment (T)		(30 Lectures)
Chapter 1	Industrial Gases and Inorganic Chemicals	(08 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 (08 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 (08 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 (06 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.
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Reference Books:

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

243cCheU6202: Industrial Chemicals and Environment (P) (15 Expts)	
	1. Determination of phosphorus from the given fertilizer sample. 2. Determination of sulfur 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^{2-}, 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 KMnO_4 solution 12. Measure chloride and salinity of water samples by simple titration method (AgNO_3 and potassium chromate). 13. Measurement of dissolved CO_2 . 14. Study of some of the common bio-indicators of pollution. 15. Analytical essay of SPM in air samples. 16. Preparation of borax/ boric acid.
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Reference Books:

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.

23ScCheU6301: Advanced Analytical Techniques (T+P)

Course Outcomes:

1. Understand the fundamental principle, theory and applications of advanced analytical techniques.
2. Explain working principle of thermal method, AAS, Fluorometry, Nephelometry and Turbidimetry, spectrophotometry
3. Design an experiment for analysis of various elements, food and pharmaceutical samples.
4. Determine the concentration of unknown compound using AAS, Fluorometry, Nephelometry and Turbidimetry, spectrophotometry.
5. Understand the instrumentation of various analytical techniques.
6. To develop the skill of instrument handling.

23ScCheU6301: Advanced Analytical Techniques (T)		
Theory		(30 Lectures 2 Credits)
Chapter 1	Thermal Methods of Analysis	(08 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 4	Atomic Absorption Spectroscopy (4 Lectures)
	• Introduction, • Principle • Advantages of AAS over FES, limitations of AAS, • Instrumentation, sensitivity and detection limit, interferences, • Applications, numerical Problems
Chapter 5	Fluorimetry (3 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.

23ScCheU6301: Advanced Analytical Techniques (P)	
Practicals	(15 Expts)
	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 λ_{max} 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 (Vit B2) 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
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Reference books:

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)

23ScCheU6004: On-Job Training

Course Outcomes:

1. Demonstrate the ability to apply theoretical knowledge learned in the classroom to real-world work scenarios effectively.
2. Acquire and enhance technical and practical skills specific to the industry or field of training.
3. Identify, analyze, and solve work-related challenges using critical thinking and creativity.
4. 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.
5. Exhibit professional behavior, responsibility, and a strong work ethic while adhering to organizational policies and standards.
6. Manage time effectively to meet deadlines, balance multiple tasks, and prioritize responsibilities in a work environment.
7. Work effectively as part of a team, respecting diversity and contributing positively to team objectives.
8. Adapt to changing work conditions, roles, and responsibilities while maintaining productivity and focus.
9. Gain insights into industry practices, work culture, and current trends that enhance career readiness and employability.
10. Reflect on personal performance, identify areas for growth, and seek opportunities for continuous learning and self-improvement.

23ScCheU6004: On-Job Training		(30 Lectures) (2 Credits)	
	Project: By Individual student		
