John Wilson Education Society's
Wilson College (Autonomous)

Chowpatty, Mumbai-400007
RE-ACCREDITED 'A' grade by NAAC

Affiliated to the

UNIVERSITY OF MUMBAI

Syllabus for Second Year (S.Y.) under
New Education Policy (NEP-2020)
Programme: B.Sc.
Programme Code: WSCHEMJ (Chemistry)

Choice Based Credit System (CBCS) with effect from

Academic year 2024–2025

Programme Outline 2024-2025

YEAR	SEM	COURSE CODE		COURSE TITLE	CREDIT
S.Y.B.Sc	III	WSCHEMJ231 (Major)	Discipline specific course (DSC: Mandatory) Theory	Physical and Inorganic Chemistry I	02 (30 h)
		WSCHEMJ232 (Major)	Discipline specific course (DSC: Mandatory) Theory	Organic and Analytical Chemistry- I	02 (30 h)
		WSCHEMJ233 (Major)	Discipline specific course (DSC: Mandatory) (Major) Practical	Chemistry Practical-III	02
		WSCHEMN231	Discipline specific course (DSC: Mandatory) (Minor) Theory	Physical and Inorganic Chemistry	02 (30 h)
		WSCHEMN232	Discipline specific course (DSC: Mandatory) (Minor) Practical	Physical and Inorganic Chemistry Practicals	02
		WSCHESE231	Skill Enhancement Course (SEC)	Applied Chemistry-Practical II	02
		WACHEOE231	Inter-disciplinary Generic/Open Elective: (OE1)	Chemistry of Food Products	02 (30 h)
		WACHEOE232	Inter-disciplinary Generic/Open Elective: (OE2)	Environment and Sustainable Energy	02 (30 h)
		WSCHEVE231	Value Education Course (VEC)	Non Conventional Sources of Energy	02 (30 h)

YEAR	SEM	COURSE CODE		COURSE TITLE	CREDIT
S.Y.B.Sc	IV	WSCHEMJ241 (Major)	Discipline specific course (DSC: Mandatory) theory	Physical and Inorganic Chemistry II	02 (30 h)
		WSCHEMJ242 (Major)	Discipline specific course (DSC: Mandatory) Theory	Organic and Analytical Chemistry- II	02 (30 h)
		WSCHEMJ243 (Major)	Discipline specific course (DSC: Mandatory) (Major) Practical	Chemistry Practical-IV	02
		WSCHEMN241	Discipline specific course (DSC: Mandatory) (Minor) Theory	Analytical and Organic Chemistry	02 (30 h)
		WSCHEMN242	Discipline specific course (DSC: Mandatory) (Minor) Practical	Analytical and Organic Chemistry Practicals	02
		WSCHEVS241	Vocational skill Course (VSC)	Applied Chemistry- Practical III	02
		WACHEOE241	Inter-disciplinary Generic/Open Elective: (OE1)	Chemicals and Laboratory Safety measures	02 (30 h)
		WACHEOE242	Inter-disciplinary Generic/Open Elective: (OE2)	Waste management and applications of Chemical analysis	02 (30 h)

PROGRAMMEE SPECIFIC OUTCOMES:

PSO 1. Apply the basic knowledge of chemistry to perform various tasks assigned at the workplace in industry and academia to meet the global standards.

PSO 2. Undertake research activities and use modern scientific tools to analyze and solve various topics in the research field.

PSO 3. Design system reactions with appropriate considerations in industries and laboratories with respect to safety, economy, health and environment.

PSO 4. Use the subject knowledge, communication and ICT skills to be an effective team leader/team member in the interdisciplinary fields.

PSO 5. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

PSO 6. Exhibit professional work ethics and norms of scientific development.

PSO 7. Practice the art of scientific approach and analytical reasoning to become lifelong learners

PREAMBLE:

Bachelor of Science (B.Sc.) in Chemistry is an undergraduate course of Department of Chemistry, Wilson College, Chowpatty, Mumbai (Autonomous). The Choice Based Credit System to be implemented through this curriculum would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities.

This syllabus is prepared to give the sound knowledge and understanding of chemistry to undergraduate students in the first year of the B.Sc. degree course. The goal of the syllabus is to make the study of Chemistry as stimulating, interesting and relevant as possible. The syllabus is prepared by keeping in mind the aim to make students capable of studying Chemistry in academic and industrial courses. Also, to expose the students and to develop interest in them in various fields of Chemistry.

The new and updated syllabus is based on a disciplinary approach with vigour and depth taking care that the syllabus is not heavy at the same time it is comparable to the syllabi of other universities at the same level. The students pursuing this course would have to develop an understanding of various aspects of chemistry. The conceptual understanding, development of experimental skills, developing the aptitude for academic and professional skills, obtaining basic ideas and understanding of hyphenated techniques, understanding the fundamental chemical processes and rationale towards application of knowledge are among such important aspects

Programme(s): S.Y.B Sc		SEMESTER: III (Major)			
Course: Physical and Inorganic Chemistry I		Course Code: WSCHEMJ231			
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA)	Semester End Examination
2.0	NA	NA	02	Marks- 40	Marks- 60

Learning Objectives:

1. To enumerate the concept of entropy, free energy functions, its variation with temperature and pressure, partial molal properties.
2. To emanate the significance of Van't Hoff Reaction Isotherm & Isochore
3. To learn and extrapolate phase rule, phase diagrams and its application
4. To solve numericals based on cell emf using Nernst equation
5. To predict the behavior of the electrolytes by conductance phenomenon and to apply
6. To apply Kohlrausch law for determination of the solubility product of salt and ionic product of water.
7. To realize the importance of transport number of an ion by solving the problems associated with it and will also gain the knowledge of the methods of determination of transport number
8. To teach learner about the basic concept and processes of electrochemistry.
9. Understanding the formation of chemical bonds using various Chemical Bonding concepts
10. To draw the Molecular orbital of diatomic molecules.
11. To compare the Valence bond theory and Molecular orbital theory

Course Outcomes: The learner will be able to

1. Apply the laws of thermodynamics to a chemical reaction by studying the spontaneous nature of a chemical process, changes in its free energy and variation in chemical potential and partial molal quantities with respect to temperature and pressure. .
2. Apply Kohlrausch's law to demonstrate various applications based on the concept of conductance.
3. $Determine\ \Delta G, \Delta H, \Delta S, EMF\ and$ its applications to pH and various concentration cells.
4. Apply knowledge of phase rules for application to one component system and two component systems.
5. Explain directional and non-directional chemical bond formation.
6. Determine the limiting radius ratio and the coordination number of the ions.
7. Draw the structure and geometry of the molecular compounds on the basis of VBT and comment on its magnetic behaviour.
8. Draw the structure of boranes and tetraboranes and calculate the number of B-H-B, B-B, B-B-B and BH_2 bonds in them

Detailed Syllabus

Course Code: WSCHEMJ231	**Unit**	**Course Title- Physical and Inorganic Chemistry I**	**02 Credits/ 30 hours**
	I	**Physical Chemistry**	**15 h**
	1.1	Chemical Thermodynamics and Phase Equilibria **(7h)** 1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature. 1.1.2 Gibbs-Helmholtz equation, van't Hoff reaction isotherm and van't Hoff reaction Isochore. (Numericals expected). 1.1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation. 1.1.4 Concept of Fugacity and Activity 1.1.5 Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. 1.1.6 Derivation of Clausius – Clapeyron equation and its importance in phase equilibria.(numericals expected) 1.1.7 Phase diagrams of one-component systems (water and sulphur).	
	1.2	Electrochemistry Electrochemistry: I **(4h)** 1.2.1 Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. 1.2.2 Kohlrausch law of independent migration of ions and at infinite dilution. 1.2.3 Applications of conductance measurements: determination of degree of ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts, ionic product of water. (Numericals expected). 1.2.4 Transference number and its experimental determination using the moving boundary method. (Numericals expected).Factors affecting transference number. Electrochemistry-II: **(4h)** 1.2.5 Electrochemical conventions, Reversible and irreversible cells. 1.2.6 Nernst equation and its importance, Types of electrodes, Standard electrode potential,Electrochemical series (Numericals expected). 1.2.7 Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. (Numericals expected) 1.2.8 Calculation of equilibrium constant from EMF data. (Numericals expected)	

	II	**Inorganic Chemistry**	**(15 L)**
	2.1	Non-Directional Bonding **(4h)** 2.1.1 Ionic Bond: Conditions for the Formation of Ionic Bond. 2.1.2 Types of Ionic Crystals. 2.1.3 Types of voids, 2.1.3 Radius Ratio Rules: Applications for coordination no. 3 and 4 2.1.4 Lattice Energy, Born-Lande Equation, Kapustinskii Equation,Born-Haber Cycle and their applications (numericals expected).	
	2.2	Directional Bonding:Orbital Approach. **(5h)** 2.2.1 Covalent Bonding The Valence Bond Theory- Introduction and limitations. 2.2.2 Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system. 2.2.3 Corrections applied to the system of two hydrogen atoms- Formation of H2 2.2.4 Resonance and the concept of Formal Charge; Rules for Resonance or Canonical structures. 2.2.5 Bonding in Polyatomic Species: The role of Hybridization and the types of equivalent and non-equivalent hybrid orbitals (sp^3, sp^2d, sp^3d, sp^2d^3 and sp^3d^2). 2.2.6 Contribution of a given atomic orbital to the hybrid orbitals (with reference to sp3 hybridisation as in CH_4, NH_3 and H_2O and series like NH_3 , PH_3 , AsH_3, BiH_3)	
	2.3 **2.4**	Molecular Orbital Theory **(3h)** 2.3.1. Comparing Atomic Orbitals and Molecular Orbitals. 2.3.2. Linear combination of atomic orbital to give molecular orbitals LCAO-MO approach for diatomic homonuclear molecules). 2.3.4. Wave mechanical treatment for molecular orbitals (H_2^+ and H_2) 2.3.5 Molecular orbital Theory and Bond Order and magnetic properties of diatomic molecules (He_2 to Ne_2) with special reference to O_2,O_2^+, O_2^-,O_2^{2-} Chemistry of Boron compounds **(3h)** 2.4.1 Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. 2.4.2 Preparation of simple boranes like diborane and tetraborane. 2.4.3 Structure and bonding in diborane and tetraborane (2e-3c bonds) 2.4.4 Synthesis of Borax.	

References:

Unit I:

Atkins P.W. and Paula J.de, Atkin's Physical Chemistry, 10th Ed., Oxford University 12 Press, 2014.

2. Ball D.W., Physical Chemistry, Thomson Press, India, 2007.

3. Castellan G.W., Physical Chemistry, 4th Ed., Narosa, 2004.

4. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).

5. Engel T. and Reid P., Physical Chemistry, 3rd Ed., Pearson (2013)

6. Peter A. and Paula J. de, Physical Chemistry, 10th Ed., Oxford University Press (2014).

7. McQuarrie D.A. and Simon J.D., Molecular Thermodynamics, Viva Books Pvt. Ltd.,New Delhi (2004).

8. Levine I.N., Physical Chemistry, 6th Ed., Tata Mc Graw Hill (2010).

9. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan (2000).
10. ArunBahl, B. S. Bahl and G. D. Tuli, Essential of Physical Chemistry, S. Chand Publication (2015).
11. Puri, Sharma and Pathania, Element of Physical Chemistry, Vishal Publication, 46th Ed., (2013)

Unit-II

1. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS,
2. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999)
3. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
4. CNR Rao edited, University General Chemistry.
5. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
6. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
7. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).

Programme(s): S.Y.B Sc		SEMESTER: III (Major)			
Course: Organic and Analytical chemistry- I		Course Code: WSCHEMJ232			
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA)	Semester End Examination
2.0	NA	NA	02	Marks- 40	Marks- 60

Learning Objectives:

1. To familiarize learners about chemical reactivity and synthesis of carbonyl compounds.
2. To let learners understand basicity, nucleophilicity, and chemical reactivity of amines.
3. Introduce classical methods of chemical analysis.
4. To provide the learner an overview of a very important branch of chemistry i.e Analytical Chemistry.
5. The various observable properties of a given analyte and the stimulus best suited for its analysis.
6. Learners are expected to appreciate the role of an Analytical Chemist and a Chemical Analyst.

Course Outcomes:

1. Learners will be able to compare reactivities of various carbonyl compounds and also will become competent to draw their syntheses and chemical reactions.
2. Synthesise amines and classify their chemical reactivities
3. Decide how to identify a sample and prepare it for analysis
4. To make learners familiar with the question of what is analysis, why it is required and the methods, techniques, procedures and protocols.
5. Use the relationship between absorbance (and its variations) and concentration of the analyte.

Detailed Syllabus

Course Code: WSCHEM 232	**Unit**	**Course Title- Organic and Analytical chemistry- I**	**02 Credits/ 30 hours**
	I	**Chemistry of amines and carbonyl compounds**	**15 h**
		1. Carbonyl compounds: (7 h) 1.1 Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds. Structure, reactivity of aldehydes and ketones and methods of preparation; Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, action of Grignard reagent on esters, Rosenmund reduction, Gattermann – Koch formylation 1.2 Reactions of aldehydes and ketones with HCN, amine, phenyl hydrazine, LiAlH4 and NaBH4. 1.3 Mechanisms of following reactions: Benzoin condensation and Knoevenagel condensation, 1.4 Active methylene compounds: Ethyl acetoacetate and Diethyl malonate,stabilised enols (alkylation reactions) **2. Nitrogen containing compounds: (8h)** 2.1 Amines: Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines. 2.2 Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Hofmann bromamide reaction. 2.3. Reactions- Hofmann's exhaustive methylation(HEM), Hofmann-elimination reaction, reaction with nitrous acid, carbylamine reaction, N-acylation, Synthesis and reactions (bromination and sulphonation) of pyrrole. 2.4 Diazonium Salts Sandmeyer reaction, Gomberg reaction, Azo coupling with naphthols	
	Unit II	**Analytical Chemistry**	**(15 h)**
		1. Role of Analytical Chemistry 03 h 1.1 Language of analytical chemistry important terms and their significance in Analytical Chemistry.	

		1.2 Purpose of Chemical Analysis, steps involved in chemical analysis and classification of analysis based on: (i) the nature of information required (Proximate, Partial, Trace, Complete Analysis) and (ii) the size of the sample used (Macro, semi-micro and micro analysis) 1.3 Classical and Non-Classical Methods of Analysis; their types and importance. **2. Classical Methods of Analysis 06 h** 2.1 Titrimetric Methods - The Basics 2.1.1 Terms involved in Titrimetric methods of analysis. Comparing volumetry and Titrimetry Types of titrimetry 2.1.2 Neutralisation (acidimetry; alkalimetry), Redox, (iodometryiodimetry), Precipitation and Complexometric titrations and indicators used in these titrations. 2.2 Neutralisation Titrations 2.2.1 Concept of pH and its importance in Neutralisation Titrations. 2.2.2 End point and Equivalence point of Neutralisation titrations. 2.2.3 Determination of End point by using i) Indicators causing colour change ii) Change in potential (by potentiometry in brief) iii) Change in conductance (by conductometry in brief) 2.3 Gravimetric analysis 2.3.1 General Introduction to Gravimetry; types of Gravimetric Methods 2.3.2 Precipitation Gravimetry i). steps involved in precipitation gravimetry analysis ii). Condition for precipitation. **3. Instrumental Methods 06 h** 3.1 Relation between the Analyte, Stimulus and measurement of change in the observable property. 3.2 Block Diagram of an Analytical instrument. 3.2 Types of Analytical Instruments i. Based on Optical properties (Spectrometry: UV-visible, Polarimetry) Based on electrochemical properties (Potentiometry, Voltammetry, ii. Amperometry, Polarography Conductometry, Coulometry) iii. Based on Thermal properties (Thermogravimetry) 3.3 Spectrometry 3.1 Interaction of electromagnetic radiation with matter: Absorption and Emission spectroscopy. 3.2 Basic Terms: Radiant Power, Absorbance, Transmittance, Monochromatic light, Polychromatic light, Absorptivity.	

		3.3 Recapitulation of Beer- Lambert law, Combined Mathematical Expression of Beer-Lambert;s Law, Validity of Beer-Lambert's Law, Deviations from Beer- Lambert's Law (Real deviations, Instrumental deviations and Chemical deviations) (Numerical problems based on Beer-Lambert's Law)	

References:

For Unit I:
1) Organic Chemistry by Morrison, Boyd, and Bhattacharjee (seventh edition)
2) Organic Chemistry by Solomon and Fryhle
3) Heterocyclic Chemistry by J. A. Joule and K. Mills (fifth edition)

Unit II:
1.Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal, Shm K. Anand pp2.107-2.148
2.Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Edition pp143-172.
3. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle 7 th Edition pp 118.

Programme(s): S.Y.B Sc	SEMESTER:III (Major)				
Course: Chemistry Practical-III	**Course Code: WSCHEMJ233**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
NA	**4.0**	**NA**	**02**	**Marks- 40**	**Marks- 60**

Learning Objectives:

1.To train the students to get equipped with instrumental techniques.
2. To enhance scientific temper and research-based skills.
3. To get hands-on experience in synthesis of organic compounds.
4. To understand purification techniques.
5.To analyse the analyte present in the sample quantitatively.

Course Outcomes:

1. Use critical aspects and safety considerations when working with various chemicals.
2. Purify and measure its physical constants.
3. Determine the viscosity of liquid samples using a viscometer.
4. Calculate the activation energy from experimental data using the Arrhenius equation
5. Analyse the effect of different parameters on rate of chemical reactions including temperature and concentration and analyzing the kinetic data obtained.
6. Construct a calibration curve by measuring the absorbance of standard solutions with known concentrations of copper ions and plotting a graph of absorbance versus concentration.
7. Determine quantitatively the amount of ions in the samples by gravimetrically.

Course code: WSCHEMJ 233	Chemistry Practical-III	02 Credits
	Paper-1 (Physical & Inorganic) Unit I: Physical Chemistry 1. To verify Ostwald's dilution law for weak acid conductometrically. 2. To determine viscosity of liquid sample (Polyvinyl alcohol solution) by using Ostwald viscometer 3. Determination of energy of activation of acid catalyzed hydrolysis of methyl acetate. 4. To investigate the kinetics of persulphate and iodide clock reaction 5. To determine the pka1 and pKa2 value of o-Phosphoric acid pH metrically 6.To determine standard EMF and the standard free energy change of Daniel cell potentiometrically. 7. Estimation of total hardness. 8. Colorimetric Determination of Copper Ions in given Solution by using calibration curve method and calculation of % error. **Paper-2 (Inorganic & Organic)** 1. Identification of cations in a given mixture and Analytically separating them (minimum 4) [From a mixture containing not more than two of the following: Pb(II), Ba(II), Ca(II), Sr (II), Cu(II), Cd(II), Mg(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II) Al(III), Cr(III)] Organic preparation and their purification: Purify the product by recrystallization. Report theoretical yield, percentage yield and melting point of the purified product. i. Tribromoaniline from aniline ii. Glucosazone from dextrose or fructose iii. m-Dinitrobenzene from nitrobenzene iv. Phthalic anhydride from phthalic acid by sublimation (MSDS of starting materials and products are mandatory)	

Reference Books for Practicals:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).

3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)
5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
8. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
9. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
10. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
11. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

Programme(s): S.Y.B Sc		SEMESTER: III (Minor)			
Course: Physical and Inorganic Chemistry		Course Code: WSCHEMN231			
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA)	Semester End Examination
2.0	NA	NA	02	Marks- 40	Marks- 60

Learning Objectives:

1. To understand and enumerate the concept of entropy, free energy functions, its variation with temperature and pressure, partial molal properties.
2. To emanate the significance of Van't Hoff Reaction Isotherm & Isochore
3. To learn advanced concepts in thermodynamics and electrochemistry
4. To learn chemical kinetics of composite reactions qualitatively
5. To learn theories of reaction rates comprehensively
6. To learn the concepts of catalysis along with mechanisms and basic understanding of nanocatalysis
7. To explain the nature of metal-ligand bond and different geometries of the coordination compounds.

Course Outcomes:

1. Apply the rules of thermodynamics to a chemical reaction by investigating the spontaneous nature of the process, changes in free energy, and variations in chemical potential and partial molal amounts in relation to temperature and pressure.
2. Analyse the theories of reaction rate such as collision theory and activated complex theory, acid-base catalysed, and enzyme catalysed reactions.
3. Evaluate the complex reactions in chemical kinetics and the factors affecting the same.
4. Find the type of hybridization present in the central metal ion/atom in a complex and predict whether the complex will be an inner orbital complex or outer orbital complex.
5. Classify the cations and anions as per their acidity.
6. Use effectively concentrated acids like hydrochloric acid, sulphuric acid and phosphoric acid.

Course Code: WSCHEMN 231	**Unit**	**Course Title- Physical and Inorganic Chemistry**	**02 Credits/ 30 hours**
	I	**Physical Chemistry**	**15 h**
	I	Chemical Thermodynamics-II 1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature. 1.1.2 Gibbs-Helmholtz equation, van't Hoff reaction isotherm and van't Hoff reaction Isochore. (Numericals expected). 1.1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation. 1.1.4 Concept of Fugacity and Activity	**5 h**
	II	2.0 Chemical Kinetics and Catalysis 2.1.0 Types of Complex Chemical reactions: Reversible or opposing, consecutive and parallel reactions (No derivations, only examples expected),Thermal chain reactions: H. and Br. reaction. (only steps involved, no kinetic expression expected). 2.1.1. Effect of temperature on the rate of reaction, Arrhenius equation, Concept of energy of activation (Ea). (Numericals expected). 2.1.2 Theories of reaction rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only 2.1.3 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation 2.1.4 Equilibrium approximation and steady state approximation 2.1.5. Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH. 2.1.6 Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)	**10 h**
	II	**Inorganic Chemistry**	**(15 h)**
	2.1	Coordination Chemistry : **(6h)** 2.2.1 Introduction to Chemistry of Coordination Compounds i. Historical perspectives and Werner's Theory Ii. Evidence for the formation of coordination compounds. iii. Basic terms and nomenclature. iv. Types of ligands v. Structural and stereoisomerism (for CN= 04 and 06) 2.2.2. Electron rules i. Effective atomic number rule.	**06 h**

		ii. Eighteen electron Rule 2.2.3. Nature of the Metal-Ligand Bond: i. Valence Bond Theory; Hybridisation of the central metal orbitals-sp^3, dsp^2, sp^2d, d^2sp^3 and sp^3d^2. ii. Inner and outer orbital complexes of (suitable examples of Mn(II) Fe(II),Fe(III),Co(II)/Co(III),Ni(II), Cu(II) Zn(II) complexes. 2.2.4. Application of coordination compounds.	
	2.2	Acidity of Cations and Basicity of Anions i. Hydration of Cations; Hydrolysis of Cations predicting degree of hydrolysis of Cations-effect of Charge and Radius. ii. Latimer Equation. Relationship between pKa, acidity and z2/r ratios of metal ions graphical Presentation iii. Classification of cations on the basis of acidity category – Non acidic, Moderately acidic, strongly acidic, very strongly acidic with pKa values range and examples iv. Hydration of Anions; Effect of Charge and Radius; Hydration of anions-concept, diagram classification on the basis of basicity	**07 h**
	2.3	Uses and Environmental Chemistry of volatile Oxides and oxo-acids i. Physical properties of concentrated oxo-acids like sulfuric, Nitric and Phosphoric acid ii. Uses and environments aspects of these acids	**02 h**

References:

Unit I

1. James E. House,Principles of Chemical Kinetics, Second Edition.
2. P.L.Soni, O.P. Dharmarha, U.N. Dash,Textbook of Physical Chemistry
3. Puri, Sharma and Pathania Principles of Physical Chemistry.
4. Ira N. Levine, Physical Chemistry 6th Edition.
5. Peter Atkins, Physical Chemistry
6. "Chemical Kinetics and Catalysis" by Masel R I January 1 2015
7. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan (2000).

Unit-II

1. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS,
2. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999)
3. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
4. CNR Rao edited, University General Chemistry.
5. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
6. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
7. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).

S.Y.B.Sc	SEM-III (Minor)				
Course: Physical and Inorganic Chemistry Practicals	**Course Code: WSCHEMN232**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
NA	**4.0**	**NA**	**02**	**Marks- 40**	**Marks- 60**

Learning Objectives:

1.To train the students to get equipped with instrumental techniques.
2. To enhance scientific temper and research-based skills.
3. To get hands-on experience in synthesis of organic compounds.
4. To understand purification techniques.
5.To analyse the analyte present in the sample quantitatively.

Course Outcomes:

1. Use critical aspects and safety considerations when working with various chemicals.
2. Determine the viscosity of liquid samples using a viscometer.
3. Investigate the kinetics of clock reaction
4. Analyse the effect of different parameters on rate of chemical reactions including temperature and concentration and analyzing the kinetic data obtained.
5. Construct a calibration curve by measuring the absorbance of standard solutions with known concentrations of copper ions and plotting a graph of absorbance versus concentration.
6. Determine quantitatively the amount of ions in the samples by gravimetrically.
7. Identify the cations present in the mixture.

Course code: WSCHEMN 232	Physical and Inorganic Chemistry Practicals	02 Credits
Paper-I	**Physical Experiments**	
	1.To verify Ostwald's dilution law for weak acid conductometrically. 2. To determine viscosity of liquid sample (Polyvinyl alcohol solution) by using Ostwald viscometer 3. Determination of energy of activation of acid catalyzed hydrolysis of methyl acetate. 4. To investigate the kinetics of persulfate and iodide clock reaction 5. To determine the pka1 and pKa2 value of o-Phosphoric acid pH metrically 6.To determine standard EMF and the standard free energy change of Daniel cell potentiometrically. 7. To determine the amount of HCl in the given sample potentiometrically 8.Colorimetric Determination of Copper ions in given solution by using calibration curve method and calculation of % error.	
Paper-II	**Inorganic Experiments**	
	1.Estimation of total hardness. . Inorganic preparation: 2. Complex cation – Tris (ethylene diamine) nickel (II) thiosulphate. 3. Complex anion – Potassium trioxalato ferrate 4. Identification of cations in a given mixture and Analytically separating them (minimum-5) [From a mixture containing not more than **two** of the following: Pb(II), Ba(II), Ca(II), Sr (II), Cu(II), Cd(II), Mg(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II) Al(III), Cr(III)]	

Reference Books for Practicals:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)
5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)

7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
8. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
9. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
10. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
11. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

Course: (SEC) Applied Chemistry- Practical II	**Course Code: WSCHESE231**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
NA	**4.0**	**NA**	**02**	**NA**	**Marks- 60**

Learning Objectives:

1. To become adept at using Excel functions and techniques for analysis.
2. To learn how to use Pivot Tables and Pivot Charts to streamline your workflow in Excel..
3. To learn the impact of one or more factors by comparing the means of different samples using ANOVA.
4. To understand to compute air parcel trajectories to determine how far and in what direction a parcel of air, and subsequently air pollutants, will travel.
5. To determine quantitatively the amount of organic pollution present in a water sample using COD study.
6. To gain hands-on experience with a range of analytical instruments (Flame photometer, Conductometer, pH meter, etc) learning how to operate, calibrate, and troubleshoot them effectively.
7. To explore the effect of buffer components, such as weak acids, weak bases, and their conjugate pairs, on buffer capacity and pH stability, and understand how changes in concentration affect buffer performance.
8. To acquire skills in sample handling and preparation techniques necessary for gravimetric analysis, including dissolution of samples, adjustment of pH, and selective precipitation of analytes.
9. To make learners competent in using laboratory skills such as distillation, chromatographic separation, chemdraw among others.
10. To introduce learners to green synthetic protocols in modern organic synthesis.

Course Outcomes:

1. Learners will be able to effectively use Excel for data entry, formatting, and formula creation.
2. Learners will be able to analyse whether there are significant differences between the means of three or more groups using ANOVA.
3. Learners will be able to use meteorological data and mathematical equations to simulate transport in the atmosphere.
4. Students will investigate the relationship between temperature and the density of water and understand how temperature affects the packing of water molecules.
5. Students will perform COD measurements on water samples and interpret the results to determine the level of organic pollution.
6. Students will interpret pH measurement data, calculate buffer capacity values, and interpret the results in the context of buffer performance and pH regulation.
7. Students will be able to analyze experimental data obtained from gravimetric analysis, including calculation of analyte concentrations, determination of experimental error, and interpretation of results.
8. Learners will acquire hands-on training for TLC, distillation, chemdraw software, etc. along with setting up chemical reactions.

Course code: WSCHESE231	**Applied Chemistry- Practical II**	**02 Credits**
Paper-I	1. Tools of Analytical Chemistry-I: a) Analytical glasswares like burettes, pipettes, Standard flasks, Separating funnels. b) Weighing tools such as two pan balance and monopan balance, digital balances: c) Incineration devices: Burners, Electrical Incinerators, Muffle Furnace, d) Drying Devices: Hot Air Oven, Microwave Oven, Desiccators, Vacuumdesiccators e) Monochromators, Filters, Sample holders, Prisms, Diffraction Gratings,Photoemissive cells, Photomultiplier tubes (The learner should draw diagrams and write-ups providing uses, care and maintenance of the items mentioned in (a) and principle, construction and uses of items (b) to (e) in the journal. 2. Gravimetric estimation of Nickel (II) as Ni-DMG and calculation of % error.(The learner is expected to know the role of the various reagents/chemicals used in the estimation, various steps involved. They should write the complete and balance the chemical reaction for the formation of the $Ni(DMG)_2$ complex. 3. Determination of buffer capacity of acid buffer and basic buffer. (The learner is expected to learn the use pH meter, standardization of pH meter, use of Henderson's equation and calculation of buffer capacity) 4. To determine the Chemical oxygen demand of the given sample (proper aim) 5.Gravimetric estimation of barium ions using K2CrO4 as precipitant calculation of % error.	

	(The learner is expected to learn the skills of using the counterpoise technique used in this gravimetric estimation; Using counterpoise method whatman No.42 for filtration. In such a case no incineration or use of silica crucible is required.They are also expected to state the error estimate of their results) 6. To determine the amount of sodium content in table salt using flame photometer 7. To Measure the density of water at different temperatures and analyze how it changes with temperature. 8 To determine the amount of acetic acid content in the supplied vinegar sample by conductometric titrations.	
Paper-II	1. Synthesis of cyclohexanone oxime from cyclohexanone and reaction mechanism drawing using **chemdraw or available softwares**. 2. Synthesis of acetanilide from aniline and confirmation of product using **thin layer chromatography.** 3. Synthesis of oil of wintergreen: **Use of distillation assembly** 4. Green synthesis: **Ultrasonic** assisted synthesis (Acetylation of aniline). 5. Practical Data Analysis in Chemistry using a short program in an Excel or Matlab spreadsheet 6. To estimate the amount of dye present in the supplied sample using a spectrophotometer by standard addition method. (ppm level concentrations to be prepared using micropipettes) 7. Statistical interpretation of data using 1-way and 2-way ANOVA. 8. The HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory) trajectory model: Air parcel movement by wind advection using spatially and temporally gridded meteorology data.	

Reference Books for Practicals:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)
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7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
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9. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
10. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
11. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996
12. Modern Analytical Chemistry, David Harvey (page numbers 53-84)
13. Fundamentals of analytical chemistry –Skoog and West
14. An Overview of the HYSPLIT_4 Modelling System for Trajectories, Dispersion, and Deposition by Roland R. Draxler NOAA Air Resources Laboratory Silver Spring, Maryland, U.S.A. and G.D. Hess Bureau of Meteorology Research Centre Melbourne, Australia.
15. https://www.arl.noaa.gov/documents/reports/MetMag.pdf.

Programme(s): S.Y.B Sc		SEMESTER: III			
Course: (OE-I) Chemistry of Food Products		**Course Code: WACHEOE231**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
2.0	**NA**	**NA**	**02**	**Marks- 30**	**Marks- 30**

Learning Objectives:

This course provides an in-depth exploration of food labels, focusing on how to interpret and understand the information provided. Students will learn to navigate through various components of food labels, including nutrition facts, ingredient lists, and health claims. Emphasis will be placed on developing critical thinking skills to make informed food choices and promote healthy eating habits.

Course Outcomes:

1. Analyze key components of food labels such as the Nutrition Facts panel, ingredient list, and health claims.
2. Interpret percent daily values (%DV) and their application in diet planning.
3. Identify common ingredients, additives, preservatives, hidden sugars, unhealthy fats, and allergens in food products through the analysis of ingredient lists, enabling learners to make healthier food choices.
4. Evaluate health claims and recognize marketing tactics and misleading labels, promoting critical thinking skills and ethical considerations in food labeling and consumer choices.

Course Code: WACHEOE231	Unit	Course Title- Chemistry of Food Products	02 Credits/ 30 hours
	I	**Nutritional Chemistry:** **Decoding Nutrition Information (11 HOURS):** Nutrition and nutrients ,Classes of nutrients, general nutritional needs of human beings, ways of assessing the nutritional status of a human being. Malnutrition, nutrient requirements-recommendations-Dietary allowance per day (RDA), caloric data of nutrients and calculation of caloric value of food. Basal metabolic rate (BMR). Factors affecting BMR. Function, daily needs, food sources of carbohydrates, proteins and fats; problems associated with excess and deficiency of carbohydrates, proteins and fats. Minerals - functions of nutrient minerals, health issues associated with deficiency of Ca, Iodine, Fe, K and Na in human body. Vitamins- sources and deficiency effects of vitamins A, D, E, F, K, B complex and C. **FOOD ADDITIVES :(4 Hours)** Definition and classification, preservatives, antimicrobial & antioxidant preservatives, food color, pH control in food, sequestrates, flavor enhances, sweeteners, anticaking agents, stabilizers and thickeners, surface active agents (emulsifiers), Roles of polyhydric alcohols as food additives.	**15 h**
	II	**Nutritional and Ingredients labeling** **FOOD ADULTERATION (3 Hours) :** Adulterants- definition, examples of adulterants in food and beverages, harmful effects of food adulteration. Detection of adulteration in edible oil, milk, beverages, spices and pulses. **Food labels (12 hours):** Overview of food labelling regulations and standards, Importance of reading food labels for health and nutrition. Understanding serving sizes and servings per container. **Key components of food labels:** Nutrition Facts panel, ingredient list, and health claims, interpreting percent daily values (%DV) and their application in diet planning. **Analyzing ingredient lists:** common ingredients, additives, and preservatives. Identifying hidden sugars, unhealthy fats, and allergens in food products. Evaluating health claims: understanding terms such as "organic," "natural," "low-fat," and "gluten-free" Recognizing marketing tactics and misleading labels, Ethical considerations in food labeling and consumer choices, Case studies and practical exercises on analyzing Nutrition Facts labels.	**15 h**

References:

1. Understanding Nutrition" by Eleanor Noss Whitney and Sharon Rady Rolfes
2. Nutrition: Concepts and Controversies" by Frances Sizer and Ellie Whitney
3. Modern Nutrition in Health and Disease" edited by A. Catherine Ross, Benjamin Caballero, and R.obert J. Cousins
4. Food Analysis Laboratory Manual" by S. Suzanne Nielsen
5. Food Labeling Compliance Review" by James L. Summers
6. Understanding Food Labels: A Guide to Food Packaging and Labeling Regulations" by Bureau of Nutrition Science and Policy

Programme(s): S.Y.B Sc	SEMESTER: III
Course: (OE -II) Environment and Sustainable Energy	**Course Code: WACHEOE232**

Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
2.0	**NA**	**NA**	**02**	**Marks- 30**	**Marks- 30**

Learning Objectives:

1) Develop competency in understanding the interconnectedness of the Environment's divisions.
2) To motivate and inspire individuals to acquire current knowledge and skills, which will lead to issue identification.
3) To foster creativity and innovation at the human-environment interface, leading to vocation/entrepreneurial opportunities.

Course Outcome:

1) Learners will be able to classify the different types of water treatment plants.
2) Learners will be able to conduct and interpret water quality analyses in the laboratory.
3) Learners will be able to control factors affecting the environment in various daily activities.
4) Learners will able to function in a work environment that involves environmental systems.

Curse Code: WACHEOE 232	**Unit**	**Course Title-ENVIRONMENT AND SUSTAINABLE ENERGY**	**02 Credits/ 30 hours**
	I	**ENVIRONMENT AND ITS SEGMENTS:** Cycles of sulphur, nitrogen, and carbon in biogeochemistry. Major atmospheric areas affected by air pollution. Types, origins, sizes, and chemical makeup of air pollutants. Ozone's influence on the environment. principal causes of pollution in the air. Pollution from NOx, SO2, CO2, CO, H2S, and control methods. effects of air pollution on vegetation and living things. global warming and the greenhouse effect, Depletion of ozone caused by halogens, nitrogen oxides, and chlorofluorocarbons; removal of sulphur from coal. Environment and Energy Energy sources include natural gas, coal, and petrol. solar energy, geothermal, tidal, hydrogen, and nuclear fusion/fission. Nuclear pollution includes the handling of nuclear accidents and waste disposal. The use of biocatalysis An overview of biocatalysis and its significance for the chemical industry and green chemistry.	**15 h**
	1.1	**WATER POLLUTION**: Water resources, aquatic ecosystems, hydrological cycle, and pollution sources and types of contaminants in water, methods for quantifying the contamination of water, effects of water pollution on ecosystems and hydrology. Techniques for purifying water. Primary, secondary, and tertiary treatment plants for wastewater. The following industries' industrial effluents and how they are treated: fertiliser, dairy, tannery, textile, electroplating, and petroleum and petrochemicals. Sludge disposal. Waste incineration is a method of managing industrial waste. Water filtration and treatment (ion exchange, reverse osmosis). Water quality standards for home, industrial, and wastewater	**15 h**

Recommended Text Books:

1. De, A. K. Environmental Chemistry: New Age International Pvt., Ltd, New Delhi, 2010.
2. Stocchi E., Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.

3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).
4. Felder R.M. and Rousseau R.W., Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
5. Dara S. S., A Textbook of Engineering Chemistry, S. Chand & Company Ltd. New Delhi.
6. Miller G.T., Environmental Science, 11th edition. Brooks/ Cole (2006).
7. Mishra, Environmental Studies, Selective and Scientific Books, New Delhi (2005)

Programme(s):		SEMESTER: III			
Course: (VEC) **Non-Conventional Sources of Energy**		**Course Code: WSCHEVE231**			
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA-I)**	**Continuous Assessment (CA-II)**
02	**NA**	**NA**	**02**	**(Marks- 30)**	**(Marks- 30)**

Learning Objectives:

1. To aware learners about the scarcity of non renewable energy resources to cater growing energy demand.
2. To let learners understand the environmental hazards of using conventional methods for energy production.
3. To introduce the latest technological development for energy generation using renewable energy sources.

Course Outcome:

After attending the course:

1. Learners will acknowledge the drawbacks of traditional energy producing systems.
2. Learners will be able to distinguish renewable and non renewable energy sources.
3. Learners will distinguish between conventional methods and cutting edge methods of waste reduction.

WSCH EVE231	Units	Course: Non Conventional Sources of Energy	02 Credits/ 30 h
	I	1.1 Introduction 1.2 Conventional sources of energy (examples) 1.2.1 Coal: reserves, production, and consumption 1.2.2 Oil: reserves, production, and consumption 1.2.3 Natural gas: reserves, production, and consumption 1.2.4 Limitation thereof 1.3 Hydrogen production 1.3.1 Natural gas steam reforming 1.3.2 Coal gasification 1.3.3 Critical challenges and key benefits thereof 1.4 Applications of conventional energy sources (e.g. thermal power plant, types of coal and issues associated) 1.4.1 Conventional routes: Limitations 1.5 Introduction to renewable energy sources, Principles of renewable energy 1.5.1 Solar radiation: Characteristics and impact 1.5.2 Hydropower 1.5.3 Wind power 1.5.4 Tidal power 1.5.5 Geothermal energy 1.5.6 Ocean gradient energy	**15 h**
	II	2.1 Modern approaches: Renewable energy sources 2.2 Waste to Energy (WTE) approach: Waste types, sources and their management methods 2.2.1 Municipal solid waste (MSW) 2.2.2 Plastic solid waste 2.2.3 e-Waste 2.2.4 Clinical solid waste 2.2.5 Waste to energy (WTE) methods: thermal degradation, catalytic degradation, pyrolysis, energy incineration 2.3 Introduction to biomass 2.3.1 Classification of biomass:Sources and composition 2.3.2 Valorisation of biomass 2.4 Hydrogen Energy 2.4.1 Types of hydrogen fuel (Brown, Green, Blue, etc. and their production method) 2.4.2 Green routes for hydrogen production 2.4.3 Introduction to photocatalysis 2.4.4 Hydrogen production by photocatalytic water splitting. 2.5 Photovoltaic (PV) power technology.	**15 h**

References:

1. Renewable Energy Resources by John Twidell and Tony Weir
2. Renewable Energy Sources and their applications, edited by R. K. Behl, R. N. Chhibar, S. Jain, U. P. Behl, and N. El Bassam

SEMESTER-IV

PROGRAM(s): S.Y.B.Sc	SEMESTER: IV Major				
Course: Paper-I & Paper II	Course Code: WSCHEMJ241 & WSCHEMJ242				
Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Continuous Assessment (CA) (Marks- 40)	Semester End Examination (Marks- 60)
02+ 02	NA	NA	02 + 02	Marks- 40 + 40	Marks- 60 + 60

Learning Objectives:

1.To learn chemical kinetics of composite reactions qualitatively
2.To learn theories of reaction rates comprehensively
3.To study different binary liquid systems and its applications.
4. To learn the concepts of catalysis along with mechanisms and basic understanding of nanocatalysis.
5.To recapitulate basic in solid state chemistry and types of crystals
6. To learn application of X-ray spectrometer and Brragg's theory in identification of crystals
7.To understand the reactivity and nature of carboxylic acid derivatives and heterocyclic compounds.
8. To learn the various applications of carboxylic acid derivatives and heterocycles in organic chemistry.
9.To introduce the different instrumental methods of analysis used in Analytical chemistry.
10. To make the learners understand the concepts and methods of analysis used in pHmetry and conductometry.
11.To make the learners aware of applications, advantages and disadvantages of pHmetry and conductometry.

Course Outcomes:

1. Learners will be able to summarize the aspects of complex reactions in chemical kinetics and the factors affecting the same.
2. Learners will be able to illustrate the theories of reaction rate such as collision theory and activated complex theory
3. Learners will describe the basic concepts of thermodynamics of ideal solution and non-ideal solutions thoroughly along with expertise in quantitative analysis from numerical data.
4. Learners will determine the change in phase of partially miscible liquids, application of immiscible liquids in solvent extraction systems along with quantitative analysis from experimental data.
5. The learners will be able to explain the characteristic features of catalysis and types of catalysis, nanocatalysis and the factors affecting the same.
6. The learners will be able to study acid-base catalysed, and enzyme catalysed reactions.
7. Learners will be able to determine the interplanar distances in simple cubic crystals from the given numerical data.

8. Learners will be able to illustrate the application of X-rays in determining the crystal structure.
9. Learners will be able to evaluate types cubic crystals from the given numerical data using Bragg's equation.
10. Find the type of hybridization present in the central metal ion/atom in a complex and predict whether the complex will be an inner orbital complex or outer orbital complex.
11. Apply the knowledge in performing the qualitative tests for the various transition metal ions.
12. Learners will distinguish the nature and reactivity of carboxylic acid derivatives and heterocyclic compounds.
13. Learners will get expertise in synthesis and reactions of carboxylic acid derivatives and heterocycles.
14. To state, explain, draw diagrams, derive expressions and apply them in solving numericals of various methods of separation in analytical chemistry.
15. The learners will be able to explain the principle, procedure, applications and differentiate the methods of Chromatography and Electrophoresis as well as different Instrumental methods of analysis like pHmetry and Conductometry.

Course Code:- WSCHEMJ241 & WSCHEMJ242	**Unit**	**Course/ Unit Title** Physical and Inorganic Chemistry- I **WSCHEMJ241**	**02 Credits/ 30 hours**
	I	**Chemical kinetics and catalysis, Solutions and solid state**	**15 h**
	1.1	1.1 Chemical Kinetics-II (5h) 1.1.1 Types of Complex Chemical reactions: Reversible or opposing, consecutive and parallel reactions (No derivations, only examples expected),Thermal chain reactions: H. and Br. reaction. (only steps involved, no kinetic expression expected). 1.1.2 Effect of temperature on the rate of reaction, Arrhenius equation, Concept of energy of activation (Ea). (Numericals expected). 1.1.3 Theories of reaction rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only) 1.2 Catalysis: (3 h) 1.2.1 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation 1.2.2 Equilibrium approximation and steady state approximation Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH.	

		1.2.3 Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)	
	1.2	1.2 Solutions: (4 h) 1.2.1 Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law–non-ideal solutions. Vapour pressure-composition and temperature -composition curves of ideal and non-ideal solutions. Azeotropes. 1.2.2 Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids with respect to Phenol-Water, Triethanolamine – Water and Nicotine –Water systems 1.2.3 Immiscibility of liquids- Principle of steam distillation. 1.2.4 Nernst distribution law and its applications, solvent extraction.	
		1.3 Solid State: (3h) 1.1.1 Recapitulation of laws of crystallography and types of crystals 1.1.2 Characteristics of simple cubic, face centered cubic and body centered cubic systems,interplanar distance in cubic lattice (only expression for ratio of interplanar distances are expected) 1.1.3 Use of X-rays in the study of crystal structure, Bragg's equation (derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected)	
II		**Inorganic Chemistry**	**15 h**
	2.1	Comparative Chemistry of the transition metals (9 h) 2.1.1 Position in the periodic table; Natural occurrence principal ores and minerals; 2.1.2 Significance of special stability of d^0, d^5 and d^{10} leading to variable oxidation states; Unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium, and chromium.) 2.1.3 Origin of colour for transition metals and their compounds: such as reflectivity, surface coatings, particle size, packing density for metals and nature of d-orbitals, number of electrons in the d-orbitals, geometry, and ability for charge transfer. 2.1.4 Magnetic properties of transition metal compounds: Origin of magnetism-spin and orbital motion of electrons; equation for spin only and spin-orbital magnetism in terms of Bohr magnetons (derivation not expected); Reasons for quenching of orbital moments. 2.1.5 Chemistry of Titanium and vanadium: preparation, properties and uses of their oxides and chlorides.	

		2.1.6 Qualitative tests for transition metal ions: General considerations in devising tests (with reference to Chromium, Manganese, iron, Cobalt Nickel and Copper)	
	2.2	Coordination Chemistry : (6 h) 2.2.1 Introduction to Chemistry of Coordination Compounds i. Historical perspectives and Werner's Theory Ii. Evidence for the formation of coordination compounds. iii. Basic terms and nomenclature. iv. Types of ligands v. Structural and stereoisomerism (for CN= 04 and 06) 2.2.2. Electron rules i. Effective atomic number rule. ii. Eighteen electron Rule 2.2.3. Nature of the Metal-Ligand Bond: i. Valence Bond Theory; Hybridisation of the central metal orbitals- sp^3, dsp^2, sp^2d, d^2sp^3 and sp^3d^2. ii. Inner and outer orbital complexes of (suitable examples of Mn(II) Fe(II),Fe(III),Co(II)/Co(III),Ni(II), Cu(II) Zn(II) complexes. 2.2.4. Application of coordination compounds.	
Paper II		Organic and Analytical Chemistry- I **WSCHEMJ242**	
Unit I		**Organic Chemistry**	**15 h**
	3.1	Carboxylic Acids and their Derivatives : **9** h 3.1.1. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids. 3.1.2. Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles. 3.1.3. Reactions: Acidity, salt formation, decarboxylation, Reduction of carboxylic acids with LiAlH4, diborane, Hell-Volhard-Zelinsky reaction,Conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides and their relative reactivity. 3.1.4. Mechanism of nucleophilic acyl substitution and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution. 3.1.5. Mechanism of Claisen condensation and Dieckmann condensation.	

	3.2	Heterocyclic Compounds: **6** h 3.2.1 Classification, nomenclature, aromaticity in 5 numbered rings containing one heteroatom 3.2.2 Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), 3.2.3 Reactivity of furan, pyrrole and thiophene towards electrophilic substitution reactions on the basis of stability of intermediate and of pyridine on the basis of electron distribution. Reactivity of pyridine towards nucleophilic substitution on the basis of electron distribution. 3.2.4 Reactions of furan, pyrrole: halogenation, nitration, sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, Ring opening. Pyrrole: Acidity and basicity of pyrrole. Comparison of basicity of pyrrole and pyrrolidine.	
Unit II		Analytical chemistry	**15 h**
		Methods of separation and Introduction to statistical analysis of data 1. Separation Techniques in Analytical Chemistry (03 hr) 1.1. An Introduction to Analytical Separations and its importance in analysis. 1.2. Estimation of an analyte without affecting separation. 1.3. Over view of Types of separation methods 1.3.1. Based on Solubilities (Precipitation and Crystallization) 1.3.2. Based on Gravity- Centrifugation 1.3.3. Based on volatility-Distillation ; 1.3.4. Based on electrical effects - Electrophoresis 1.3.5. Based on retention capacity of a Stationary Phase - Chromatography and ion exchange Chromatography; 1.3.6. Based on distribution in two immiscible phases-Solvent Extraction; 1.4. Electrophoresis: Principles, Basic Instrumentation, Working and Application in separation of biomolecules like enzymes and DNA. (02h) 1.5. Solvent extraction (02 hr) 1.5.1. Introduction, Nernst distribution Law, Distribution Ratio, Partition Coefficient. 1.5.4. Batch and continuous extraction 1.6. Chromatography : (02h) 1.6.1. Introduction to Chromatography 1.6.2. Classification of chromatographic methods based on stationary	

		and mobile phase 1.6.3. Paper Chromatography: Principle, technique and applications of Paper Chromatography. 1.6.4. Thin layer Chromatography Principle, technique and Applications in determining the purity of a given solute; Following progress of a given reaction .	
		2. Instruments based on the electrochemical properties of the analytes 2.1. Potentiometry: (02 h) 2.1.1. Principle. 2.1.2. Role of Reference and indicator electrodes 2.1.3. Applications in Neutralisation reactions with reference to the titration of a Strong acid against a Strong Base (using quinhydrone electrode)	
		3.1.Nature of Indeterminate Errors: (02h) 3.1.1. The true and acceptable value of a result of analysis 3.1.2. Measures of central tendency: mean, median. mode, average 3.1.3. Measures of dispersion: Absolute deviation, relative deviation, relative average deviation, standard deviation,(s,sigma) variance, coefficient of variation 3.2..Criteria for rejection of doubtful result (02h) (i) 2.5 d rule (ii) 4.0 d rule (iii) Q test [Numerical problems wherever possible, expected]	

References:

Paper I

Unit I

1. Atkins P.W. and Paula J.de, Atkin's Physical Chemistry, 10th Ed., Oxford University 12 Press, 2014.
2. Ball D.W., Physical Chemistry, Thomson Press, India, 2007.
3. Castellan G.W., Physical Chemistry, 4th Ed., Narosa, 2004.
4. Mortimer R.G., Physical Chemistry, 3rd Ed., Elsevier: NOIDA, UP (2009).
5. Engel T. and Reid P., Physical Chemistry, 3rd Ed., Pearson (2013)
6. Peter A. and Paula J. de, Physical Chemistry, 10th Ed., Oxford University Press (2014).
7. McQuarrie D.A. and Simon J.D., Molecular Thermodynamics, Viva Books Pvt. Ltd.,New Delhi (2004).
8. Levine I.N., Physical Chemistry, 6th Ed., Tata Mc Graw Hill (2010).

9. K.L. Kapoor, A Textbook of Physical Chemistry, Macmillan (2000).
10. ArunBahl, B. S. Bahl and G. D. Tuli, Essential of Physical Chemistry, S. Chand Publication (2015).
11. Puri, Sharma and Pathania, Element of Physical Chemistry, Vishal Publication, 46th Ed., (2013)
12. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964

Unit II

1. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS
2. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999)
3. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
4. CNR Rao edited, University General Chemistry.
5. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
6. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
7. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).

Paper II

Unit I:

1. Organic Chemistry by Morrison, Boyd, and Bhattacharjee (seventh edition)
2. Organic Chemistry by Solomon and Fryhle
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
5. Heterocyclic Chemistry by J. A. Joule and K. Mills (fifth edition)

Unit II:

1.Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal, Shm K. Anand pp2.107-2.148
2.Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Edition pp143-172.
3. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle 7 th Edition pp 118.

PROGRAM(s): S.Y.B.Sc.	SEMESTER: IV Minor				
Course: Paper-I	Organic and Analytical Chemistry- I **Course Code: WSCHEMN241**				
Teaching Scheme					**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Internal Assessment (CIA) (Marks- 40)**	**Semester End Examination (Marks- 60)**
2.0	**NA**	**–**	**2**	**40**	**60**

Learning Objectives:

1. To learn Nomenclature, structure and physical properties, acidity of carboxylic acids and their Derivatives
2. To learn preparations and reactions of carboxylic acids and their derivatives.
3. To understand nomenclature, synthesis and reactivity and nature of different amines.
4. To introduce the concepts, terms, nature and scope of Analytical chemistry.
5. To make the learners understand the concepts of chemical analysis and sampling.
6. To make the learners aware of errors and its measurements in Chemical Analysis

Course Outcomes:

1. The learners will be able to summarize the Nomenclature, structure and physical properties, acidity of carboxylic acids
2. The learners will be able to differentiate nomenclature, preparation and reactions of carboxylic acid derivatives.
3. Learners will be able to illustrate the nomenclature, synthesis and reactions of different amines.
4. The learner will be able to explain the various terms applications of Analytical chemistry.
5. The learners will be able to differentiate between the methods of analysis and its application in chemical analysis.
6. The learners will be able to identify, apply and carry out the steps in the process of sampling.
7. The learners will be able to perform the calculations for errors determination in Chemical Analysis.

Detailed Syllabus-Paper-II

Course Code:- WSCHE MN241	**Unit I**	**Organic chemistry**	**2 Credits/ 30 Lectures**
			15 h
	1.1	Carboxylic Acids and their Derivatives : 1.1.1. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids. 1.1.2. Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles. 1.1.3. Reactions: Acidity, salt formation, decarboxylation, Reduction of carboxylic acids with LiAlH4, diborane, Hell-Volhard- Zelinsky reaction,Conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides and their relative reactivity. 1.1.4. Mechanism of nucleophilic acyl substitution and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution. 1.1.5. Mechanism of Claisen condensation and Dieckmann condensation.	**9** h
	1.2	1.2.1 Amines: Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines 1.2.2 Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Zn-acetic acid, reduction of nitriles, ammonolysis of halides, reductive amination , Hofmann bromamide reaction. 1.2.3 Reactions- Salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation(HEM),Hofmann-elimination reaction, reaction with nitrous acid, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation.	**6** h

	Unit II	Analytical chemistry	**15**h
		1.1. Role of Analytical Chemistry 1.1.1. Language of analytical chemistry: important terms and their significance in Analytical Chemistry. 1.1.2 Steps involved in analysis 1.1.3. Purpose of Chemical Analysis; Analysis Based (i) On the nature of information required:(Proximate, Partial, Trace, Complete Analysis) and (ii) On the size of the sample used (Macro, semi-micro and micro analysis ultra micro analysis) 1.1.4. Classical and Non-Classical Methods of Analysis; their types and importance. 1.2. Significance of Sampling in Analytical Chemistry 1.2.1. Terms involved in Sampling 1.2.2. Types of Sampling 1.2.3. Overview of Sampling techniques 1.2.4 Importance of sampling in forensic science 1.3. Results of Analysis. (4L) 1.3.1. Errors in Analysis and their types 1.3.2. Precision and Accuracy in Analysis 1.3.3. Corrections for Determinate Errors (Problems including Numericals expected wherever required) **2 Instrumental Methods** 2.1.Introduction:Types of Cells and their differences. Types of electrodes. Instruments based on the electrochemical properties of the analytes. 2.2. pHmetry: Principle 2.2.1. Types of pH meters. 2.2.2. Principle, Construction and Working of Combined Glass electrode 2.2.3. Applications in Titrimetry (Strong acid - Strong Base) biological and environmental analysis. 2.3. Conductometry: 2.3.1. Principle 2.3.2. Conductivity cell its construction and care 2.3.3. Applications in Neutralisation Titrimetry with respect to i. Strong Acid-Strong Base ii.Mixture of Strong and weak acid Vs Strong Base 2.3.4. Advantages & limitations of conductometric titrations.	**8**h **7**h

References:

1. Organic Chemistry by Morrison, Boyd, and Bhattacharjee (seventh edition)
2. Organic Chemistry by Solomon and Fryhle
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
5. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986)
6. Fundamentals of Analytical Chemistry, D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)
7. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998)
8. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F. A. Settle Jr 6th Ed CBS (1986)
8. Electroanalytical Chemistry, J.J . Lingane, 2nd Ed Interscience, New York (1958)

PROGRAM(s): S.Y.B.Sc.	SEMESTER: IV
Course: **Chemistry Major Practical**	Chemistry Practicals- III **Course Code: WSCHEMJ243**

Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks-40)**	**Semester End Examination**
NA	**4.0**	**NA**	**02**	**Marks- 40**	**Marks- 60**

Learning Objectives:

1. To understand the various factors affecting reaction kinetics and to calculate order of reaction.
2. To learn the use of potentiometric titration for the quantitative determination of hydrochloric acid samples.
3. To understand handling of conductometer and find out solubility and solubility product of sparingly soluble salts.
4. To understand the preparation of inorganic complexes using the microscale method.
5. To understand chemical methods in identification of unknown organic compounds.
6. To understand the principle,working and application of paper chromatography and potentiometer.
7. To introduce the technique of solvent extraction as a method of separation and quantification.
8. To understand the principle,working and application of spectrophotometer.

Course Outcomes:

1. Learners will develop a practical hand in kinetics experiment and calculate various parameters of kinetics.
2. Learners will gain expertise in potentiometric titration in quantitative determination of hydrochloric acid samples.
3. Learners will be able to calculate the solubility and solubility product of sparingly soluble salt conductometrically.
4. Learners will learn chemical methods to identify given unknown organic compounds.
5. The learner will be able to apply the technique of paper chromatography in separation and identification of analyte.
6. To apply the technique of solvent extraction in separating and quantifying the analyte
7. The learner will get expertise in handling spectrophotometer.

Major practical	**Chemistry Practicals -III** **Course Code: WSCHEMJ243**	02 Credits
Paper 1	(Physical and Inorganic)	
1	To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentrations of the reactants	
2	Compare the strengths of HCl and H_2SO_4 by studying kinetics of acid hydrolysis of methyl acetate.	
3	To determine the amount of HCl in the given sample potentiometrically.	
4	To determine solubility and solubility product of sparingly soluble salt conductometrically.	
5	Complex anion – Potassium trioxalato ferrate	
6	Complex cation – Tris (ethylene diamine) nickel (II) thiosulphate.	
7	Inorganic preparation – Nickel dimethylglyoxime using microscale method.	
8	Industrial visit report.	
Paper 2	(Organic and Analytical)	
1	Organic spotting -1 (Bifunctional Groups)	
2	Organic spotting -2 (Bifunctional Groups)	
3	Organic spotting -3 (Bifunctional Groups)	
4	Organic spotting -4 (Bifunctional Groups)	
5	Separation of a solute between two immiscible solvents to determine the distribution ratio and/or extraction efficiency.	
6	Estimation of Fe(II) in the given solution by titrating against K2Cr2O7 potentiometrically.	
7	Separation and identification of cations like Fe(III) , Ni(II) and Cu(II) in a sample by paper chromatography	
8	To estimate the amount of reducing sugar by DNSA method spectrophotometrically by calibration curve method..	

Reference Books for Practicals:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).

2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).

3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)
5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
6.Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
8. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
9. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

PROGRAM(s): S.Y.B.Sc.	SEMESTER: IV
Course: **Chemistry Minor Practical**	Organic and Analytical Chemistry Practicals **Course Code: WSCHEMN242**

Teaching Scheme				Evaluation Scheme	
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
NA	**4.0**	**NA**	**02**	**Marks- 40**	**Marks- 60**

Learning Objectives:

1. To understand the role of various tools and terms used in Analytical Chemistry
2. To learn the technique of complexometry in determining the amount of metal ion like Cu (II).
3. To give Industrial visit experience.
4. To understand the principle,working and application of spectrophotometer.
5. To get along with melting and boiling point apparatus and methods.
6. To understand chemical methods in identification of unknown compounds.

Course Outcomes:

1. Learners will be able to learn different tools and terms of Analytical Chemistry
2. The learner will be able to apply the technique of conductometry to the estimation of acid in commercial samples.
3. The learner will get expertise in handling spectrophotometer.
4. Learners will get insight of industrial visit.
5. Learners will be able to analyse the analyte by complexometrically and gravimetrically.
6. Learners will learn chemical methods to identify given unknown organic compounds and will get expertise in taking melting and boiling points.

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Minor practical	Organic and Analytical Chemistry Practicals **Course Code: WSCHEMN242**	02 Credit
Paper 1	(Analytical and Organic)	
1	Tools of Analytical Chemistry a. Filtration Flasks, Funnels, Separating Funnels, Distillation apparatus, Vacuum Distillation assembly, Centrifuge machine, Electrophoresis apparatus. b. Development chamber for chromatography c. Electrodes like Reference Electrodes and Indicator Electrodes (with respect to care and maintenance.) d. Conductivity cell (with respect to care and maintenance.) e. Combined Glass electrode (with respect to care and maintenance.) f. Types of Salt Bridges and preparation of any one or use of salt bridge, its effect on the potential of a given electrode/cell (The learner should draw diagrams and write-ups providing uses of the items mentioned in (a and b) and Principle, Construction care and Uses of items (c) to (f) in his journal.)	
2	To determine the amount of Copper (II) present in the given solution complexometrically.	
3	Conductometric titration: Estimation of given sample of commercial acid by conductometric titration with strong base and calculation of % error.	
4	To estimate the amount of reducing sugar by DNSA method spectrophotometrically.	
5	Qualitative Analysis of bi-functional organic compounds on the basis of 1. Preliminary examination 2. Solubility profile 3. Detection of elements C, H, (O), N, S, X. 4. Detection of functional groups 5. Determination of physical constants (M.P/B.P) Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysis to be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halides. Students are expected to write balanced chemical reactions wherever necessary. Organic spotting -1 Organic spotting -2 Organic spotting -3 Organic spotting -4	

Reference Books for Practicals:

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
4. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., 11. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

PROGRAM(s): S.Y.B.Sc.		SEMESTER: IV		
Course: VSC		**Applied Chemistry Practicals- I** **Course Code: WSCHEVS241**		
Teaching Scheme				**Evaluation Scheme**
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Semester End Examination (Marks- 60)**
NA	**4.0**	**NA**	**02**	**60**

Learning Objectives:

1. To learn chemical method of identification of sugars and separation method like paper chromatography.
2. To prepare inorganic complexes using the microscale method.
3. To understand handling of conductometer and find out dissociation constant of weak acid.
4. To handle and learn the application of pH meter, conductometer meter and potentiometer.
5. To learn the technique of solvent extraction and complexometric titration.
6. To learn to prepare solutions of given concentrations for standardization of unknown solutions.

Course Outcomes:

1. Learners will be able to carry out separation of cations in a sample using paper chromatography, to perform calculations for preparing solutions, Calibrate pH meter & measure pH of solutions of different concentrations.
2. Learners will be able to perform Gravimetric estimation and inorganic synthesis.
3. Learners will gain expertise in potentiometric titration in quantitative analysis.
4. Learners will gain expertise in calculation of dissociation constant of weak acid conductometrically.
5. The learner will be able to apply the knowledge of the technique in estimation of metal ions in various commercial samples.
6. The learners will be able to perform the test of osazone formation and identify the sugar present in the sample.

VSC (Practical)	**Applied Chemistry Practicals- I** **Course Code: WSCHEVS241**	02 Credit
Paper 1		
1	To estimate the amount of primary aromatic amino group by diazotization	
2	To determine acid neutralizing capacity of an antacid.	
3	To prepare paracetamol from p-aminophenol by acetylation	
4	Gravimetric estimation of Sulfate as $BaSO_4$ and calculation of % error.	
5	Estimation of Fe (II) in the given solution by titrating against $K_2Cr_2O_7$ potentiometrically and calculation of % error.	
6	Determination of saponification value of an oil or fat.	
7	Preparation of Hexammine Nickel (II) chloride	
8	Estimation of benzoic acid in the given solution by back titration.	
Paper 2		
1	Preparation and determination of pH of buffers	
2	To determine the E_{cell} of the quinhydrone electrode.	
3	Partition Co-efficientof benzoic acid between CCl_4 and water	
4	To determine the molar conductivity at infinite dilution of a weak mono-basic acid conductometrically	
5	Paper chromatography: Separation and identification of amino acids present in the palm of hand.	
6	Determination of chloride concentration in a sample of water	
7	To check the purity of the given DNA sample spectrophotometrically	
8	Identification of sugar samples by osazone formation.	

Reference Books for Practicals:

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)
5. Practical Inorganic Chemistry by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
6.Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
8. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
9. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,

PROGRAM(s): S.Y.B.Sc.	SEMESTER: IV
Course: **Chemistry open elective (Paper-I & II)**	**Chemicals and Laboratory Safety measures** **Course Code: WACHEOE241** **Waste management and Applications of Chemical Analysis** **Course Code:WACHEOE242**

Teaching Scheme					Evaluation Scheme
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA)**	**Semester End Examination**
02+02	**NA**	**NA**	**02+02**	**Marks- 30 +30**	**Marks- 30 +30**

Learning Objectives:

1. To understand chemical and laboratory safety methods.
2. To become familiar with different types of Laboratory Hazards and Instruments Handlings methods.
3. To understand safer techniques for handling chemicals in the laboratory.
4. To understand various case studies of chemical and laboratory accidents and take proper precautions while working in the laboratory.
5. Acquire knowledge for environmental management.
6. Visualize the environmental concerns in a critical, imaginative, and evidence-based ways.
7. Gain knowledge about environmental pollution and monitoring techniques.

Course Outcomes:

After the completion of this course, student will be able to-

1. State, demonstrate and apply the chemical, laboratory safety, Laboratory Hazards safety rules and Instruments Handling methods
2. Enlist the different types of Laboratory Hazards and Instruments Handlings methods.
3. Discuss the safe Handling chemicals and Minimizing hazards in the laboratory.
4. Write a report on Case studies of chemical and laboratory accidents.
5. Compare the present-day global environmental issues
6. Practice and teach the community for segregating the waste.
7. Classify the waste generated from different sources as per their nature.

OE(Theory)	Chemicals and Laboratory Safety measures .	**30 h**
Paper 1	**Course Code: WACHEOE241**	
Unit 1	1.1 Introduction to Chemical and Laboratory Safety Introduction to Good lab practice (GLP) History, Scope, fundamental Points of GLP, Four Principles of safety-RAMP, The Student Safety Ethics, Safety rules, Role as a Student, analysis of Lab incidents, Standard Operating Procedures (SOP) in the laboratory.	3 h
	1.2 Understanding Laboratory Hazards Potential pathways of exposure and blocking these pathways to prevent exposure, Hazard recognition through the basics of understanding label, signs, symbols, terms, and other sources of information, Safe handling and interpreting the material safety data sheet (MSDS), overview of GHS Safety Data Sheets and GHS labelling.	4 h
	1.3 Laboratory Hazards and Responses : Chemical Hazards: corrosive acids, bases, gases, oxidizers, flammables, fire triangle, water reactive compounds, pyrophoric chemicals and reactions, peroxides, cryogens. Radiation Hazards: ionizing, nonionizing radiations and electric and magnetic field. Biological Hazards: hazards of biological agents and some general approaches to prevent exposures. Electrical Hazards: electric shock and burns from contact with live parts, explosion caused by unsuitable electrical apparatus, measures to avoid electrical hazard. Fire-fighting in Chemical Lab: Fire Safety in Chemical Lab, Classification and Use of Fire Extinguishers, Introduction of Fire-fighting Equipment and Fire Safety Symbols) Responses: chemical spills (acids, bases and other chemicals) and fire, classes of fires and types of fire extinguishers. First aid in chemical lab, emergency safety equipment.	8 h
Unit 2	2.1 Handling Chemicals and Minimizing Hazards in Laboratory Introduction to handling hazardous chemical waste, storing flammable and corrosive liquids, maintaining a safe and secure laboratory, managing chemicals in the laboratory. Safety measures for common laboratory operations. Managing risk- decision about safety, eye and face, skin protection- clothes, gloves and tools, chemical hoods, contamination and ventilation, safety measures for common laboratory operations, radiation, laser and biological safety cabinets. Lab waste management.	8 h
	2.2 Instruments Handlings, Heating Devices and thermal safety, Ovens, Hot plates, heating mantles, Oil, salt and sand baths, High pressure vessels, vacuum pumps, rotary evaporators, refrigerators and freezers.	4 h

	2.3 Case Studies of Chemical and Laboratory Accidents Introduction to chemical and Laboratory Accidents, its causes, The Bhopal gas disaster & Case Studies of Chemical and Laboratory Accidents etc.	3 h
Paper 2	**Course Code: WACHEOE242**	
	Waste management and Applications of Chemical Analysis	
Unit 1	1.1. Introduction to Solid Waste Management: Classification of solid wastes (source and type based), solid waste management (SWM), elements of SWM, ESSWM (environmentally sound solid waste management) and EST (environmentally sound technologies), factors affecting SWM, Indian scenario, progress in MSW (municipal solid waste) management in India.Indian and global scenario of e-waste. 1.2. Waste Generation Aspects: Waste stream assessment (WSA), waste generation and composition, waste characteristics (physical and chemical), health and environmental effects (public health and environmental), comparative assessment of waste generation and composition of developing and developed nations, a case study results from an Indian city, handouts on solid waste compositions. E-waste generation. 1.3.Collection, Storage, Transport and Disposal of Wastes: Waste Collection, Storage and Transport: Collection components, storage-containers/collection vehicles, collection operation, transfer station, waste collection system design, record keeping, control, inventory and monitoring, implementing collection and transfer system, a case study. Waste Disposal: key issues in waste disposal, disposal options and selection criteria, sanitary landfill, landfill gas emission, leachate formation, environmental effects of landfill, landfill operation issues, a case study. 1.4.Hazardous Waste Management and Treatment: Identification and classification of hazardous waste, hazardous waste treatment, pollution prevention and waste minimization, hazardous wastes management in India. E-waste recycling.	3 h 5 h 4h 03 h
Unit 2	Chemical Analysis : concept, types, methods of analysis, classification of Analysis, steps involved in chemical analysis, importance of analysis Concept Of pH, effect of carbon dioxide on pH, measurement of pH and application of pHmetry in various fields. Introduction to forensic science, nature and scope, case studies in forensic science, types of forensic evidences, phases of forensic evidences in crime investigation, career opportunities in forensic science.	08h 05 h
	Glycemic index: Concept, importance, examples of food having low and high glycemic index and effects of high and low glycemic index.	02h

References

1. Laboratory safety for Chemistry students, second edition, Robert H. Hill, Jr.David C. Finster, John Wiley & Sons.
2. Handbook of Good laboratory practice (GLP),UNDP/World Bank/WHO Special Program for Research and Training in Tropical Diseases (TDR) https://fctc.who.int/publications/i/item/handbook-good-laboratory-practice-%28 glp%29
3. Solid Waste Management, Principles and Practice, Ramesha Chandrappa, Diganta Bhusan Das, Springer.
4. Production-Integrated Environmental Protection and Waste Management in the Chemical Industry, Claus Christ, WILEY-VCH.
5. Laboratory safety Handbook, FENS Laboratory safety Team, 1st edition 2016. https://fens.sabanciuniv.edu/sites/fens.sabanciuniv.edu/files/2021 08/labsafety_web.pdf
6. Fundamentals of Industrial Safety and Health Dr. K.U. Mistry, Siddharth Prakashan. 7. Hazardous waste management rules-2016, 1st edition, Ministry of environment, forest & climate change, govt. of India
7.Environmental Studies by Surana, D. M., Malviya, H. O. SBPD Publishing House.
8.Introduction to Environmental Science, New Delhi: TERI by Khoiyangbam, R. S., Navindu,G
9."Recycling: A Guide to the Waste Management Industry" by John G. Hindle.
10. "Solid Waste Technology & Management" by Thomas Christensen, Raffaello Cossu, and David C. Blink.

Theory Examination Pattern:

Modality of Assessment

A. Internal Assessment- 40%- 40 Marks per paper

Sr. No.	Evaluation Type	Marks
1	**Written Objective Examination**	**20**
2	**Assignment/ Case study/ field visit report/ presentation/ project & Attendance**	**20**
	Total	**40**

B. External Examination- 60%- 60 Marks per paper

Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be 03 questions each of 20 marks on each unit
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1	4 out of 8	20	Unit-I
Q.2	4 out of 8	20	Unit II
Q.3	5 out of 8	20	Units (I + II)
	TOTAL	**60**	

Practical Examination Pattern:

A. Internal Examination: 40%- 40 Marks

Particulars	Paper I	Paper II
Journal	05	05
Experimental tasks	10	10
Participation	05	05
Total	**20**	**20**

B. External Examination: 60%- 60 Marks

Semester End Practical Examination:

Particulars	Paper I	Paper II
Viva	05	05
Experimental tasks	25	25
Total	**30**	**30**

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified.
The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Overall Examination & Marks Distribution Pattern

Semester III & IV

Course	I			II			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practicals	20	30	50	20	30	50	100

Preliminary document stating nature of evaluation for various courses.

Type Of Course	Nature of Evaluation
Major/Minor subject Courses	Will be based on continuous internal evaluation – 40 marks(nature of evaluation to be selected from the table 1 below) and a semester end examination – 60 marks.
Open/Generic Electives	Will be based on 2 assignments(nature of assignments to be selected from the table 1 below) each of 30 marks, total 60 marks.
Skill Enhancement course	Will be based on single semester end exam of 60 marks.
Vocational Skill Course	Will be based on single semester end exam of 60 marks.
Value education Course	Will be based on 2 assignments(nature of assignments to be selected from the table 1 below) each of 30 marks, total 60 marks.
Indian Knowledge Systems course	Will be based on 2 assignments(nature of assignments to be selected from the table 1 below) each of 30 marks, total 60 marks.
Ability enhancement course	Will be based on single semester end exam of 60 marks.
NSS/NCC/ Co Curricular course/ Field Project/ Research project/ On Job Training/ Internship	Will be directly graded on a set of methods chosen from table 2 below.(Rubrics will be set up by each agency in consultation with the exam department).

Table 1

Modes of Assessment	Time to be spent by student.
Class Tests, Quizzes, Class Assignment,presentations.	Between 1 ~ 2 minutes for one mark.
Take home exam, home assignments, surveys, projects, out of campus activities.	Between 15 ~ 20 minutes for one mark.
Open book tests, Unsupervised exams, tutorials, on campus activities.	Between 5 ~ 10 minutes for one mark.
Term papers	1 hour work per mark.
Journal entries, Viva, Extension experiments, Skills tests, Projects. (For practical courses only)	Up to 30% of time allotted for practicals

Table 2

Modes of Assessment	Time to be spent by student.
Tests, Essays, articles.	1 hour per credit
Group assignments	5 hours per credit
Reports, Reflective journals, Diaries.	5 hours per credit.

Portfolios, Dessertations, Reviews	**5 hours per credit.**
Observation of students	**As per nature of the course**

Research Project Evaluation

Semester III (4 Credit)			**Semester IV (4 Credit)**		
Log book	**Report/ Dissertation**	**Viva-Voce**	**Log book**	**Report/Dissertation**	**Viva-Voce**
Marks- 30%	**Marks- 40%**	**Marks- 30%**	**Marks- 30%**	**Marks- 40%**	**Marks- 30%**