गोंय विद्यापीठ
ताळगांव पठार,
गोंय – ४०३ २०६
फोन : +९१-८६६९६०९०४८

Goa University
Taleigao Plateau, Goa-403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website : www.unigoa.ac.in

(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2024-25/831 Date: 05.03.2025

CIRCULAR

Ref: GU/Acad –PG/BoS -NEP/2024/663 dated 21.11.2024

In supersession to the above referred Circular, the approved Syllabus of the **Bachelor of Science in Chemistry** Programme with following changes is attached.

- Number of Credits for Course CHC-406 "Materials Chemistry" shall be 2T instead of 4T.

The Dean/ Vice-Deans of the School of Chemical Sciences and Principals of the Affiliated Colleges offering the **Bachelor of Science in Chemistry** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.03.05 17:09:27 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,
1. The Dean, School of Chemical Sciences, Goa University.
2. The Vice-Deans, School of Chemical Sciences, Goa University.
3. The Principals of Affiliated Colleges offering the Bachelor of Science in Chemistry Programme.

Copy to:
1. The Director, Directorate of Higher Education, Govt. of Goa
2. The Chairperson, BoS in Chemistry.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, UG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Programme Structure for Semester I to VIII Under Graduate Programme- Chemistry										
Sem	**Major -Core**	**Minor**	**MC**	**AEC**	**SEC**	**I**	**D**	**VAC**	**Total Credits**	**Exit**
I	**CHC-100 Fundamentals of Chemistry (3T+1P)**	**CHC-111 Basic Concepts in Chemistry (4)**	**CHC-131 Introduction to Chemistry (3)**		**CHC-141 Water and Soil Analysis (1T+ 2P)** **OR** **CHC-142 Skills in Qualitative Organic Analysis (1T+ 2P)** **OR** **CHC-143 Chemistry of Cosmetics and Perfumes (1T+ 2P)**					
II										**CHE-161 Systematic Chemistry Laboratory Techniques (1T+3P)**

Issued on: 05/03/2025

III	**CHC-200 Concepts in Inorganic and Physical Chemistry (3T+1P)** **CHC-201 Concepts in Organic and Analytical Chemistry (3T+1P)**	**CHC-211 Basic Industrial Chemistry (3T+1P)**	**CHC-231 Environmental Sustainability: Natural resources and community (3)**		**CHC- 241 Mathematical Aspects and Computers in Chemistry (1T+ 2P)** **OR** **CHC-242 Introductory skills in Green Chemistry (1T+ 2P)** **OR** **CHC-243 Drug Synthesis and Analysis (1T+ 2P)**					

Issued on: 05/03/2025

IV	CHC-202 Organic Chemistry-I (3T+1P) CHC-203 Inorganic Chemistry-I (3T+1P) CHC-204 Physical Chemistry-I (3T+1P) CHC-205 Pharmaceutical Chemistry-I (2)	CHC-221 (Minor Vocational-1) Basics of Chemical Laboratory Management (3T+1P)								CHE-261 Basic Techniques in Qualitative and Quantitative Analysis (1T+3P)
V	CHC-300 Organic Chemistry-II (3T+1P) CHC-301 Inorganic Chemistry-II (3T+1P)	CHC-321 (Minor Vocational-2 Chemistry of Food and Nutrients (3T+1P)				CHC-361 Summer Internship [2]				

Issued on: 05/03/2025

	CHC-302 Physical Chemistry-II (3T+1P) **CHC-303 Green Chemistry Techniques (2)**									
VI	**CHC-304 Advanced Organic Chemistry-I (3T+1P)** **CHC-305 Advanced Inorganic Chemistry-I (3T+1P)** **CHC-306 Advanced Physical Chemistry-I (3T+1P)** **CHC-307 Project (4)**	**CHC-322 (Minor Vocational-3) Instrumentation and Analysis (3T+1P)**								

Issued on: 05/03/2025

VII	**CHC-400 Advanced Organic Chemistry-II (3T+1P)** **CHC-401 Advanced Inorganic Chemistry-II (3T+1P)** **CHC-402 Advanced Physical Chemistry-II (3T+1P)** **CHC-403 Molecular symmetry and spectroscopy (4)**	**CHC-411 Advanced Analytical Techniques-I (3T+1P)** **OR** **CHC-412 Advanced Pharmaceutical Chemistry and Analysis-I (3T+1P)**								
VIII	**CHC-404 Research Methodology (4)** **OR**	**CHC-413 Advanced Analytical Techniques-II (3T+1P)**					**CHC-462 Dissertation [12]**			

	CHC-405 Advances in Organic Synthesis (3T+1P) **OR** **CHC-406 Materials Chemistry (2)** **OR** **CHC-407 Organic spectroscopy, pericyclic and photochemical reactions (3T+1P)** **OR** **CHC-408 Essentials of Stereochemistry (3T+1P)**	**OR** **CHC-414 Advanced Pharmaceutical Chemistry and Analysis-II (3T+1P)**						

	OR **CHC-409 Advanced Inorganic Chemistry-III (3T+1P)** **OR** **CHC-410 Advanced Physical Chemistry-III (3T+1P)**									

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-100**
Title of the course : **Fundamentals of Chemistry**
Number of Credits : **3T+1P**
Effective from AY : **2023-24**

Pre-requisites for the Course	Nil	
Course Objectives:	● To study the postulates of kinetic theory of gases and understand the deviations of real gases from ideal behaviour. ● To study the surface tension and viscosity of liquids. ● To introduce the concepts of atomic structure. ● To understand the basic concepts in organic chemistry. ● To understand the preparation and reactivity of alkanes, alkenes and alkynes.	
Content		**No. of Hours**
	Fundamentals of Physical Chemistry **Gaseous state** Postulates of Kinetic Theory of gases and deviation from ideal behaviour, Vander Waal's equation of state. Critical phenomenon; PV isotherms of real gases, continuity of states, the isotherms of Vander Waal's equation relation between critical constants and Vander Waal's constants. Law of corresponding states, reduced equation of state. Molecular velocities: root mean square, average and most probable velocities, Qualitative discussion of Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Numerical problems. **Liquid State** Surface Tension, Units of Surface Tension, Determination of Surface Tension by Capillary Rise Method and stalagmometer method. Viscosity, Units of Viscosity, Poiseuille equation, Measurement of Viscosity by Ostwald Method, Effect of Temperature on Viscosity of a Liquid. Numerical problems.	**10** **05**
	Fundamentals of Inorganic Chemistry **Atomic Structure:** Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to atomic structure. Introduction to Schrodinger equation (**equation not to be derived**) and wave function. Radial and angular parts of the hydrogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Quantum numbers and their significance, Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Shapes of s, p and d atomic orbitals, nodal planes.	**15**

	Rules for filling electrons in various orbitals, electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.	
	Fundamentals of Organic Chemistry **Basic Organic Chemistry** Curved arrow notation, drawing electron movement with arrows, half and double headed arrows, in organic reaction mechanisms. Physical Effects, Electronic Displacements: Inductive Effect, Mesomeric effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pKa values. Aromaticity: Benzenoids and Hückel's rule. **Aliphatic Hydrocarbons: Functional group approach for the following reactions** (Preparations & reactions) to be studied in context to their structure Alkanes: Preparation: Wurtz reaction, Kolbe's synthesis, Reactions: Free radical Substitution: Halogenation. Alkenes: Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides Reactions: Addition of HX (Markownikoff's and anti-Markownikoff's addition) Alkynes: Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of HX and bromine.	**08** **07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. A. Bahl and G. D Tuli Essentials of physical chemistry, S. Chand Publications 2020 2. Puri, Sharma, Pathania Principles of Physical Chemistry, Vishal publishing Co. 2021 3. G. W. Castellan Physical Chemistry 4th Edition Addison-Wesley Publishing Co.2004 4. C. N. R. Rao University General Chemistry, Macmillan Publishers 1973 5. J. N. Gurtu Physical Chemistry Vol. I , Pragati Prakashan,10th Edition 2016 6. Gurtu and Gurtu Advanced Physical Chemistry, Pragati Prakashan 2019 7. J. D. Lee, *Concise Inorganic Chemistry, 5th Edn.*; Wiley India, (2003). 8. B. E. Douglas and D. H. McDaniel, *Concepts & Models of Inorganic Chemistry,* Oxford, 1970. 9. M. C. Day and J. Selbin, *Theoretical Inorganic Chemistry*, ACS Publications, 1962. 10. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, 33rd Edn, Vishal Publishing Co. 2020	

	11. S. Prakash, G. D. Tuli, S. K. Basu and R D. Madan, *Advanced Inorganic Chemistry*, Vol 1, S. Chand & Company Pvt. Ltd. 2013. 12. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons. 2014 13. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013. 14. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi. 1988. 15. Finar, I. L. *Organic Chemistry* (Vol. I & II), E.L.B.S., 5th Edition. 2001. 16. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010. 17. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010. 18. Francis Carey, *Organic Chemistry*; 4th edition Edition, Tata McGraw Hill India. 2000. 19. Paula Yurkanis Bruice, *Organic Chemistry*; 3rd Edition, Pearson Education Asia. 2018. 20. Jerry March, *Advanced Organic Chemistry*; 4rd Edition, John Wiley, 2007.
Course Outcome:	At the end of the course, students will be able to 1. Identify the properties of liquid and gases. 2. Explain the applications of liquid and gases. 3. Elucidate the atomic structure based on Quantum theory. 4. Identify the use of curved arrow notations in organic reaction mechanisms. 5. Understand various methods of preparation and reactions of alkanes, alkenes and alkynes.

Title of the course: Fundamentals of Chemistry
Number of Credits: 01 (Practicals)

Course Objectives:	● To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for chemistry. ● To introduce the fundamentals and basic techniques of volumetric and gravimetric estimations.	
Content		**No of hours**
	1. Determination of surface tension of two unknown liquids or dilute solutions by stalagmometer method.	**04**
	2. Determination of viscosity of two unknown liquids or dilute solutions by using Ostwald's viscometer.	**04**
	3. Study of the variation of viscosity of an aqueous solution with concentration of solute.	**02**
	4. Pre-Lab session (Laboratory safety, concept of normality and molarity and stoichiometric calculations)	**02**
	5. Calibration of Burette and Pipettes.	**02**
	6. To prepare 100 mL of standard 0.1 M $K_2Cr_2O_7$ solution and carry out dilution to 0.05, 0.01, 0.005, and 0.001 M in 100 mL standard flasks	**02**
	7. Volumetry: To prepare 100 ml of 0.1 N KHP solution and standardize the given approximate 0.1 N NaOH solution.	**02**

	8. Gravimetric analysis: Determination of percentage composition of the given mixture ZnO + $ZnCO_3$ 9. Purification of organic compounds: i) Recrystallization of Benzoic acid by using water as solvent and determination of melting point. ii) Distillation of Acetone and determination of boiling point. iii) Sublimation of Naphthalene and Determination of Melting point. 10. Determination of solubility and chemical nature of both solids and liquids. Water insoluble (Acid//phenol/ Base/Neutral) and water soluble (Acid/Neutral) of given compound. (8 compounds to be analysed)	**02** **06** **04**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. S. W. Rajbhoj and T. K. Chondhekar, *Systematic Experimental Physical Chemistry*, Anjali Publication, Second Edition 2000. 2. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011). 3. O. P. Pandey, D. N. Bajpai, S. Giri, *Practical Chemistry*, S. Chand Publication 2013. 4. Shikha Gulati, J. L. Sharma & Shagun Manocha, Practical *Inorganic Chemistry,* CBS Publishers, 2017. 5. G. H. Jeffery J. Bassett J. Mendham R C. Denney, *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Edn., John Wiley, New York. 1989. 6. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Edn., Pearson Education Asia, 2000. 7. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012. 8. A.I. Vogel, A., R. Tatchell, B. S. Furniss, A.J. Hannaford, *Vogel's Textbook of Practical Organic Chemistry*, 5thEd., Prentice Hall; 2011. 9. D. Pasto, C. Johnson and M. Miller, *Experiments and Techniques in Organic Chemistry*, 1st Ed., Prentice Hall, 1991. 10. L.F. Fieser, K.L. Williamson, *Organic Experiments*, 7th edition D. C. Heath, 1992. 11. R.K. Bansal, *Laboratory Manual in Organic Chemistry*, New Age International, 5thEdition, 2016.	
Course outcomes	1. To acquire the knowledge and skill of basic volumetric and gravimetric estimations. 2. The students will be able to get hands on experience on the purification techniques for organic compounds. 3. The students will be able to get hands on experience on the identification of chemical nature of organic compounds	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-111**
Title of the course : **Basic Concepts in Chemistry**
Number of Credits : **4**
Effective from AY : **2023-24**

Pre-requisites for the Course	Nil	
Course Objectives:	● To define the terms and state laws involved in thermodynamics and chemical equilibrium. ● To solve numerical based on chemical energetics and chemical equilibrium. ● To understand the development of periodic table and periodic trends. ● To explain the theories of acids and bases. ● To understand IUPAC nomenclature of organic compounds. ● To understand the types of organic reactions, reactive intermediates and importance of selected organic compounds.	
Content		**No of hours**
	Thermodynamics I Thermodynamics I: Definition of thermodynamic terms, system, surroundings etc. Types of thermodynamic systems and thermodynamic processes. Intensive and extensive properties. Concept of heat and work, first law of thermodynamics, definition of internal energy and enthalpy. Heat capacity – heat capacities at constant volume and at constant pressure and their relationship, calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and reversible conditions. Numerical problems are expected	**08**
	Solutions Solutions of liquids in liquids, Raoult's law and deviation from Raoult's Law (Ways of expressing concentration: Molarity, Normality, Molality Mole fraction, parts per million) Solutions of gases in Liquids: Factors influencing the solubility of gases. Henry's law. Numerical problems	**05**
	Chemical Equilibrium Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Definition of ΔG and ΔG^{o}, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.	**07**
	Introduction to the periodic table Development of the periodic table- Dobereiner's Triads, Newland's Law of Octaves, Mendeleev's periodic table and Modern periodic table (Theories and limitations), Classification of the elements into s,p,d and f -block elements on the basis of electronic configuration, Trends in the periodic table (atomic and ionic size)	**12**
	Acid- Base Theories	**08**

	Arrhenius Concept, Bronsted Theory, The Lux – Flood Solvent Systems, Solvent System theory and Lewis Concept of Acids and Bases. (Theories and limitations)	
	Carbon, IUPAC nomenclature of organic compounds, and aromaticity. Valency of carbon-structure of methane, sp^3 hybridisation. Selected functional group of organic compounds with IUPAC nomenclature (alkanes, alkenes, alkynes, alcohols, ethers, carboxylic acids, esters, thiol, amine, amides, halides, nitriles, nitro compounds aldehydes and ketones). Concept of aromaticity, Huckel's Rule, nomenclature of benzenoids (halo, nitro, alkyl), naphthalene and anthracene compounds.	**10**
	Types of organic reactions and structure, properties and uses of selected organic compounds Types of organic reactions with two examples of each: addition, elimination, substitution, oxidation, reduction and rearrangement. Structure and stability of intermediates carbocation, carbanion, free radical. Structure, properties and uses of the following selected organic compounds. Ethanol, acetone, ethyl acetate, formaldehyde, acetylene, benzoic acid, n-butane, chloroform, diethyl ether, cresol, benzaldehyde, aniline, urea, glucose, lauric acid. Preparation of ethanol, benzoic acid, acetone, acetylene, ethyl acetate, diethyl ether.	**10**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. A. Bahl, B.S Bahl and G.D. Tuli, *Essentials of Physical Chemistry,* S. Chand Publication. 2009. 2. Puri, Sharma and Pathania, *Principles of Physical Chemistry*. 47th edition. 2020. 3. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa. 2004. 4. C. N. R. Rao., University General Chemistry, Macmillan Publishers. 1973 5. J.N.Gurtu Physical Chemistry Vol.I ,Pragati Prakashan,10th Edition. 2016 6. Gurtu and Gurtu Advanced Physical Chemistry, Pragati Prakashan. 2019. 7. Samuel Glasstone Textbook of Physical chemistry Macmillan Publications 2nd Edition. 1953. 8. R.L.Madan Chemistry for degree students S.Chand Publications 2nd revised edition. 2014. 9. J. D. Lee, *Concise Inorganic* Chemistry, 5th Edn. Wiley India. 2003. 10. P. W. Atkins, T. L. Overton, J. P. Rourke, M. T. Weller & F. A. Armstrong, *Shriver & Atkins' Inorganic Chemistry*, 5th Edn.; Oxford University Press. 2010.. 11. N. N. Greenwood & A. Earnshaw, *Chemistry of the Elements*, 2nd Edn., Pergamon Press, Exeter. 1984. 12. F. A. Cottton, G. Wilkinson and P. L. Gaus, *Basic Inorganic Chemistry.* 3rd Edn. Wiley India. 2007. 13. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry,* 33rd Edn, Vishal Publishing Co. 2020.	

	14. S. Prakash, G. D. Tuli, S. K. Basu and R D. Madan, Advanced Inorganic Chemistry, Vol 1, S. Chand &Company Pvt. Ltd. 2013. 15. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons. 2014. 16. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013. 17. Sykes, P. A *Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi. 1988. 18. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S., 5th Edition. 2001 19. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010. 20. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010. 21. Francis Carey, *Organic Chemistry*; 4th Edition, Tata McGraw Hill India. 2000 22. Paula Yurkanis Bruice, *Organic Chemistry*; 3rd Edition, Pearson Education Asia. 2018 23. Jerry March, *Advanced Organic Chemistry*; 4rd Edition, John Wiley, 2007. 24. https://www.jagranjosh.com/general-knowledge/list-of-important-organic-compounds-1456306311-1
Course Outcome:	At the end of the course, students will be able to 1. Explain the terms involved in chemical thermodynamics and equilibrium. 2. Evaluate different thermodynamic parameters. 3. Discuss the development of Modern Periodic table and periodic trends 4. Classify the acids and bases using the various theories. 5. Write the names and structures of the organic compounds using IUPAC nomenclature. 6. Understand the importance of selected organic compounds.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-131**
Title of the Course : **Introduction to Chemistry**
Number of Credits : **3**
Effective from AY : **2023-2024**

Pre-requisites for the Course:	Nil	
Couse Objectives:	● To introduce chemistry as a scientific discipline ● To describe the development of chemistry ● To describe the utility of chemistry in medical and industrial fields. ● To explain the underlying chemical aspects of chemistry in environment and pollution. ● To introduce important Indian scientists and discuss their valuable contributions.	
Content:		**No of hours**
	1. Importance of science in life Towards scientific approach, involvement of science in daily life, different branches of science: significance and applications (viz: chemistry, physics, biology, microbiology, medical science etc.)	**04**
	2. History and development of Chemistry History of Chemistry, Different branches of chemistry (Organic, Physical, Inorganic, Analytical, Pharmaceutical, Green chemistry): their evolution and progress. Wöhler's synthesis of urea, Relations of heat to chemical phenomena, Antoine Lavoisier-Mercury Calx, M. Tswett's invention of Chromatography, P. Anastas's principles of Green Chemistry, Important Discoveries in chemistry: Hydrogen, Oxygen, Concept of Atom, X-ray, Rubber, Penicillin, Nuclear reactor, Plastic.	**08**
	3. Chemistry in medical sciences Classification of Drugs, names and uses of the following drugs with one example each: Antibiotics, Analgesics, Antihistamines, Anticonvulsant, Hypnotics and Sedatives.	**04**
	4. Medicinal plants Introduction: Importance of plant kingdom in general and medicinal plants in particular. Viz. Tulsi, Aloe vera, Turmeric, Vinca rosea, Cinchona, Datura etc. Compounds obtained from them, their uses and applications.	**05**
	5. Chemistry & Industry Minerals and ores: general awareness, chemical plants: cost, environmental impact and recycling.	**04**
	6. Chemistry of Environment & Pollution Introduction to segments of Environment (Atmosphere, Hydrosphere, Lithosphere) Definition of pollutant, pollution. Air Pollution: Composition of Air, Acid rain, Greenhouse effect and Global warming, ozone layer depletion.	**08**

	Water Pollution: Water cycle, Hardness of water, Factors deteriorating the water quality, Eutrophication, Fluoride in drinking water Soil Pollution: Chemical composition of Soil, Soil pollutants, Effects of soil pollution, Control of soil pollution. **7. Indian Scientists and their contributions to nation** 1. Jagdish Chandra Bose – Physicist (1858-1937). 2. Anandibai Joshi – Physician (1865 - 1887). 3. Sir C. V. Raman – Nobel laureate & Physicist (1888-1970). 4. Janaki Ammal – Botanist (1897 - 1984). 5. Kamala Sohonie – Bio-chemist (1912 – 1998). 6. Asima Chatterjee – Chemist (1917 – 2006) 7. Anna Mani – Physicist and meteorologist (1918- 2001). 8. Rajeshwari Chatterjee – Scientist (1922-2010). 9. A.P. J. Abdul Kalam – Scientist (1931-2015) 10. Darshan Ranganathan – Chemist (1941 – 2001). 11. Prof. C.N.R Rao- Chemist (1934) 12. S. Nambi Narayanan- Aerospace Scientist (1941) 13. Raghunath Mashelkar- Chemical Engineer (1943)	**12**
Pedagogy:	Mainly lectures and tutorials with assignments	
References/Readings:	1. A History of Chemistry by Sir Edward Thorpe, The Rationalist Press Association, Ltd., 1909, Vol I. 2. Chemistry by Richard Harwood, Cambridge University press. published 1998. 3. Organic Chemistry. Morrison, Boyd, Bhattacharjee. Pearson. 2010 Fundamentals of Chemistry, Vol. 1. A History of Chemistry. Fabrizio Tuifivo and Ferruccio Trifivo from UNESCO - Encyclopedia Life Support Systems 5. Food Science, Nutrition and Safety, Sukhneet Suri and Anita Malhotra, Pearsons. 2013 6. Medicinal Chemistry by A. Kar. New Age International Pvt. Ltd Publishers, 2007 7. Jagdish Chandra Bose by Sanjay Goyal. Prabhat Prakashan. 2015. 8. First lady doctor of India. The Telegraph. Retrieved 2016-05-01. 9. Lilavati's Daughter's-The Women Scientists of India by Indian Academy of Sciences (Bangalore) 2008.* 10. Prof. C. V. Raman: A biography by Uma Parameswaran., Penguin, Ed. 2011 11. https://ethw.org/Rajeshwari_Chatterjee 12. https://www.sanskritimagazine.com/rajeswari-chatterjee-first-woman-scientist/ 13. https://www.indiatimes.com/technology/news/rajeshwari-chatterjee-karnataka-women-engineer-518515.html 14. Wings of fire: An Autobiography by A. P. J. Abdul Kalam. Universities Press. 2009 15. https://medium.com/sci-illustrate-stories/darshan-ranganathan-84c88a96d3a 16. https://feminisminindia.com/2019/03/19/darshan-ranganathan-organic-chemistry/	

	17. https://www.jncasr.ac.in/sites/default/files/2022-04/CV-PROF%20CNR%20RAO.pdf 18. https://journalsofindia.com/c-n-r-rao-and-his-contributions/ 19. https://en.wikipedia.org/wiki/Nambi_Narayanan 20. https://www.outlookindia.com/magazine/story/a-gladiator-in-the-space-ring/299101 21. https://www.beaninspirer.com/raghunath-anant-mashelkar-story-indomitable-will-great-scholar-indian-chemical-engineer/ Durdamya Aashawadi Dr Raghunath Mashelkar, Dr. Sagar Deshpande, Sahyadri Prakashan. [*A Marathi Book*] 23. S. M. Khopkar, Environmental Pollution Analysis, New Age International Limited, Publishers, New Delhi. 2020 24. A.V. Salker, Environmental Chemistry: Pollution and Remedial Perspective, Narosa Publishing House, Navi Mumbai. 2017 [**Contains Anandibai Joshi, Janaki Ammal, Kamala Sohonie, Asima Chatterjee, Anna Mani, Darshan Ranganathan*]
Course Outcomes:	Students will be able to: 1. Describe the chemistry as a scientific discipline. 2. Describe the development and branches of Chemistry 3. Appreciate the utility of chemistry in day-to-day life. 4. Explain the preliminary chemical aspects of environment and pollution. 5. Describe and appreciate the contributions of important Indian scientists.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-141**
Title of the course : **Water and Soil Analysis**
Number of Credits : **(1T+2P)**
Effective from AY : **2023-24**

Pre-requisites for the Course	Nil	
Course Objective:	● To define the various terms encountered in sampling and study the techniques involved. ● To study methods that can be employed for the determination of the various physico-chemical parameters of water and soil.	
Content		**No of hours**
	1.Sampling Techniques: Terms encountered in sampling: the population or the universe, Sample, Sampling unit, increment, the gross sample, the sub sample, Analysis sample, Bulk ratio, Size to weight ratio, Random sampling, Systematic sampling, Multistage sampling, Sequential sampling. Sampling of Liquids and Solids. Preservation, storage and preparation of sample solution. **2.Analysis of soil**: Composition of soil, Concept of pH and pH measurement, chelation, chelating agents, use of indicators. Bulk density, Specific gravity, moisture content, water holding capacity, pH, electrical conductivity, alkalinity, calcium, magnesium and organic matter. **3.Analysis of water**: Definition of pure water, sources responsible for contaminating water, water purification methods (For domestic and industrial waters). Water analysis: Dissolved oxygen, free carbon dioxide, B.O.D., C.O.D. and total carbohydrates	**05** **05** **05**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers / assignments / presentations / industry visits / mini projects / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. K. De, *Environmental Chemistry*. New age international Publishers, 4th Edition. 2007 2. B. K. Sharma, *Environmental Chemistry*. Krishna Prakashan Media (P) Ltd. 2014. 3. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012. 4. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009. 5. Dr Sunita Rattan *Experiments in Applied chemistry*, 3rd Edition, -S. K. Kataria and Sons. 2011 6. Pandey, O.P., Bajpai D. N. & Giri S. *Practical Chemistry*, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014	
Course Outcome:	At the end of the course students will be able to 1. Understand the fundamentals and techniques of water and soil sampling.	

	2. To describe the methods for the determination of various physico-chemical parameters of soil and water

Title of the course: Water and Soil Analysis

Number of Credits: 02 (Practicals)

Course Objectives:	● To help in better understanding of the techniques of sampling soil and water studied in theory, through demonstration. ● To apply the knowledge studied in theory for the determination of various physico-chemical parameters of soil and water and thereby develop related skills.	
Content		**No of hours**
	1. Techniques of soil sampling (Demonstration) 2. Determination of pH of soil sample 3. Determination of Bulk density of soil sample 4. Determination of Moisture content of soil sample 5. Determination of conductivity of soil sample 6. Determination of organic content in soil sample 7. Techniques of water sampling (Demonstration) 8. Determination of pH and conductivity of a water sample 9. Determination of dissolved oxygen (DO) in a given water sample 10. Determination of magnesium content 11. Determination of total hardness in the water sample 12. Determination of acidity of a water sample 13. Determination of alkalinity in a given water sample 14. Measurement of dissolved CO_2 15. Determination of total solids in water.	**15 x 4 = 60**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Minimum two samples each to be analysed for every experiment involving soil and water analysis (4 hours each practical session).	
References / Readings	1. K. De, *Environmental Chemistry*. New age international Publishers, 4th Edition. 2007 2. B. K. Sharma, *Environmental Chemistry*. Krishna Prakashan Media (P) Ltd. 2014. 3. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012. 4. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009. 5. Dr Sunita Rattan *Experiments in Applied chemistry* ,3rd Edition, -S. K. Kataria and Sons. 2011 6. Pandey, O.P., Bajpai D. N. & Giri S. *Practical Chemistry*, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014.	
Course outcomes	At the end of the course students will be able to: 1. Observe and understand the techniques employed for soil and water sampling. 2. Develop skill for the determination of the various physico-chemical parameters of soil and water.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-142**
Title of the course : **Skills in Qualitative Organic Analysis**
Number of Credits : **(1T+2P)**
Effective from AY : **2023-24**

Pre-requisites for the Course	Nil	
Course Objective:	● To understand the theoretical aspects of qualitative organic analysis ● To explain mechanistically the chemical tests in qualitative organic analysis.	
Content		**No of hours**
	1. Chemical nature of organic compounds Nature of organic compounds based on physical state of the following compounds: benzoic acid, m-nitroaniline, β-naphthol, acetone, aniline, naphthalene, benzophenone, m-dinitrobenzene (to be shown with structure); presence of saturated and unsaturated compounds using bromine water, potassium permanganate solution; water solubility of organic compounds (any two water soluble and water insoluble compounds); chemical nature of organic compounds (to be explained with reactions)- water insoluble acid/phenol/base/neutral, water soluble acid/phenol/neutral. **2. Analysis of hetero elements and functional groups** Detection and presence of hetero elements - N/S/X (to be explained with reactions); Detection and presence of functional groups – CH(O) acid- salicylic acid, CH(O) phenol- β-naphthol, CH(O) neutral- acetone, benzaldehyde, ethyl acetate and ethanol, CH(O)N acid p-nitrobenzoic acid, CH(O)N phenol -nitrophenol, CH(O)N base - nitroaniline, CH(O)N neutral- urea, CH(O)N, S neutral- thiourea, CH(O)Cl neutral- chlorobenzene (to be explained with reactions). **3. Purification Techniques** Recrystallisation, distillation, sublimation. Determination of physical constants of organic compounds- melting point, boiling point.	07 06 02
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / mini projects / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. 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. 2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960. 3. Pandey, O.P., Bajpai D. N. & Giri S. *Practical Chemistry*, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014. 4. N. K. Vishnoi, Advanced Practical Organic Chemistry, third edition, 2010	
Course Outcome:	At the end of the course students will be able to 1. Explain reactions involved in identifying the chemical nature of organic compounds.	

	2. Understand role of sodium fusion extract in detecting the presence of heteroelements. 3. Explain the reactions of various functional groups present in organic compounds. 4. Understand the need for purification techniques in organic analysis.

Laboratory Course
Number of Credits: 02

Course Objective:	● To get hands on experience for the systematic qualitative analysis of the organic compounds. ● To learn the purification techniques for organic compounds.	
Content		**No of hours**
	1. Purification of organic compounds: i) Solids by recrystallization process using water and ethanol as solvent and determination of melting point. ii) Simple distillation of acetone and determination of boiling point. iii) Sublimation of naphthalene/ anthracene/ camphor and determination of melting point. **2. Identification of unknown organic compounds based on water solubility, chemical type, elemental analysis, group test and physical constants** (organic spotting) i) Water soluble solids (Acid and Neutral) – *Any 3* ii) Water insoluble solids (Acid, Base, Phenol and Neutral) – *Two compounds to be analysed of each category.* iii) Liquids: Water miscible neutral, water immiscible (base/ neutral)	4 2 2 (3×4 = 12) (8×4 = 32) (2×4 = 08)
Pedagogy:	Mainly laboratory work to be demonstration to students, supervision of their labwork. Prelab and Post-lab exercises / journal assessment.	
References / Readings	1. 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. 2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960. 3. Pandey, O.P., Bajpai D. N. & Giri S. Practical Chemistry, Revised Edition, (For BSc. I, II, III Year Students of All Indian Universities) S. Chand Company Pvt Limited, 2014. 4. N. K. Vishnoi, Advanced Practical Organic Chemistry, third edition, 2010	
Course outcomes	At the end of the course students will be able to: 1. Get hands on experience for the systematic qualitative analysis of the organic compounds. 2. Acquire skills in applying purification and separation techniques for organic compounds	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-143**
Title of the course : **Chemistry of Cosmetics and Perfumes**
Number of Credits : **(1T+2P)**
Effective from AY : **2023-24**

Pre-requisites for the Course	Nil	
Course Objective:	● To explain the term Cosmeticology and define cosmetics. ● To describe preparation and uses of cosmetic products. ● To define herb and classify herbal cosmetics. ● To study the formulation and preparation of herbal skincare and haircare products. ● To understand the classification of perfumes and categorise as per the ingredients. ● To understand the importance of essential oils in cosmetic industries. ● To describe the general methods of obtaining volatile oils from plants and its composition of volatile oils.	
Content		**No of hours**
	1. Chemistry of Cosmetics Meaning of Cosmeticology. Definition of cosmetics as per EU and Indian guidelines. A general study including preparation and uses of the following: Hair dye, shampoo, face powder, shampoo, lipsticks, talcum powder, creams (cold, vanishing and shaving creams). Definition of herb, herbal medicine, herbal medicinal product, herbal drug preparation. Classification of herbal cosmetics. Herbal cosmetics for skin care (face packs, soaps). Herbal cosmetics for hair care: Henna and Hibiscus	**08**
	2. Chemistry of Perfumes Definition of Perfume. Formulation of Perfume. Sense of perfume smell-Top notes, middle notes and base notes. Classification of perfumes: Traditional and Modern. Fragrance Wheel. Comparison between deodorant and antiperspirant. Triclosan as antibacterial agent-Structure. Benefits and adverse effects of perfumes. Natural and artificial flavours with examples. Essential oils and the importance in cosmetic industries with reference to peppermint oil-Menthol, clove Oil- Eugenol, lemongrass-Geraniol, Structure, synthesis and use of 2-phenyl ethyl alcohol, Sources, Structure and uses of Jasmone, Civetone, Muscone. Methods of separation of essential oils (steam, water and vacuum distillation), solvent extraction, mechanical expression.	**07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers / assignments / presentations / industry visits / mini projects / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Harry's Cosmeticology- Wilkinson, J. B., Harry, Ralph G. **H**ill Books, Leonard, 1973 2. Cosmetics science and Technology, Edward Sagarin, Inter Science Publications, 1957.	

Issued on: 05/03/2025

	3. De Navaree, The Chemistry and Manufacture of Cosmetics- vol. 1 to 4 (Von. Nostrand) 1962. 4. Modern Cosmetics. Edgar George Thomssen, Francis Chilson (Universal Publishing). 1964 5. Formulation and Function of Cosmetics. Jellinek. S, Wiley Blackwell, 1971. 6. Cosmetic & Skin. F.V. Wells and I. Lubowe, Reinhold Publications, 1964. 7. Cosmetics- Formulation, manufacturing and Quality Control, P. P. Sharma, 5th Edition, 2014. 8. The Principles and Practice of Modern Cosmetics: Cosmetic materials, their origin, characteristics, uses and dermatological action, Ralph Gordon Harry, Chemical Publishing Company, 1963. 9. Drug and Cosmetics Act 1940 10. Vimaladevi M. Textbook of herbal cosmetics, CBS Publishing 1st Ed. 2015. 11. H. Panda, The complete technology book on herbal beauty products with formulation and processes, Asia pacific business press Inc. 2005. 12. John Gordon, Essential oils: A practical guide, Aetheric publishing. 2017 13. Ernst T. Theimer, Fragrance Chemistry: The Science of the Sense of Smell, Academic Press, 1982. 14. Berger, Ralf Günter, Flavors and Fragrances**:** chemistry, bioprocessing and sustainability (ed.), 1st edition. 2007. 15. K. Husnu Can Baser, Gerhard Buchbauer, Handbook of Essential Oils: Science, Technology, and Applications, Second Edition, CRC Press, 2015. 16. Olindo Secondini, Handbook of Perfumes and Flavors, 1990.
Course Outcome:	At the end of the course students will be able to 1. Define cosmetics as per EU and Indian guidelines. 2. Describe the preparation and uses of various cosmetic products mentioned. 3. Describe the formulation and packaging of cosmetics for hair - Shampoo and hair dye. 4. Classify herbal cosmetics. 5. Explain the terms herbal medicine and herbal medicinal products. 6. Describe the preparation of herbal drug. 7. Describe the formulation and preparation of Herbal cosmetics for skin care and hair care. 8. Classify the perfumes and categorize the perfume ingredients. 9. Explain the importance of essential oil in cosmetic industries. 10. Describe the composition of different volatile oils and methods of obtaining them.

Laboratory Course
Number of Credits: 02

Course Objective:	● To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for Cosmeticology and perfume chemistry. ● To understand the concept of cosmetics and develop formulation skills in the preparation of various cosmetic products.	
Content		**No of hours**
	1. Preparation of cosmetic products. (Any 8)	(8 x 3) = 24

	Explain in brief about cosmetic ingredients Talcum powder, face powder, Shampoo, hair dye, Cold cream, Vanishing cream, Nail polish, nail polish remover, Shaving cream, Toothpaste, Lipsticks, eyeliner. 2. Preparation of Herbal cosmetics and its evaluation. (Any 4) Turmeric face pack, Papaya face pack, Henna hair dye, Herbal lotion, Herbal soap, Herbal shampoo 3. Extraction of essential oils as perfumery and identification of compound. (Any 5) a) Steam distillation of cinnamon sticks to cinnamon oil and identification of Cinnamaldehyde. b) Steam distillation of cloves to clove oil and identification of Eugenol. c) Water distillation of lemon peel/Orange peel to give D-Limonene. d) Extraction of banana oil from bananas (Esters as perfumery). e) Extraction of rose oil f) Extraction of citronella oil from lemongrass plant. g) Extraction of caffeine from tea. h) Extraction of jasmine oil from Jasmine flowers and identification of jasmone.	(4 x 4)= 16 (5 x 4) = 20
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.	
References / Readings	1. A.I. Vogel, A., R. Tatchell, B. S. Furniss, A.J. Hannaford, Vogel's *Textbook of Practical Organic Chemistry*, 5thEd., Prentice Hall; 2011. 2. Belinda Carli*, Cosmetic Formulations: A beginners Guide*, 7th Edn, 2020. 3. Andre O. Barel Marc Paye Howard I. Maibach, *Handbook of Cosmetic Science and Technology*-Third and fourth Edition, 2009. 4. ProFound Klaus Duerbeck, *Natural Ingredients for Cosmetics*, 2005.	
Course outcomes	At the end of the course students will be able to: 1. Understand the concepts of various cosmetic products. 2. Prepare various cosmetic products. 3. Prepare various herbal cosmetic products. 4. Extract naturally flavoured compounds/essential oils.	

Name of the Programme : B.Sc. Semester II, Chemistry
Course Code : CHE- 161 (Exit Course)
Title of the course : Systematic Chemistry Laboratory Techniques
Number of Credits : 1T+3P

Prerequisites for the course	NIL	
Course Objectives:	1. To understand the various steps involved in designing of laboratory and the safety precautions. 2. To acquire knowledge of various laboratory apparatus and equipment.	
Content		**No. of hours**
	1. Introduction to Chemistry Laboratory General introduction of chemistry laboratory, common instructions for safe working in chemical laboratories, laboratory design, storage, ventilation, lighting, fume cupboard, arrangement of store, safety provisions. organization of practical work, maintenance of laboratory equipment/ apparatus, cleaning of laboratories and preparation room.	**05**
	2. Introduction to Laboratory Apparatus Glass apparatus - Separating funnel, Liebig Condensor, measuring cylinder, Kipp's apparatus, Column, Petridish and desiccator. Handling and storage of glass apparatus. Volumetric Apparatus and measurements - Burette, pipette, volumetric flask, analytical balance, single-pan electronic balance/ electrical analytical balance etc. Miscellaneous apparatus- Buchner funnel, burette stand, retort clamp, china dish/evaporating dish, wire gauze, cork borers, vaccum pump, crucible, Mohr clip, pipe clay triangle, mortar and pestle, spatula, thermometer, pH meter/pH paper, centrifuge machine. Apparatus for heating: Bunsen burner, water bath, oil bath, hot plate, sand bath, hot air oven, heating mantle.	**05**
	3. Preparation of solutions Water as a solvent, types of water, solutions, components of a solution, types of solutions, solubility, concentration of solutions: percentage, molarity, normality, molality, mole fraction, ppm, ppb and stoichiometric calculations.	**05**
	Total	**15 hrs**
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature	
References / Readings	1. Svehla,G.,Vogel's textbook of Macro and semimicro qualitative Inorganic Analysis, 7th edition Longman Group Limited, London. 2012. 2. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C., Vogel's textbook of chemical quantitative analysis, 5th edition Longman Scientific & Technical,U K. 1989. 3. Ahluwalia,V. K.,Aggarwal, R., Comprehensive Practical Organic Chemistry, Universities Press India limited, India. 2000.	

	4. Bansal,R. K., Laboratory Manual of Organic Chemistry, 5th revised edition New Age International Publishers,India. 2008. 5. Khosla, B. D., Garg, V.C., Gulati, A., Senior Practical Physical Chemistry, 18th edition , R. Chand & Co, India. 2018. 6. Pandey,O. P., Bajpai, D.N., Giri, S., Practical Chemistry, revised edition S. Chand Publishing, India. 2013. 7. Singh, J., Singh, R.K p., Singh, J., Yadav, LD.S., Siddhiqui, I.R., Srivastava, J., Advanced practical chemistry, 9th edition, Pragati Prakashan, India. 2019.

Number of Credits: 03 (Practicals)

Course Objectives:	1. To acquire knowledge in handling various laboratory glasswares. 2. To develop skills in common laboratory techniques. 3. To acquire skills in preparation of solutions and various laboratory reagents used for qualitative and quantitative chemical analysis. 4. To produce well trained Staff /Technicians /Assistants to work in chemistry laboratories, especially at the Schools, Colleges, industries more efficiently and productively.	
Content		**No. of hours**
	1. Calibration: burette, standard flask, bulb and graduated pipette.	**04**
	2. Cleaning of soiled glasswares	**02**
	3. Preparation of laboratory reagents: 2N NH_4OH, 2N H_2SO_4, 2N NaOH, 2NHCl, 2N $NaNO_2$, 2N HNO_3, Aqueous $FeCl_3$, Alcoholic $FeCl_3$, sat. $NaHCO_3$, iodine solution, bromine water, 1:1 NH_4OH, 2,4-DNP reagent, Fehlings solution A and B, Chlorine water, 0.3 M NH_4OAc, Nesslers reagent, and neutral ferric chloride.	**12**
	4. Preparation of solutions: 0.1N$K_2Cr_2O_7$, 0.1N $KMnO_4$, 0.1NKHP and 0.1NNa_2CO_3, 2N Stannous Chloride	**04**
	5. Preparation of indicators: phenolphthalein, starch, xylenol orange, methyl orange, Eriochrome Black T and Murexide.	**04**
	6. Preparation of acidic and basic buffer solution and determination of its pH value.	**04**
	7. Calibration of instruments and preparation of general SOP guidelines for maintenance of balance, pH meter, conductometer, potentiometer and electrodes.	**12**
	8. Preparation of hydrogen sulphide (H_2S) gas using Kipp's apparatus, separating the precipitate using centrifuge, Incineration of $ZnCO_3$ to ZnO using incinerator.	**06**
	9. Washing methods for apparatus and drying in oven.	**02**
	10. Preparation of distilled, deionized and double distilled water.	**06**
	11. Calibration and maintenance of UV-spectrophotometer.	**04**
	12. Filtration: By gravity and vacuum.	**02**
	13. Determination of melting point of organic compounds using thiels tube (Any three)	**02**
	14. Determination of boiling point of organic compounds using thiels tube (Any three)	**02**
	15. Demonstration on using of PPE in chemistry laboratory.	**04**
	16. Creation of MSDS for Inorganic and organic chemicals	**06**
	17. Labelling of chemicals based on OSHA guidelines.	**06**

	18. Checking the solubility of organic compounds in water and organic solvents. (8 solid and 4 liquid compounds)	**04**
	19. Separation of aqueous and organic solvent using separating funnel. (mixture of water and dichloromethane) and (mixture of water and diethyl ether). Measurement of volume of each liquid using measuring cylinder.	**04**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Svehla,G.,Vogel's textbook of Macro and semimicro qualitative Inorganic Analysis, 7th edition Longman Group Limited, London. 2012. 2. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C., Vogel's textbook of chemical quantitative analysis, 5th edition Longman Scientific & Technical, U K. 1989. 3. Ahluwalia,V. K., Aggarwal, R., Comprehensive Practical Organic Chemistry, Universities Press India limited, India. 2000. 4. Bansal,R. K., Laboratory Manual of Organic Chemistry, 5th revised edition New Age International Publishers, India. 2008. 5. Khosla, B. D., Garg, V.C., Gulati, A., Senior Practical Physical Chemistry,18th edition , R. Chand & Co, India. 2018. 6. Pandey,O. P., Bajpai, D.N., Giri, S., Chemistry Practical,revised edition S. Chand Publishing, India. 2013. 7. Singh, J., Singh, R.K p., Singh, J., Yadav, LD.S., Siddhiqui, I.R., Srivastava, J.,Advanced practical chemistry, latest edition Pragati Prakashan, India. 2016.	
Course Outcomes	Students will be able to: 1. Handle commonly used chemicals, apparatus, minor equipment etc. 2. Explain theoretical aspects and working principles of chemistry lassware. 3. Handle fire extinguishers and other safety appliances. 4. Clean and maintain glassware, equipment, apparatus and laboratory premises. 5. Prepare standard solutions, buffer solutions, indicators, and common laboratory reagents. 6. Handle and maintain minor electronic equipment and electrodes	

Semester III
Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC-200
Title of the course : Concepts in Inorganic and Physical Chemistry
Number of Credits : 3T+1P
Effective from AY : 2024-25

Pre-requisites for the Course	Students should have basic knowledge of periodic table, atomic structure, solids and solvent properties	
Course Objectives:	1. To understand the origin of the periodic table and to study various periodic properties and their trends. 2. To learn the postulates of Valence Bond Theory, Molecular Orbital Theory and Valence Shell Electron Pair Repulsion Theory and to study the general characteristics of covalent and ionic compounds through theories of bonding. 3. To study the structures of cubic crystals and the laws governing them. 4. To introduce colligative properties and to study the distribution law.	
Content		**No of hours**
	1. **Periodicity of Elements** The Origin of the periodic table, Mendeleev's Periodic table, Modern/Long form of Periodic table and Periodic classification of elements into s, p, d, and f-block. Periodicity, and magic numbers. Valence Electronic configurations. Periodic properties of the elements and their trends: Atomic radii, van der Waal's radii, Ionic radii and Covalent radii, shielding or screening effect, Effective nuclear charge, Slater rules. Ionization Energy, Successive ionization energies and factors affecting ionization energy. Electron Affinity. Electronegativity: Pauling's and Allred-Rochow's scale. Calculation of electronegativity (Pauling's Method), Factors affecting electronegativity, applications of electronegativity (numericals are expected).	**08**
	2. **Chemical Bonding and Molecular Structure** Concept of electron density, Types of chemical bonds: a) Covalent bonding, Lewis theory, octet rule, the concept of Formal Charge. Valence bond theory: Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system. Corrections applied to the system of two hydrogen atoms. Resonance, Rules for Resonance or Canonical Structures. Bonding in Polyatomic Species: Promotion, Hybridization, (with reference to sp^3 hybridisation in CH_4, NH_3 and H_2O) Equivalent and Non-Equivalent hybrid orbitals. Contribution of a given atomic orbital to the hybrid orbitals and series like NH_3, PH_3, AsH_3, BiH_3) Types of hybrid orbitals-sp, sp^2, sp^3, sp^3d, sp^3d^2 and sp^3d^3. b) Co-ordinate covalent bond: VSEPR Theory: Assumptions, Application of the theory to explain the geometry of molecules like H_2O, NH_3, $TiCl_4$, ClF_3, OF_2, NH_4^+ and ICl_2^-.	**15**

	Molecular Orbital Theory (MO) approach: Comparing Atomic Orbitals and Molecular Orbitals. Linear combination of atomic orbitals to give molecular orbitals, Bonding and Antibonding MOs. LCAO-MO diagrams for diatomic homonuclear molecules (O_2, N_2). Heteronuclear diatomic molecules: With reference to mixing of orbitals CO, NO and NO^+ and bond orders. Prediction of stability/reactivity and magnetic nature with special reference to O_2, O_2^+, O_2^-, O_2^{2-}. Comparison of VB and MO approaches. c) Ionic bonding**:** Energy considerations in ionic bonding; Types of Ionic Crystals, Radius Ratio Rules. Lattice energy, solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy; Born-Haber cycle and its applications; Polarizing power and polarizability, Fajan's rules; ionic character in covalent compounds; bond moment; dipole moment and percentage ionic character.	
	3. **Solids** Forms of solids, symmetry elements, unit cells, crystal systems, Bravais lattice. Laws of crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices, X–Ray diffraction by crystals, Bragg's law. Determination of lattice parameters using powder method. Structures of NaCl, KCl and CsCl (qualitative treatment only). (Numerical are expected)	**07**
	4. **Phase equilibria & Colligative properties** Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Phase diagrams of one-component systems (water, sulphur and CO_2), two component systems involving eutectics, congruent and incongruent melting points (Zn-Mg, Ag-Pb, NaCl- H_2O). Introduction to Raoults law. Colligative properties- Lowering of vapour pressure, depression in freezing point, elevation in boiling point. Osmosis and osmotic pressure. Experimental methods and determination of molecular weight. (Numerical are expected).	**10**
	5. **Distribution Law:** Nernst Distribution Law – Statement. Distribution constant, factors affecting distribution constant, validity of distribution law, modification of distribution law when molecules undergo a) association b) dissociation. Application of distribution law - solvent extraction, determination of association, dissociation in one solvent or both the solvent. (Numericals are expected)	**05**
Pedagogy	• Lectures and Tutorials, Seminars/ Term papers/ Assignments/ Applicative Quiz sessions/ Presentations / self-study or a combination of some of these can be used. • ICT mode will be preferred. • Sessions should be interactive in nature to enable peer group discussions and learning.	

References / Readings	1. Satya Prakash, G.D. Tuli, S.K. Basu, R.D. Madan, Advanced Inorganic Chemistry, Vol. I, 19th edn., S. Chand Publishers (2016) 2. P. L. Soni and Mohan Katyal, Textbook of Inorganic Chemistry by, Sultan Chand and Sons, 20th Edition (1997) 3. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing Co. (2018). 4. Krishna Mohan Srivastava, Essentials of Inorganic Chemistry, Bio-Green Books (2023). 5. L. Pauling, The Nature of The Chemical Bond, 3rd Ed.; Cornell University, Press, 1960. 6. J. D. Lee, Concise Inorganic Chemistry by, Chaman and Hall, 5th ed. (1996). 7. C. N. R. Rao edited, University General Chemistry-An Introduction to Chemical Science, 1st Edn 1973 (Reprint 2009). 8. A. Bahl and G.D. Tuli, Essentials of Physical Chemistry by S. Chand Publication (2019, New Delhi, 26th Edn. 9. Puri, Sharma and Pathania , Principles of Physical Chemistry. Vishal publishing house, (2018), New Delhi 1st Edn. 10. J.N. Gurtu, Physical Chemistry, Pragati Prakashan, (2020) Meerut, 9th Edn. 11. Gurdeep Raj , Advanced Physical Chemistry, Goel publication, (2010), 36th Edn. Meerut. 12. R. L Madan, Chemistry for degree students, S, Chand and Co. Ltd. (2017) New Delhi, 1st Edn.

Number of Credits: 01 (Practicals)		
Course Objectives:	1. To prepare standard solutions and determine strength of solutions. 2. To synthesize metal oxalates and estimate the metal ions by volumetric and gravimetric methods. 3. To introduce colligative properties and their applications. 4. To study the Nernst distribution law and its applications.	
Content		**30 hrs**
	Inorganic Chemistry experiments	**(14 hrs)**
	1. Preparation of 0.1N HCl and standardization with anhydrous Na_2CO_3/Borax.	**02**
	2. Estimation of the amount of calcium in the given calcium chloride solution (EDTA method).	**02**
	3. Determination of the strength of sodium thiosulphate using standard iodine solution.	**02**
	4. Determination of the percentage composition of the mixture of NH_4Cl and $BaSO_4$.	**02**
	5. Estimation of Fe as Fe_2O_3 from the given solution of ferrous ammonium sulphate.	**02**
	6. Preparation of Fe(III) Oxalate.	**02**
	7. Preparation of Zn(II) Oxalate.	**02**
	Physical Chemistry experiments	**(16 hrs)**
	1. Indexing and determination of lattice parameters of Simple cubic, FCC and BCC crystal systems.	**06**
	2. To determine the partition coefficient of iodine between 1,2-dichloroethane and water	**02**

	3. To determine the molecular condition of benzoic acid by distribution method	**02**
	4. To draw the phase diagram of binary system; Diphenylamine and α-Naphthol	**02**
	5. Determination of molal boiling point elevation constant of NaCl in water system	**02**
	6. Determination of molal freezing point depression constant of NaCl and water system	**02**
Pedagogy:	• Students shall be given pre-lab and post-lab assignments • Theoretical concept underlying the experiments prior to each experiment. • Each student shall perform the experiments independently.	
References / Readings	1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson Education. 2. G. Marr and B. W. Rockett, Practical inorganic Chemistry, Van Nostrand Reinhold Company, London. (1972) 3. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, Second Edition 2000. 4. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 2018. 5. B. Sc. Chemistry Experiments, Talent Development Centre, IISc. 2021, Bengaluru. 6. C. Suryanarayana**,** M. Grant Norton, X-Ray Diffraction: A Practical Approach, Plenum Press (1998) New York, 1st Edn.	
Course Outcome:	At the end of the course, students will be able to: 1. explain the trend of periodic properties of elements, geometry of molecules, and stability of ionic solids. 2. construct and interpret the molecular orbital diagram of homonuclear and heteronuclear molecules. 3. predict the colligative properties of different systems. 4. calculate the distribution coefficient of binary systems. 5. prepare normal and molar solutions of a substance. 6. calculate the amount of substance in given solutions. 7. carry out volumetric and gravimetric experiments for the estimation of unknown substances. 8. deduce the lattice parameters of crystalline solids.	

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC-201**
Title of the course : **Concepts in Organic and Analytical Chemistry**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have basic knowledge of functional group chemistry and methods of analysis.	
Course Objectives:	1. To understand the preparation of aromatic compounds, organic halides, alcohols, phenols and carbonyl compounds. 2. To study the reactions of aromatic compounds, organic halides, alcohols, phenols and carbonyl compounds. 3. To understand scope and importance of analytical chemistry and to interpret steps involved in chemical analysis. 4. To study concepts of data analysis for determining central tendency and dispersion. 5. To study classical methods of analysis inclusive of principles and instrumentation of UV – Visible spectrophotometry and solvent extraction.	
Content		**No. of hours**
	1. Aromatic hydrocarbons Preparation (case benzene): from phenol, from acetylene. Reactions: (case benzene): electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation): Preparation of toluene, ethylbenzene, isopropylbenzene, acetophenone, propiophenone, butyrophenone, *n*-propylbenzene, *n*-butylbenzene, *t*-butylbenzene, isobutylbenzene. Side chain oxidation of following alkyl benzenes to benzoic acid: Toluene, ethylbenzene, isopropylbenzene. *o*-xylene to phthalic acid, *p*-xylene to terephthalic acid.	**07**
	2. Alkyl and Aryl Halides Alkyl Halides: IUPAC Nomenclature (examples upto 5 Carbons), Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation. Types of Nucleophilic Substitution (S_N1 & S_N2) reactions (mechanism without stereochemistry). Aryl Halides: Preparation: (chloro, bromo and iodobenzene): Sandmeyer reaction. Reactions (Chlorobenzene): Aromatic nucleophilic substitution S_NAr-mechanism (replacement by –OH group to give phenol and effect of nitro substituent). Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).	**07**
	3. Alcohols, Phenols, Ethers and Carbonyl Compounds Alcohols: IUPAC Nomenclature (examples upto 5 Carbons), Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$).	**08**

Issued on: 05/03/2025

	Phenols: Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: nitration, halogenation and sulphonation. Ethers (aliphatic and aromatic): Williamson's synthesis of ethers. Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (acetaldehyde, acetone, benzaldehyde and acetophenone) Preparation: from alcohols and acid chlorides. Reactions–with HCN, ROH, NH_3, 2,4-DNP, NH_2OH, Iodoform test. Aldol condensation-only reaction for preparation of chalcone.	
	4. Introduction to analytical techniques Chemical analysis and analytical chemistry, Scope and importance of analytical chemistry, Classification of instrumental methods, analytical process (steps involved in chemical analysis): defining the problem, sampling, separation of desired components, actual analysis, presentation and interpretation of results.	**03**
	5. Evaluation of analytical data Errors: Classification of errors - determinate and indeterminate error, constant and proportionate errors, absolute and relative error, correction and minimization of errors. Accuracy and precision, determination of accuracy in terms of relative error. Measures of central tendency and dispersion – Mean, Median, Mode, Range, Relative Deviation, Average Deviation, Relative Average Deviation (RAD), Standard deviation, Variance and Coefficient of variance. Significant figures and rounding off, Significance of zero in computation, Rules of computation. (*Numericals to be solved*)	**06**
	6. Classical methods of analysis Principles of gravimetric analysis: precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration and washing of precipitate, drying and ignition. Principles of titrimetric analysis: Theories of acid-base, redox (including iodometric/iodimetric), complexometric, and precipitation titrations - choice of indicators for Acid base titrations.	**05**
	7. Solvent Extraction Basic Principle, percentage extraction (derivation not required), role of complexing agents in solvent extraction, separation factor, types of extraction (batch, continuous, counter current), (Numerical problems are to be solved)	**04**
	8. UV-Visible Spectroscopy Interaction of electromagnetic radiation with matter, Beer's and Lambert's law, derivation of Beer-Lambert's law, deviations from Beer's law, Quantitative calculations. Principles of instrumentation: Sources, monochromators, cells. Types of instruments: Photoelectric colorimeters and Spectrophotometers: Single & Double beam; comparison	**05**

	between colorimeter and spectrophotometer; applications: qualitative & quantitative analysis. (*Numericals to be solved*)	
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Graham Solomons, T.W., Fryhle, C.B. and Snyder, S. A., *Organic chemistry*, 12th ed., John Wiley & Sons, UK, 2016. 2. McMurry, J., *Fundamentals of organic chemistry*, 7th ed., Cengage Learning India Edition, Noida, India, 2013. 3. Sykes, P., *A guide book to mechanism in organic chemistry*, 6th ed., Longman Scientific & Technical, England, UK,1985. 4. Finar, I. L., *Organic Chemistry* (Vol. I), 6th ed., Pearson Education, India, 1973. 5. Finar, I. L., *Organic Chemistry* (Vol. II), 3rd ed., Longmans, London, UK, 1964. 6. Morrison, R.T., Boyd, R.N. and Bhattacharjee, S. K., *Organic Chemistry*, 7th ed., Pearson, Bangalore, India, 2010. 7. Bahl, A. and Bahl, B. S., *Advanced Organic Chemistry*, S. Chand, New Delhi, India, 2012. 8. Carey, F., *Organic Chemistry*, 4th ed., McGraw Hill, New York USA, 2000. 9. Bruice, P. Y., *Organic Chemistry*, 3rd ed., Pearson Education, Asia, 2014. 10. March, J., *Advanced Organic Chemistry*, 4th ed., John Wiley, New Jersey, USA, 2007. 11. B. K. Sharma. *Instrumental Methods of Chemical Analysis,5th ed.* Goel Publishing House, Meerut. 2004. 12. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, *Basic principles in Analytical Chemistry*, 5th edition, Shet Publications Pvt. Ltd. 13. G. Chatwal and S. Anand, *Instrumental Methods of Chemical Analysis*, 5th edition Himalaya publication. 2003. 14. H.Willard,L. Meritt and J.A. Dean. *Instrumental Methods of Analysis*, 7th edition, HCBS publication. 2004. 15. D.A. Skoog and J.J. Leary, *Principles of Instrumental analysis*, 4th Edition, Saunders College Publication.1992. 16. G. D. Christian, *Analytical Chemistry*, 6th edition, Wiley publication, NewYork 2004	

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic preparation experiments. 3. To acquire hands on training in organic qualitative analysis. 4. To evaluate data for central tendency and dispersion. 5. To apply extraction methods to separate given mixtures	
Content		**No. of hours**
	I. Organic preparations List of organic preparations to be performed. Purification by recrystallization, calculation of % yield and determination of melting point. (**Any 2)**	**06**

	a) Bromination of acetanilide to *p*-bromoacetanilide. b) Oxidation of Toluene to benzoic acid using $KMnO_4$. c) 2,4-dinitrophenylhydrazone of benzaldehyde/acetophenone. d) Oxime of Cyclohexanone.	
	II. Organic qualitative analysis Preliminary tests, chemical nature, detection of elements, functional group determination and physical constant. (**any one from each category**). a) Water soluble compounds: succinic acid, oxalic acid, urea, thiourea. b) Water insoluble Acids/ Phenols: benzoic acid, cinnamic acid, salicylic acid, *p*-nitrobenzoic acid, *o*-chlorobenzoic acid, *α*-naphthol, *β*-naphthol. c) Water insoluble Base: m-nitroaniline, *p*-toluidine. d) Water insoluble Neutral: acetanilide, benzamide, *p*-dichlorobenzene, *m*-dinitrobenzene, e) Liquids: Acetone, ethyl acetate, ethanol, benzaldehyde, acetophenone, aniline.	**10**
	III. Evaluation of data 1. Titration of supplied calcium chloride solution with 0.01M EDTA solution. (More than 5 observations to be taken followed by statistical analysis to determine - mean, median, range, accuracy in terms of relative error) 2. Titration of given 0.1N NaOH solution using primary standard 0.1N Succinic acid solution. (5 observations to be taken followed by statistical analysis to determine - Relative Deviation, Average Deviation, Relative Average Deviation (RAD), Standard deviation, Variance and Coefficient of variance, *True Value to be provided*).	**04**
	IV. UV-Visible spectrophotometry and Colorimetry 1. Determine λ_{max} for 0.1M $K_2Cr_2O_7$ by spectrophotometry. 2. Verify Beer's law using $KMnO_4$ by colorimetric method and determine molar extinction coefficient. 3. Estimation of Cu^{2+} as $[Cu(NH_3)_4]^{2+}$ complex in the given unknown solution using Calibration curve method.	**06**
	V. Solvent Extraction 1. Separation of mixture of benzoic acid and β-naphthol using ethyl acetate by solvent extraction method. 2. Determination of partition coefficient of acetic acid in water and n-butyl alcohol. 3. Extraction of Caffeine from tea leaves decoction using dichloromethane as organic solvent.	**04**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., UK, 2011.	

	2. Pasto, D., Johnson C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2009. 5. Jeffery, G. H., Bassett, J., Mendham,J., Denney, R. C., *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 6. Mendham,J., Denney,R.C., Barnes, J.D., Thomas,M., *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, 2000, 7. Elias, A.J., *Collection of Interesting chemistry experiments*, University Press(India) private limited, Hyderabad 2002
Course Outcome:	At the end of the course, students will be able to 1. Write the mechanism for substitution reactions of alkyl and aryl halides. 2. Write reactions for preparation and reactivity effects in case of alcohols, phenols, aldehydes, ketones and benzene. 3. Explain the Scope and importance of analytical chemistry and principles involved in Classical methods of analysis, UV-Visible spectrophotometric and Solvent extraction. 4. Synthesize simple organic compounds. 5. Analyse and identify organic compounds using classical qualitative analysis. 6. Solve numericals based on statistical data obtained from experimental results. 7. Compare different methods of quantitative and qualitative analysis. 8. Perform extraction and separation of chemical mixtures.

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC-211**
Title of the course : **Basic Industrial Chemistry**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have basic knowledge general chemistry and an overview of the chemical industry	
Course Objectives:	1. Define and explain the scope of industrial chemistry, along with history and development of the chemical industry in India. 2. Introduce the concept of intellectual property, covering patents, copyrights, and trademarks in the context of the chemical industry. 3. Understand the working principles and applications of temperature and pressure measuring instruments in industrial settings 4. Analyze the basic requirements, raw materials, and operational essentials of major industrial sectors	
Content		**No. of hours**
	Understanding Key Industries Introduction, raw materials and basic requirements of following industries: petroleum industry, glass industry, cement industry, fertilizers, chlor - alkali industry, polymer industry, paper industry, sugar industry, paint industry, leather industry, electrothermal industries, electrochemical industries, iron & steel industry, Pharmaceutical industry.	**15**
	Temperature and pressure measurement Temperature measuring instruments Principle, construction and working of following measuring instruments: Temperature glass thermometers, bimetallic thermometer, vapor filled Thermometer resistance thermometer radiation pyrometers. Pressure measuring instruments Principle, construction and working of Manometers, barometers, bourdon pressure gauge: bellow type, diaphragm type pressure gauges, Macleod gauges, Pirani gauges.	**15**
	Industrial waste and treatment processes Introduction, the problem of sustenance and the chemical industry, characteristics of industrial wastes, types of industrial wastes, solid industrial waste, principles of industrial waste treatment, protection of biosphere, basic trends in biosphere protection for industrial wastes, treatment and disposal of industrial waste, effluents of industrial units and their purification.	**15**
	Total:	**45 hrs**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Industrial Chemistry Vol. I & II by B. K. Sharma, 7th edition, Krisha Prakashan, Meerut, 2014	

	2. Engineering Chemistry by Jain & Jain. 17th Edition, Dhanpat Rai Publishing company, New Delhi, 2015 3. A textbook of Industrial Chemistry by Pol, Date, Adhav & Shinde, Manali Prakashan, Pune, 2021 4. Industrial Chemistry by Dr. Helen Njeri Njenga, African Virtual University, 2019. 5. J. A. Kent: Riegel's Handbook of Industrial Chemistry, 10th edition, Springer, New York, 2012 6. The Chemical Process Industries, by R. Norris Shreve, 4th edition, McGraw-Hill Publishers.	
Course Outcome:	At the end of the course, students will be able to: 1. Apply principles of temperature measurement and understand the working and applications of these instruments in industrial settings. 2. Integrate knowledge gained in different modules to propose comprehensive solutions to challenges in industrial chemistry. 3. Analyze the characteristics of industrial wastes, and understand principles of waste treatment thus proposing effective methods for the treatment and disposal of industrial waste 4. Segregate the industrial waste and treat it separately	
	Laboratory course: (30 Hrs) (01 credit)	
Course Objectives	1. Apply the methods of synthesizing various dyes and pigments 2. Understand and evaluate the principles of colour theory and interaction of different pigments 3. Understand and implement the process carried out in paper industries 4. Comprehend the significance of pH and temperature measurement in industries	
	1. Preparation of dyes and pigments a. Preparation of Azo dye b. Preparation of Chrome Yellow ($PbCrO_4$). c. Preparation of Prussian blue. 2. Preparation of various shades of pigment by understanding the principles of colour theory. 3. Preparation of pulp from waste/recycled papers. 4. To determine the pH of different pharmaceutical formulations. 5. Calibration of thermometer and measurement of temperature. 6. To determine the rate of corrosion on a metallic plate in acidic medium. 7. Qualitative analysis of essential nutrients in different fertilizers.	06 04 04 04 04 04 04
	Total	**30 hrs**
Pedagogy	Laboratory practical /industry visits/ self-study or a combination of some of these can also be used. ICT mode may be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. B.Sc. Chemistry Experiments by M. S. Hegde, Talent Development Centre, IISc, 2021. 2. Svehla, G., Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis, 7th edition Longman Group Limited, London. 2012. 3. Industrial Chemistry Vol. I & II by B. K. Sharma, 7th edition, Krisha Prakashan, Meerut, 2014.	

	4. Engineering Chemistry by Jain & Jain. 17th Edition, Dhanpat Rai Publishing company, New Delhi, 2015
Course Outcome:	At the end of the course, students will be able to: 1. Synthesize and analyze various dyes, pigments, and chemical compounds. 2. Apply principles of colour theory, prepare paper pulp, and measure pH of different formulations. 3. Demonstrate proficiency in essential laboratory techniques, including temperature calibration, nutrient analysis, and corrosion rate determination

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC- 231**
Title of the course : **Environmental Sustainability: Natural resources and Community**
Number of Credits : **03**
Effective from AY : **2024-25**

Prerequisites for the course	NIL	
Course Objectives:	1. To introduce the various terms encountered in environment and sustainability. 2. To explain the underlying aspects of environmental pollution, waste management and municipal water treatment. 3. To discuss the various natural resources, environmental issues, human rights and disaster management.	
Content		**No. of hours**
	1. **Introduction to environment** Concept and types of environment, components of environment, significance of environment for life, Objectives of environmental education, sustainability.	**08**
	2. **Ecosystems and Food Chain** Definition, features, components, tropic levels, functioning, types of food chain and food web.	**07**
	3. **Natural Resources** Land and water resources, forest resources and energy resources. Renewable and non-renewable resources, utilisation of resources. Biodiversity, factors responsible for determination of biodiversity, reasons for conserving biodiversity and obstacles in biodiversity conservation.	**10**
	4. **Environmental issues and concern** Environmental pollution and hazards. Waste management, Global environmental issues, Municipal waste water treatment.	**10**
	5. **Human communities and Environment** Human population: Growth and trends, human health and welfare, human rights and value education. Disaster management: floods, earthquakes, cyclones, landslides.	**10**
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations / industrial visit/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to motivate peer group learning.	
References / Readings	1. Bharucha, E., Textbook of environmental studies for undergraduate courses. 3rd edition, University Grants Commission, New Delhi, 2021. 2. Agrawal, K. C., Environmental biology, Agro Botannica, Bikaner,1999. 3. Chhatwal, R. J., Environmental sciences: A systematic approach,1st revised edition, UDH Publishers & Distributors (P) Ltd, New Delhi, 2009. 4. Khopkar, S.M., Environmental Pollution Analysis, 2nd edition, New Age International Limited Publishers, New Delhi, 2020. 5. Salkar, A. V., Environmental Chemistry: Pollution and Remedial Perspective, Narosa Publishing House, Navi Mumbai, 2017.	

	6. De, A. K., Environmental Chemistry, 10th edition, New Age International Limited Publishers, New Delhi, 2021.
Course Outcome:	At the end of this course, students will be able to 1. To describe the fundamentals of environment and sustainable development. 2. To discuss the significance of natural resources and biodiversity. 3. To propagate environmental education, human rights and awareness of disaster management.

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC-241**
Title of the course : **Mathematical Aspects and Computers in Chemistry**
Number of Credits : **1T+2P**
Effective from AY : **2024-25**

Pre-requisites for the Course	**NIL**	
Course Objective:	1. To familiarize various mathematical concepts in chemistry. 2. To understand various methods of data handling and data analysis. 3. To introduce use of computers in chemistry.	
Content		**No of Hours**
	1. Introduction to various functions: Logarithmic functions, exponential functions and trigonometric functions.	**03**
	2. Curve sketching, time-displacement graphs, graphs of linear equations	**04**
	3. Differentiations, partial differentiations, Maxima and Minima, Integrations	**04**
	4. Methods of statistical data analysis: Mean, Median, Std. Deviation	**02**
	5. Introduction to computer software's - MS Excel, Chemdraw and their use in chemical data management, data analysis, graphing and in sketching chemical structures	**02**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. A. Bahl and G.D. Tuli, Essentials of Physical Chemistry by, S. Chand Publication, 2019, New Delhi, 26th Edition. 2. Puri, Sharma and Pathania, Principles of Physical Chemistry, Vishal Publishing Company, 2018, New Delhi, 1st edition. 3. N. Joshi, S.G. Chitale, G. Venkat, S.R. Rege, Statistical techniques, Sheth Publishers, 2010, Mumbai., 4. E. Joseph Billo, Excel for Scientists and Engineers: Numerical methods, Wiley-Interscience, 2007, New Jersey, USA, 1st edition. 5. D. A. McQuarrie and J. D. Simon, Physical chemistry: A molecular approach, Viva Books Pvt Ltd, 2012, Mumbai, 1st edition. 6. P. Atkins, J De Paula and J. Keeler, Atkins' Physical Chemistry, International Edition, Oxford University press, 2018, England, 11th edition 7. R. G. Mortimer, Mathematics for Physical Chemistry, 4th edition, Academic Press, 2013, USA.	

Practicals Credits: 02

Course Objectives:	1. To apply theoretical knowledge for plotting graphs. 2. To understand the use of computers for calculations and graphical representations.	
Content		**No of hours**
	Laboratory course: (60 hrs)	

	1. To solve and plot the integrated rate law equations for a. Zeroth order b. First order c. Second order	**06**
	2. To plot a function and its derivative using Henderson-Hasselbalch equation.	**04**
	3. To find the critical points in a function using Henderson-Hasselbalch equation and characterize them using a. Graphical method b. Derivative method	**06**
	4. To find the critical points in a radial distribution function for 2s orbital and characterize them using a. Graphical method b. Derivative method	**06**
	5. Plotting atomic orbitals and finding how shapes of orbitals emerge.	**04**
	6. Obtain Mean, Median, Standard deviation from the given data.	**04**
	7. Numerical problems in logarithmic functions.	**04**
	8. Demonstration of MS excel for calculations and graphical representations for above experiments 1-6.	**06**
	9. Demonstration of use of Chemdraw/ Chemsketch for drawing chemical structures.	**06**
	10. Graphical representation on Cartesian and spherical polar coordinate.	**04**
	11. Problem solving on differentiation, partial differentiation.	**06**
	12. Problem solving on maxima and minima.	**04**
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment and post laboratory assignments. Each student performs the experiment individually.	
References / Readings, References for practicals	1. A. Bahl and G.D. Tuli, Essentials of Physical Chemistry, S. Chand Publication, 2019, New Delhi, 26th edition. 2. Puri, Sharma and Pathania, Principles of Physical Chemistry, Vishal Publishing Company, 2018, New Delhi, 1st edition. 3. N. Joshi, S.G. Chitale, G. Venkat, S.R. Rege, Statistical techniques, Sheth Publishers, 2010, Mumbai. 4. E. Joseph Billo, Excel for Scientists and Engineers: Numerical methods, Wiley-Interscience, 2007, New Jersey, 1st edition. 5. D. A. McQuarrie and J. D. Simon, Physical chemistry a molecular approach, Viva Books Pvt Ltd, 2012, Mumbai 1st edition. 6. R. G. Mortimer, Mathematics for Physical Chemistry, 4th edition, Academic Press, 2013, USA.	
Course Outcome:	At the end of the course, students will be able to 1. To plot various mathematical functions. 2. To solve numerical problems in chemistry. 3. To apply computer software's for data analysis. 4. To explain the types of orbitals and their shapes. 5. To identify order of the reaction by graphical method. 6. To solve numericals from the given data.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-242**
Title of the course : **Introductory Skills in Green Chemistry**
Number of Credits : **1T+2P**
Effective from AY : **2024-25**

Prerequisites for the course	NIL	
Course Objective:	1. To create environmental awareness and promote green chemistry. 2. To understand the concept and principles of green chemistry. 3. To design experiments to understand green chemistry principles.	
		No of hours
Content	**1. Introduction:** Why there is a need for green chemistry? Introduction to various disasters in the world: Chernobyl nuclear disaster, Bhopal gas tragedy**,** Love Canal, Cuyahoga fire disaster. EPA introducing the concept of green chemistry. Definition of green chemistry. Green Chemistry Institutes promoting green chemistry for better sustainability-Their mission and objectives- United States Environmental protection agency, Green Chemistry Centre of Excellence-University of York, ACS green chemistry institute, Centre for Green Chemistry and Green Engineering at Yale and Beyond Benign.	**05**
	2. Green chemistry principles: Brief overview of 12 green chemistry principles by Paul Anastas and John Warner. Prevention, Atom economy as no waste concept by Barry Trost. Illustrative examples for calculation of atom economy of addition, substitution, elimination, rearrangement reaction. Specific examples for calculation of atom economy: Diels-Alder Reaction and Wittig reaction. Less hazardous chemical synthesis- Thiamine hydrochloride catalysed Benzoin condensation, Designing safer synthesis, Safer solvents and auxiliaries (water as solvent in Diels-Alder reaction) and solvent-free reaction (Aldol condensation between 3,4-dimethoxy benzaldehyde and indanone). Energy efficient synthesis-Ambient process. Biomass as renewable feedstock-Adipic acid from glucose, Shorter and economical synthesis of Ibuprofen. Catalysis-Natural catalyst (L-proline). Design for Biodegradation (examples of biodegradable chemicals). Preventing pollution by real time monitoring (reaction monitoring), PPE for accident prevention (handling of hazardous substances).	**10**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers / assignments / presentations / industry visits / mini projects / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Anastas, P.T. and Warner, J.K.*, Green Chemistry- Theory and Practice*, Oxford University Press, UK, 2000. 2. Sharma, R.K.; Sidhwani, I.T. and Chaudhari, M.K., *Green Chemistry Experiments: A monograph* I.K. International Publishing House Pvt Ltd. New Delhi, 2012.	

	3. Ahluwalia, V.K., *Green Chemistry: Environmentally Benign Reactions*, Anne Books India, New Delhi, 2006. 4. Ahluwalia, V. K.; and Kidwai, M., *New trends in Green Chemistry*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2004. 5. Beetseh, C.I.; and Audu, M.S.S., Green Chemistry to the Rescue of Disasters of the 1900-2020 Period, *Journal of Environment and Earth Science.* 11(2), 2021. 6. Hill, R.H.; and Finster,D.C., *Laboratory Safety for Chemistry students*, John Wiley and Sons, Hoboken, New Jersey, USA, 2010. 7. https://www.epa.gov/ 8. https://www.york.ac.uk/chemistry/research/green/ 9. https://www.acs.org/greenchemistry/about.html 10. https://greenchemistry.yale.edu/ 11. https://www.beyondbenign.org/

Number of Credits: 02 Practical Course

Course Objective:	1. To apply theoretical concepts to experiments. 2. To design innovative green approaches for conventional methods.	
Content		**No of hours**
	1. Demonstration on Laboratory safety methods	**04**
	2. Preparation of Green Catalyst (Any 2) Silica sulphuric acid, Calcined egg shell, IBX, PCC-silica I_2-silica.	**08**
	3. Green innovative identification of elements (N/S/Halogens) in organic compounds. (Any 4) p-nitrobenzoic acid, urea, m-nitroaniline, thiourea, p-dichlorobenzene, m-nitrophenol, m-dinitrobenzene, acetanilide, p-nitroaniline, p-nitrophenol, o-chlorobenzoic acid.	**04**
	4. Green Inorganic qualitative analysis (Any 7 mixtures): Identification of cations and anions in a mixture of salts.	**14**
	5. Green synthesis, calculation of atom economy, % yield and melting point. (Any 4) 1. Benzoin condensation using thiamine HCl. 2. Oxidation of Benzoin to benzil using zeolite A. 3. Chalcone-Aldol condensation by mechanogrinding. 4. Solid-solid synthesis of azomethines from p-toluidine and vanillin. 5. Synthesis of Benzimidazole using silica sulphuric acid. 6. Synthesis of tetraphenylporphyrin and metallation. 7. Synthesis of copper phthalocyanines. 8. Dibenzalacetone using lithium hydroxide	**16**
	6. Green Chemistry experiments (Any 2) a) Trans stilbene to stilbene dibromide b) Salicylic acid to 5-nitrosalicylic acid c) Acetophenone to acetophenone oxime d) Benzil to benzilic acid e) Aniline to acetanilide f) Benzophenone to benzopinacol	**06**
	7. Valorisation experiments (Any 2)	**08**

	a) Plastic from milk. b) Plastic from potato starch c) Biodiesel from spent ground coffee d) Biodiesel from waste vegetable oil e) Copper nanoparticles from green tea	
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., South Asia, 2011. 2. Anastas, P.T. & Warner, J.K. *Green Chemistry- Theory and Practice*, Oxford University Press, UK, 1998. 3. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. *Green Chemistry Experiments: A monograph*, I.K. International Publishing House Pvt Ltd. New Delhi, 2012. 4. Ahluwalia, V.K., *Green Chemistry: Environmentally Benign Reactions*, Anne Books India, New Delhi, 2006. 5. Ahluwalia, V. K.; and Kidwai, M., *New trends in Green Chemistry*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2004. 6. Kumar, S.A.; Lamba, M.S.; and Makrandi, J. K., An efficient green procedure for the synthesis of chalcones using C-200 as solid support under grinding conditions. *Green Chemistry Letters and Reviews*, 2008, 1(2), 123-125. 7. Horvath, I. T.; and Anastas, P. T., Innovations and Green Chemistry. *Chem. Rev.* 2007, 107, 2169-2173. 8. Lankey, R. L.; and Anastas, P. T., Life-Cycle Approaches for Assessing Green Chemistry Technologies. *Ind. Eng. Chem. Res.* 2002, 41, 4498-4502. 9. Doxsee, K. M.; and Hutchison, J. E., *Green Organic Chemistry: Strategies, Tools, and Laboratory Experiments*; Thomson Brooks/Cole: Belmont, C A , 2003. 10. Kirchhoff, M.; and Ryan, M. A., *Greener Approaches to Undergraduate Chemistry Experiments*, American Chemical Society, USA, 2002. 11. Austen, L.I.; Dugmore, T.I.J.; Matharu,A.; and Hurst, G.A., By-product Valorization: From Spent Coffee Grounds to Fatty Acid Ethyl Esters. *J. Chem. Educ.* 2023, 100, 327−335. 12. Jefferson, M.T.; Rutter, C.; Fraine, K.; Borges, G. V.B.; de Souza Santos, G. M.; Schoene, F. A. P.; and Hurst, G.A., Valorization of Sour Milk to Form Bioplastics: Friend or Foe*: J. Chem. Educ.* 2020, 97, 1073−1076. 13. Campos, D. A.; Ribeiro,T. B.; Teixeira, J. A.; Pastrana, L.; and Pintado, M.M.,. Integral Valorization of Pineapple (Ananascomosus L.) By-Products through a Green Chemistry Approach towards Added Value Ingredients. *Foods* 2020, 9, 60, 1-22. 14. Making a plastic from potato starch extracting starch-*RSC Advancing the Chemical Sciences*, Nuffield Foundation and the Royal Society of Chemistry, UK. 15. Bhausaheb, G.S., Production of Biodegradable Plastic from Potato Starch, *International Journal of Science and Research (IJSR)*. Vol-12 (2), 2023. 16. Thomas, A.A.; Varghese, R. M.; and Rajesh Kumar, S., Green Synthesis of Copper Nanoparticles using Green Tea and Neem Formulation and	

	Assessment if its Antimicrobial Effects. *Indian Journal of Forensic Medicine and Toxicology*, Vol.16 (4), 2022.
Course Outcome:	At the end of the course students will be able to: 1. Understand the chemical disasters in the world. 2. Explain the need for green chemistry. 3. Explain the concept of green chemistry and its 12 principles. 4. Apply the knowledge of green chemistry principles in designing green and innovative experiments. 5. Understand the practical aspects of green chemistry. 6. Calculate atom economy for measuring greenness. 7. Prepare bioactive compounds within the framework of green chemistry. 8. Apply the concept of waste valorization to get useful products.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-243**
Title of the course : **Drug Synthesis and Analysis**
Number of Credits : **1T+2P**
Effective from AY : **2024-25**

Prerequisites for the course	NIL	
Course Objective:	1. To understand the retrosynthetic approach for synthesis of selected drugs. 2. To understand purity analysis of drugs.	
Content		**No of hours**
	1. Drug Synthesis Drug: Definition. Drug-Receptor interaction, Pharmacophore, Toxicophore, Metabiophore. Classification of natural, semi-synthetic and synthetic drugs with two examples of each. Synthesis, drug class, use and side-effects of Aspirin, Benzocaine, Niclosamide, Dilantin, Ibuprofen. Aspirin, Benzocaine, Niclosamide, Dilantin, Ibuprofen. Retrosynthetic approach-(Ibuprofen).	**08**
	2. Analysis of Drugs Introduction to Assay, Potency, Types of Assay, Chemical Assay-Functional groups, Titrimetric (Aspirin) and Instrumental (Paracetamol) assay-Advantages and Disadvantages. Introduction to Bioassay-Principle, types of bioassay. Differences between In vitro and In vivo assay. Comparison between Chemical assay and Bioassay.	**07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ mini projects/self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Patrick, G.L., *Introduction to Medicinal Chemistry*, 7th ed., Oxford University Press, UK, 2023. 2. Singh, H.; and Kapoor, V.K.; *Medicinal and Pharmaceutical Chemistry*, 3rd ed., Vallabh Prakashan, Pitampura, New Delhi, 2012. 3. Foye, W.O.; Lemke, T.L.; William, D.A., *Principles of Medicinal Chemistry*, 7th ed., B.I. Waverly Pvt. Ltd. New Delhi, 2012. 4. Beale, J.H.; and Blocks, J.H., *Wilson and Gisvold's Textbook of Organic, Medicinal and Pharmaceutical Chemistry*, 12th ed., Lippinkott Williams and Wilkins,2011. 5. Lednicer, D.; and Meischer, L.A., *Organic Chemistry of Drug Synthesis*. Vol. I to III. John Wiley & Sons, New York, 2005. 6. Sriram, D.; and Yogeshwari, P., *Medicinal Chemistry*, 1st ed., Pearson Education, New York, 2007 7. Sriram, D.; and Yogeshwari, P., *Medicinal Chemistry*, 2nd ed., Pearson Education, New York, 2010. 8. Wolff, M. E., *Burger's Medicinal Chemistry and Drug Discovery*, 5th ed., John Wiley & Sons N.Y,1997. 9. Chatwal, G.R., *Medicinal Chemistry*, 2nd ed., Himalaya Publishing house, India, 2002.	

	10. Chatwal, G.R., *Synthetic drugs*, 2nd ed., Himalaya Publishing house,India, 1996.

Number of Credits: 02 Practical Course

Course Objective:	1. To apply theoretical concepts to experiments. 2. To understand the role of various organic reactions in drug synthesis. 3. To learn about methods of drug analysis.	
Content		**No of hours**
	1. Recrystallisation, water solubility and identification of various functional groups in drugs and drug like entities. (Any 6) Benzoic acid (COOH), Aspirin (COOH, OAc), Ibuprofen (COOH), Paracetamol (-Phenolic-OH, $NHCOCH_3$), Salicylic acid (Phenolic-OH, COOH), Camphor (Ketone), Benzocaine (Ester, NH_2). Methyl salicylate (Ester, phenolic-OH), sulphanilamide (Amino), acetanilide (anilide)	**06**
	2. Synthesis of FDA-approved drugs: (Any 3) a) Aspirin from salicylic acid. b) Dilantin from Urea c) Benzocaine from p-aminobenzoic acid d) Paracetamol from 4-aminoacetanilide/p-aminophenol e) Methyl salicylate from salicylic acid.	**12**
	3. Synthesis of drug-like entities (Any 3) a) 7-hydroxy-4-methylCoumarin by Pechmann Condensation b) 2,3-diphenylquinoxaline from benzil c) 4-chlorobenzalacetone by aldol condensation d) Benzimidazole from formic acid by oxidative cyclization e) 2-(p-Chlorophenyl)Benzoxazole by oxidative cyclization	**12**
	4. Titrimetric assay of the following drugs (Any 4) a) Aspirin b) Ibuprofen c) p-Amino Salicylic acid d) Benzocaine e) Paracetamol f) Ascorbic acid	**16**
	5. TLC of following drugs/drug like entities and determination of Rf value (Any 6): Paracetamol, aspirin, dilantin, benzocaine, sulphanilamide, 7-hydroxy-4-methylCoumarin, 2,3-diphenylquinoxaline	**06**
	6. Instrumental assay of the following drugs/tablet. (Any 2) UV-spectrophotometric method for purity analysis of paracetamol/Isoniazid/Metformin/Albendazole	**08**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5thed., Pearson Education Ltd., New York, 2011. 2. *Indian Pharmacopoeia*, Latest edition.	

	3. K.A. Connors, *Text book of Pharmaceutical analysis*, 3rd ed., Wiley Interscience Publication, New York, 1990. 4. M. Jahangir, *Pharmaceutical Laboratory Procedures*, 1st Ed., New Delhi Cengage Learning India Pvt. Ltd. 2010. 5. Ashutosh. Kar, *Advanced Practical Medicinal Chemistry*, New Age International Limited Publishers, India, 2004. 6. JEF Reynolds, Martindale, *The Extra Pharmacopoeia*, The Pharmaceutical Press, London, 1989.
Course Outcome:	At the end of the course students will be able to 1. Explain various organic reactions for synthesis of drugs. 2. Write the retrosynthetic approach for synthesis of drugs. 3. Identify types of assay. 4. Compare chemical and bioassay. 5. Identify functional groups in approved drugs. 6. Perform synthesis of drugs and drug like entities. 7. Determine the purity of drugs titrimetrically as well as by instrumental method. 8. Perform TLC analysis of drugs.

Semester IV

Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC-202
Title of the course : Organic Chemistry I
Number of Credits : 3T+1P
Effective from AY : 2024-25

Prerequisites for the course	Knowledge of functional group chemistry and three-dimensional shapes of molecules	
Course Objectives:	1. To understand the preparation and reactions of carboxylic acids and amines. 2. To apply knowledge of UV-Visible spectroscopy in calculating absorption values. 3. To understand stereochemistry of organic compounds.	
Content		**No. of hours**
	1. Carboxylic acids and its derivatives Carboxylic acids (aliphatic and aromatic) IUPAC nomenclature, Preparation: Acidic and Alkaline hydrolysis of esters, Oxidation of Toluene to benzoic acid. Hydrolysis of cyanides, Grignard synthesis of carboxylic acids. Reactions: Hell - Volhard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (up to 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversions, Reactions: Comparative study of the nucleophilicity towards acyl derivatives. Hydrolysis of acid chlorides, acid amide to carboxylic acids.	**09**
	2. Amines and Diazonium Salts Amines (aliphatic and aromatic) (upto 5 carbons) IUPAC nomenclature, Preparation: from alkyl halides, Gabriel's phthalimide synthesis, Hofmann bromamide reaction (with mechanism). Reduction of cyanides, reduction of nitroarenes. Reactions: Elimination reactions Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann reaction. Electrophilic substitution of aniline: nitration, bromination, sulphonation. Diazonium salts: Preparation from aromatic amines, conversion to benzene, phenol, chlorobenzene, bromobenzene. Preparation of azo dye of aniline with *β*-naphthol.	**10**
	3. UV –Visible Spectroscopy in Organic Chemistry Introduction to spectroscopy: UV Spectroscopy: Beer-Lambert's law (statement, expression and terms involved), Types of electronic transitions, Intensity of absorption, Chromophores and Auxochromes with examples, λmax, Bathochromic and Hypsochromic shifts, hypochromic and hyperchromic effects. Visible Spectroscopy: Effect of conjugation on colour: w.r.t benzene, nitrobenzene, *p*-nitroaniline and *β*-Carotene. Application of Woodward - Fieser rules for calculation of λmax for the following systems: *α*, *β* unsaturated aldehydes, ketones. Conjugated dienes: alicyclic, homoannular and heteroannular,	**14**

	extended conjugated systems (aldehydes, ketones and dienes) (problems to be solved). Applications of UV-Visible spectroscopy.	
	4. Introduction to Stereochemistry Concept of isomerism. Types of isomerism. Stereoisomerism, conformational isomerism. Conformations with respect to ethane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds. Threo and erythro; D and L; cis – trans nomenclature; Cahn Ingold Prelog Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).	**12**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Kemp, W., *Organic spectroscopy*, 3rd ed., Palgrave Macmillan, New York, USA, 1991. 2. Pavia, D. L., Lampman, G. M. and Kriz, G. S., *Introduction to Spectroscopy*, 3rd ed., Thomson Learning, Fort Worth, USA, 2001. 3. Silverstein, R. M. and Webster, F., *Spectrometric Identification of Organic Compounds*, 5th ed., John Wiley & Sons, New York, USA, 1991. 4. Graham Solomons, T.W., Fryhle, C.B. and Snyder, S. A., *Organic chemistry*, 12th ed., John Wiley & Sons, New Jersey, USA, 2016. 5. Sykes, P., *A guidebook to mechanism in organic chemistry*, 6th ed., Longman Scientific & Technical, England, UK, 1985. 6. Finar, I. L., *Organic Chemistry* (Vol. I), 6th ed., Pearson Education, India, 1973. 7. Finar, I. L., *Organic Chemistry* (Vol. II), 3rd ed., Longmans, London, UK, 1964. 8. Morrison, R.T., Boyd, R.N. and Bhattacharjee, S. K., *Organic Chemistry*, 7th ed., Pearson, Bangalore, India, 2010. 9. Bahl, A. and Bahl, B.S., *Advanced Organic Chemistry*, S. Chand, New Delhi, India, 2012. 10. Carey, F., *Organic Chemistry*, 4th ed., McGraw Hill, New York, USA, 2000. 11. Bruice, P. Y., *Organic Chemistry*, 3rd ed., Pearson Education, Asia, 2014. 12. March, J., *Advanced Organic Chemistry*, 4th ed., John Wiley, New Jersey, USA, 2007. 13. Nasipuri, D., *Stereochemistry of Organic compounds - Principles and Applications*, 4th ed., New Academic Science, Kent, UK, 2013. 14. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 15. Potapov, V. M., *Stereochemistry*, Mir Publishers, Moscow, Russia,1979. 16. Kalsi, P. S., *Spectroscopy of Organic compounds*, 6th ed., New Age International Publishers, New Delhi, India, 2004.	

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic preparation. 3. To acquire hands on training in organic qualitative analysis.	
Content		**No. of hours**
	I Preparation of organic derivatives. List of organic preparations to be performed. Purification by recrystallization, calculation of % yield and determination of melting point. (**Any 4)** a) Osazone derivative from Glucose b) Benzoyl derivative of *β*-Naphthol c) Azo dye from Aniline and *β*-Naphthol d) Acid derivative of benzamide e) Anhydride derivative of phthalic acid. f) Amino derivative of *m*-dinitrobenzene.	**10**
	II Organic qualitative analysis Preliminary tests, chemical nature, detection of elements, functional group determination and physical constant. (**any one from each category**) a) Water insoluble Acids: cinnamic acid, *p*-nitrobenzoic acid. b) Water insoluble Phenol: *o*-nitrophenol, *p*-nitrophenol. c) Water insoluble Base: *p*-nitroaniline, *o*-nitroaniline. d) Water insoluble Neutral: benzophenone, benzamide. e) Water soluble solids: succinic acid, thiourea. f) Liquids: methyl acetate, nitrobenzene, *N*-methylaniline, cyclohexanol.	**14**
	III Organic Estimation (Any 2) a) Estimation of Acetamide b) Estimation of Glucose c) Estimation of nitroaniline	**06**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992 4. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India 2009.	
Course Outcome:	At the end of the course, students will be able to 1. Explain the preparation and reactions of carboxylic acids and amines. 2. Identify conjugation and calculate λmax of organic compounds.	

	3. Draw stereoisomers of organic compounds. 4. Assign E/Z and R/S configuration to organic compounds. 5. Estimate the organic compounds. 6. Acquire hands on training in organic chemistry preparation methods. 7. Analyse and identify organic compounds using classical qualitative analysis. 8. Apply theoretical knowledge in understanding laboratory skills.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-203**
Title of the course : **Inorganic Chemistry - I**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the Course	Knowledge of periodic table and coordination chemistry is essential	
Course Objectives:	1. To understand the theoretical aspects related to inorganic qualitative analysis. 2. To study the comparative chemistry of s, p and d block elements. 3. To learn the chemistry of coordination compounds and understand their role in the biological systems. 4. To study the properties, structure and bonding in noble gases compounds.	
Content		**No of hours**
	1. Theoretical Basis for the Qualitative Inorganic Analysis Common ion effect, solubility product, complex ion formation, buffers, applications in inorganic qualitative analysis.	**03**
	2. s - block Elements Occurrence, extractions (Li and Be only), Electronic configuration, Periodic trends in Properties viz. size of atom, ion, ionization potential, flame colouration, and reactivity. Anomalous behaviour of Li & Be. Diagonal relationship between Li-Mg and Be-Al, Solubility and hydration, Biological roles.	**06**
	3. Selected topics on p-block elements **a. Chemistry of Group 13 elements:** Comparative study w.r.t. oxides, halides & hydrides. Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. Boranes and types of Boranes, Wade's formula. Preparations, structure and bonding in diborane and tetraborane. Introduction to carboranes. Borates: Introduction and classification. **b. Chemistry of Group 14 elements:** Comparative study w.r.t. oxides, halides & hydrides. Occurrence and extraction of Germanium. Preparation of extra pure Silicon and Germanium, applications in the semiconductor industry with special reference to Solar Panels. Silicates: Introduction, classification and structure. **c. Chemistry of Group 15 elements:** Comparative study w.r.t. oxides & oxyacids, halides & hydrides. Structures of NO, NO_2, N_2O, N_2O_4. Synthesis of ammonia by Haber-Bosch process, synthesis of HNO_3 by Ostwald's process (Physico-chemical principles not expected). Introduction to fertilizers.	**14**
	4. Chemistry of Noble Gases Introduction, electronic configuration, chemical properties and uses. Clathrates. Chemistry of xenon; preparation, structure and bonding in xenon compounds (XeF_2, XeF_4, XeO_6, XeO_4, XeO_2F_2, $[XeO_6]^{-4}$, $XeOF_4$).	**04**
	5. Comparative Chemistry of the Transition Metals	**10**

	Introduction, occurrence, electronic configuration, significance and special stability of empty, half-filled and completely filled d-orbitals. Complex formation, variable oxidation states, unusual oxidation states and their stabilities in aqueous solutions (w.r.t. vanadium and chromium), colour, magnetic and catalytic properties of transition metals and their compounds. Chemistry of titanium and vanadium w.r.t. properties of their oxides and chlorides. Qualitative tests for the ions of the first transition series.	
	6. Introduction to Coordination Compounds Molecular compounds: double salts and complex salts. Werner's theory of coordination compounds. Experimental evidences for Werner's theory: Precipitation and Molar conductivity measurements. Terminology and nomenclature of coordination compounds. Coordination numbers and geometries, Effective atomic number Rule. Structural isomerism: Ionization isomerism, Hydration isomerism, Coordination isomerism, Linkage isomerism. Stereoisomerism w.r.t. C.N. = 4 and 6 only. Role of coordination compounds in biology and medicine w.r.t. Chlorophyll, Haemoglobin and cisplatin.	**08**
Pedagogy	1. Lectures and Tutorials, Seminars/ Term papers/ Assignments/ Applicative Quiz sessions/ Presentations / self-study/ industry visit or a combination of some of these can be used. 2. ICT mode will be preferred. 3. Sessions should be interactive in nature to enable peer group discussions and learning.	
References / Readings	1. G. Svehla, Vogel's Qualitative Inorganic Analysis, Pearson Education, (2012). 2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th edn. Pearson Education. 3. J.C. Kotz, Paul M. Treichel, Grabriela C. Weaver, Chemistry and Chemical Reactivity, 6th edn. Thomson Books/Cole (2006). 4. P.L. Soni and Mohan Katyal, Textbook of Inorganic Chemistry by, Sultan Chand and Sons, 20th edn. (1997) 5. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd edn., Vishal Publishing Co. (2018). 6. J.D. Lee, Concise Inorganic Chemistry by, Chaman, and Hall, 5th edn. (1996). 7. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd edn. Wiley, (Reprint 2008). 8. N. N. Greenwood, A. Earnshaw, Chemistry of the Elements, Pergamon Press, 1st edn. (1984). 9. Glen E. Rodgers, Inorganic Chemistry, 3rd edn. Brooks/Cole (2012). 10. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 3rd edn. 11. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th edn.; Oxford Publications, (2009). 12. Geoff Raymer and Tina Overton, Descriptive Inorganic Chemistry, 4th edn.	

	13. J.E. Huheey, E.A. Keiter, R.L. Keiter, U.K. Medhi, Inorganic Chemistry – Principles of structure and reactivity by, 1st impression (2006) Pearson Education Publishers. 14. Neil G. Connelly, Ture Damhus, Richard M. Hartshorn, Alan T. Hutton, Nomenclature of Inorganic Chemistry. IUPAC RECOMMENDATIONS 2005, RSC Publishing. 15. Catherine E. Housecroft and Alan G. Sharpe, Inorganic chemistry 4th edn., Pearsons, 2012.

Number of Credits: 01 (Practicals)		
		30hr
Practical course objectives	1. To apply the fundamental theoretical aspects of qualitative inorganic analysis. 2. To use various titrimetric techniques to estimate the analytes. 3. To use gravimetric methods to estimate metal ions. 4. To prepare inorganic coordination compounds.	
Content		**No. of hours**
	Qualitative analysis: (4 mixtures to be analyzed) Semi-micro qualitative analysis of water soluble mixtures containing two cations and two anions. **Cations:** Ba^{2+}, Cu^{2+}, Fe^{2+}, Ni^{2+}, K^{+}, NH_4^{+} **Anions:** CO_3^{2-}, NO_3^{-}, Cl^{-}, SO_4^{2-}, S^{2-} (To precipitate metal sulphide aqueous H_2S solution can be used)	**16**
	Volumetric Analysis 1. Estimation of the amount of nickel in the given nickel sulphate solution (EDTA method). 2. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using the internal indicator.	**06**
	Gravimetric Analysis 1. Estimate the amount of Ni as bis-(dimethylglyoximato)nickel(II) in the given solution of nickel chloride using counter poise method. 2. Estimation of Mn as manganese pyrophosphate present in the given manganese sulphate solution. **Inorganic Preparations** 1. Preparation of tris-(ethylenediamine)nickel(II)chloride 2. Preparation of chrome red.	**08**
Pedagogy:	1. Students shall be given pre-lab and post-lab assignments 2. Theoretical concept underlying the experiments prior to each experiment. 3. Each student shall perform the experiments independently.	
References / Readings	1. G. Svehla, Vogel's Qualitative Inorganic analysis, 7th edn. Pearson Education Ltd. 2. V. Alexeyev. Quantitative Analysis. 2nd edn. Mir Publishers. 1969. 3. J. Derek Woollins, Inorganic experiments, WILEY-VCH, 4. George Brauer, Handbook of Preparative Inorganic Chemistry Vol. 2, 2nd edn., Academic Press (1964)	

Course outcome	At the end of this course, students will be able to: 1. explain the principles underlying inorganic qualitative analysis. 2. explain the characteristics of s, p and d-block elements and postulates of Werner's theory of coordination compounds. 3. write IUPAC nomenclature and identify different types of isomers of coordination compounds. 4. describe the structure and bonding in noble gas compounds. 5. perform a qualitative analysis of inorganic mixtures. 6. prepare coordination compounds of transition elements. 7. determine unknown concentration of analytes using volumetric and gravimetric procedures.

Name of the Programme : **B.Sc. Chemistry**
Course Code : **CHC – 204**
Title of the course : **Physical Chemistry I**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the Course	Students should have basic knowledge of thermodynamics, chemical kinetics and nuclear chemistry	
Course Objectives:	1. To study the laws of thermodynamics and various state functions 2. To understand rates of chemical reactions of zero, first and second order. 3. To introduce the composition of nucleus and study the applications of radioisotopes. 4. To know the photo-physical processes and their significance.	
Content		**No of hours**
	1. Thermodynamics-I First law of thermodynamics, definition of internal energy and enthalpy. Heat capacity: Heat capacities at constant volume and at constant pressure and their relationship, calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and reversible conditions**.** Second law of thermodynamics: - Statements of second law of thermodynamics. Carnot cycle and its efficiency. Concept of entropy. Entropy as a state function. Entropy as a function of V & T, P & T, entropy change in physical and chemical processes. entropy change in reversible, irreversible and equilibrium conditions. Gibbs free energy and Helmholtz work function. Third law of thermodynamics and calculation of absolute entropies of substance (numericals to be solved).	**13**
	2. Chemical Kinetics-I The concept of reaction rates. Law of Mass action, effect of temperature, pressure and catalyst on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Introduction to theories of reaction rates (derivations is not required; numericals are expected).	**12**
	3. Nuclear Chemistry Composition of the nucleus, Mass defect and binding energy, Q – value of nuclear reactions, nuclear binding force; Nuclear models – shell model and liquid drop model, radioactive disintegration, decay constant, half life and average life, Group displacement law, units of radioactivity and radiation energy, artificial radioactivity, detection and measurement of radioactivity, ionisation chamber, GM counter and proportional counter, Scintillation counter. Nuclear Fission, discovery, Nuclear reactor – essential parts of the nuclear reactor, classification of nuclear reactors, Breeder reactor, chain reaction and its control, reprocessing of spent fuel, application of radio isotopes- in the field of medicine, agriculture,	**13**

	industry, as traces (2-3 examples of each) and in carbon dating. (numerical to be solved)	
	4. Photochemistry Introduction, Absorption and emission of light and Beer-lamberts law. Laws of photochemistry: Grothus-Draper law, Stark-Einstein law. Quantum yield or efficiency, factors affecting quantum efficiency. Primary and secondary photophysical processes and Jablonski diagram. Kinetics of photochemical reactions of H_2 & Br_2. Distinction between luminescence, fluorescence, phosphorescence and chemiluminescence. Introduction to LASER. (numericals to be solved).	**07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. Bahl and G.D. Tuli, Essentials of Physical Chemistry, S. Chand Publication, 2019, New Delhi, 26th Edition. 2. P. Sharma and Pathania, Principles of Physical Chemistry, Vishal Publishing Co, 2018, Jalandhar, Delhi,1st edition. 3. J.N. Gurtu, Physical Chemistry, Pragati Prakashan, 2020, Meerut, 9th edition. 4. G. Raj, Advanced Physical Chemistry, Goel publication, 36th edition, 2010, Meerut. 5. R. L. Madan, Chemistry for degree students, S Chand publications, 2017, New Delhi, 1st edition. 6. U. N. Dash, Nuclear Chemistry, S. Chand & Sons Publications, 2010, New Delhi. 7. K. K. Rohatgi-Mukherji, Fundamentals of Photochemistry, 3rd edition, New Age international Publishers, 2017, New Delhi. 8. H. J. Arnikar, Essentials of Nuclear Chemistry, New Age International Publishers, New Delhi, 2011, Reprint 2018, 4th edition.	

Practicals Credits: 01

Course Objectives:	1. To acquire knowledge on the various types of reactions and their order. 2. To understand the thermodynamic parameters used in laboratory techniques. 3. To study complex formation and determination of stability constant colorimetrically.	
Content		**No of hours**
	1. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.	**04**
	2. To determine the rate constant and order of reaction between KI and $K_2S_2O_8$.	**04**
	3. Determination of energy of activation for ethyl acetate and NaOH using equal concentration.	**04**
	4. Determination of enthalpy of ionization of Acetic acid and NaOH.	**04**

	5. Determination of enthalpy of neutralization of Acetic acid and NaOH.	**04**
	6. To study complex formation between Ni(II) and O-phenanthroline by Job's method. (Colorimetry)	**02**
	7. To study the complex formation between Fe(III) ions and Salicylic acid and to find the formula and stability constant of the complex using colorimetry.	**04**
	8. To measure the Combustion Enthalpies of Coal via Bomb Calorimetry.	**04**
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment and post laboratory assignments to be given. Each student performs the experiment individually.	
References / Readings, References for practicals	1. S. W. Rajbhoj and T. K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, 2nd Edition, 2000, Aurangabad. 2. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi, 2018, 18th edition. 3. O. P. Pandey, D. N. Bajpai, S. Giri, Practical Chemistry, S. Chand Publication, 2013, New Delhi, Revised Edition. 4. B. Viswanathan, P. S. Raghavan, Practical Physical Chemistry, Viva Books Private limited, 2012, Mumbai. 5. J. N. Gurtu and A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Prakashan, 2008, Meerut, Revised Edition. 6. A. M. Ranjika and P. Bopegedera, Evaluating the heats of combustion of coals using Bomb calorimetry in the general chemistry laboratory, *J. Chem. Educ.* 2023, 100, 1, 298–305	
Course Outcome:	At the end of the course, students will be able to 1. calculate and explain various thermodynamic parameters of chemical reactions. 2. differentiate between different nuclear counters. 3. estimate quantum yields of photochemical reactions. 4. compare the strength of the acids. 5. determine graphically order of reaction and estimate the energy of activation. 6. estimate the stability constant of various complexes.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-205**
Title of the course : **Pharmaceutical Chemistry**
Number of Credits : **2**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have information about different types of diseases and illnesses	
Course Objectives:	1. To understand the terminologies in pharmaceutical chemistry 2. To study the structures of selected drugs. 3. To understand the IUPAC nomenclature of drugs. 4. To predict the mechanism of action and SAR analysis of drugs.	
Content		**No of hours**
	1. Introduction to Pharmaceutical Chemistry Why the need to study pharmaceutical chemistry? Importance of chemistry in pharmacy. Definitions of Pharmaceutical Chemistry, Pharmacophore, Pharmacognosy, Pharmacokinetics, Pharmacodynamics, Pharmacopoiea, Drug. Classifications of drugs based on their uses, definition, giving one example with structure: Anti-infective agents: Antibacterial (Sulphaacetamide), Antifungal (Clotrimazole), Antiviral (Amantadine HCl), Anthelmintics (Mebendazole), Antiamoebic (Metronidazole), Antimalarial (Chloroquine), Antitubercular (Isoniazid), Antihypertensive (Methyl Dopa), Anticoagulant (Warfarin), Diuretics (Acetazolamide), Analgesic (Paracetamol), NSAIDs (Ibuprofen), Local Anaesthetic (Benzocaine), antibiotics (Chloramphenicol), Central nervous depressant (phenobarbital), Anticonvulsant (Phenytoin).	**10**
	2. IUPAC names, Synthesis and uses of following drugs Synthesis of Aspirin, paracetamol, Ibuprofen, Sulphacetamide, Amantadine HCl, Clotrimazole, Phenobarbital, Glyceryl trinitrate, Dapsone, metronidazole.	**06**
	3. Mechanism of Action of representative drugs Analgesic and Anti-inflammatory drugs (Ibuprofen), Antilepral agent (Dapsone), Sulphonamides, antiamoebic (metronidazole), Central nervous depressant (Phenobarbital), Antimalarial (Chloroquine).	**07**
	4. Structure Activity Relationship of representative drugs Effect of functional groups on physiological activity of drugs: hydroxy, acidic, alkyl, aldehyde, ketone, cyano, halogens, ether and ester groups with one example each Analgesic and Anti-inflammatory drugs (Ibuprofen), Antilepral agent (Dapsone), Sulphonamides (sulphacetamide), antiamoebic (metronidazole), Central nervous depressant (Phenobarbital)	**07**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	

Issued on: 05/03/2025

References / Readings	1. Patrick, G. L., *Introduction to Medicinal Chemistry*, 7th edn., Oxford University Press, UK, 2023. 2. Singh, H. and Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, 3rd edn., Vallabh Prakashan, Pitampura, New Delhi, 2012. 3. Foye, W.O. Lemke, T.L. William, D.A., *Principles of Medicinal Chemistry*, 7th edn., B. I. Waverly Pvt. Ltd., New Delhi, 2012. 4. Beale, J. H. and Blocks, J. H., *Wilson and Gisvold's Textbook of Organic, Medicinal and Pharmaceutical Chemistry*, 12th edn., Lippinkott Williams and Wilkins, Philadelphia, USA, 2011. 5. Lednicer, D. and Meischer, L.A., *Organic Chemistry of Drug Synthesis*. Vol. I to III. John Wiley & Sons, New Jersey, USA, 2005. 6. Sriram, D. and Yogeshwari, P., *Medicinal Chemistry*, 1st edn., Pearson Education, London, 2007. 7. Sriram, D.; and Yogeshwari, P., *Medicinal Chemistry*, 2nd edn., Pearson Education, London, 2010. 8. Wolff, M. E., *Burger's Medicinal Chemistry and Drug Discovery*, 5th edn., John Wiley & Sons, New Jersey, USA, 1997.
Course Outcome:	At the end of the course, students will be able to 1. Explain the terminologies in pharmaceutical chemistry. 2. Write the structures of selected drugs. 3. Write the mechanism of action of drugs. 4. Present structure activity relationship analysis of drugs.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-221 (Minor Vocational-1)**
Title of the course : **Basics of Chemical Laboratory Management**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the Course:	NIL	
Course Objectives:	1. To train students in basics of managing a chemical laboratory 2. To apprise students with safety measures in a chemistry laboratory 3. To acquaint with the chemicals, reagents, apparatus, electrical appliance and equipment in chemistry laboratory 4. Introduce students to different terms to label strength of solution.	
Content:		**No. of hours**
	1.General Safety measures and precaution Instruction for safe working in chemical laboratory- Personal protection, conduct in laboratory, tidiness, cleanliness, accident procedures, after hour working. Storage of chemical laboratory, glassware, waste disposal. Explosion and fire Hazards- General aspects, Explosive compounds, potentially dangerous mixture, some specific dangers of explosion, Fire hazards, Dangerous operation in Laboratory, Conduct of explosive or violent reaction. Reactive inorganic reagents- Strong Acids, Strong Bases, Halogens, Reactive halides, Chromium trioxide, chromate and dichromates Hazards due to toxic chemical- ingestion, Inhalation, Direct absorption, Highly toxic solids, toxic gases, Other harmful substance, Carcinogenic substance.	**12**
	2.Chemical management Green chemistry for laboratory- Prevent waste, Microscale work and wet chemical elimination, use safer solvent, materials, and design. Experimental products for degradation after use, Include real-Time Control to prevent pollution, minimize potential for accidents. Acquisition of chemicals- ordering chemicals, receiving chemicals, Inventory and tracking of chemicals- General consideration, Recycling of chemicals and laboratory materials, Safety datasheet (SDS), Globally Harmonized System (GHS) for hazard communication, Labeling commercially packaged chemicals, chemical container, Experimental materials. Storage of chemicals in stock room and laboratories- general consideration, storage according to compatibility, Containers and equipment, cold storage, storing flammable and combustible liquids, storing gas cylinders, storing highly reactive substances, storing highly toxic substance.	**12**
	3.Common Apparatus and glassware	**10**

Issued on: 05/03/2025

	Balances: The analytical balance, non-analytical balance, weight and reference masses, Care and uses of analytical balances, errors in weighing, Graduated glassware-units of volume, Graduated apparatus, Temperature standards, graduated flask, pipettes, Burettes, weight burettes, Piston burettes, Graduated (measuring) cylinders. Water for laboratory use- purified water, wash bottles General apparatus- glassware, ceramics, plastic ware, heating apparatus, Desiccators and dry boxes, Stirring apparatus, filtration apparatus, weighing bottles. Types of ground joints, care and maintenance of ground glass joints, Apparatus for preparative organic chemistry, other types of interchangeable joints and stopcocks, Use of cocks and rubber stopper cutting and bending of glass tubing.	
	4.Reagents and standard solution Grades of Reagents, Preparation of standard solution, defining concentration in terms of Molarity, Molality, Normality, ppm, ppb, mole fraction, percentage (calculation expected with examples), Strength and dilutions of acids and bases, buffer solutions, Basic techniques of weighing of sample, preparation of solution of a sample.	**06**
	5.Construction, working and maintenance of cells and electrodes Conductivity cell, Reference electrode, Saturated Calomel electrode, hydrogen electrode, silver electrode, working electrode- platinum electrode, copper electrode, zinc electrode**.**	**05**
Pedagogy:	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive and practical oriented in nature to enable peer group learning.	
References/ Readings:	1. G.H. Jeffery, J. Bassett, J. Mendham, R. C. Denny.Vogel's Textbook of Quantitative Chemical Analysis, 5th edition, Longman Scientific and Technicals England.1989 2. Brian S. Furniss, Antony J. Hannaford, Peter W.G.Smith, Austin R. tatchell.Vogel's Textbook of practical Organic chemistry,5th edition,8th impression 2011 Publisher-Person education Ltd England 1989 3. National Research council of Naional Academies, Prudent Practices in Laboratory-handling and management of chemical hazards. The National Academies press. Washington D.C 2001 4. John O'M Bockris, Amulya K.. Reddy Modern Electrochemistry 1 Ionics ,2nd Edition, ,Publisher-Springer, UK 1989 5. John Kenkel, Analytical chemistry for Technicians 4th edition, CRC press, Tylor & Francis Group, Boca Raton, London, 2013	

Number of Credits: 01 (Practicals)

Course Objectives:	1. Enable student to identify and classify different glass wares 2. To prepare solution of different concentration and dilution 3. Distinguish between different types of electrodes

	4. Acquaint students with hazard symbols and labels	
Content		**No. of Hours**
	Identification and classification of glassware 1. To identify and classify different types of flasks and funnels (Minimum four different types of each.) 2. To identify and classify different types of pipettes and burettes (Minimum two different types of each.) 3. Classification, Assembling and Application of condensers- Normal condenser (Liebig Condenser), Double coiled condenser, Hickman distilling head and fractional distillation (Description and labeled diagrams expected)	**10**
	Preparation of solution and dilution 1. Prepare 100 ml of 0.5 N NaOH solution and standardize using 0.5N KHP. Dilute and prepare 100 ml of 0.3N NaOH and standardize to determine correctness of dilution. 2. Prepare 100ml 0.05 M $KMnO_4$ and dilute to 0.05 N $KMnO_4$ solution. 3. Dilute the given standard solution of 0.05 M oxalic acid to 0.02N, 0.025N, 0.03N. 4. Determination of mole fraction of Cu and Cl in a $CuCl_2$. 2 H_2O solution (0.010 g $CuCl_2$.2 H_2O diluted to 100 ml.) 5. Preparation and dilution of 100 ppm Fe solution using any salt of iron and to dilute to 80 ppm and 50 ppm.	**10**
	Identification and classification of Electrode 1. To identify and classify different types of Reference electrodes (any two) 2. To identify and classify different types of Working electrode (any Two) (Description and labeled diagrams expected)	**04**
	Identification of labels and Hazard Symbols 1. Draw the label and describe the information on commercial chemical and reagent labels- (Minimum two solids and two liquids) 2. Draw and identify the hazard symbols (ref-Safety datasheet (SDS), Globally Harmonized System (GHS) for hazard communication). Note-Minimum Nine Symbols to be studied. 3. Classification of fire and fire extinguisher (Description and labeled diagrams expected of minimum four types of each)	**06**
Pedagogy	Students should be given suitable explanation, with revision the of theoretical aspects of experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. G.H. Jeffery, J. Bassett, J. Mendham, R. C. Denny.*Vogel's Textbook of Quantitative Chemical Analysis,* 5th edition, Longman Scientific and Technicals , England.1989 2. Brian S. Furniss, Antony J. Hannaford, Peter W.G.Smith, Austin R. tatchell.*Vogel's Textbook of practical Organic chemistry,*5th edition,8th impression 2011 Publisher-Person education Ltd England 1989	

	3. National Research council of Naional Academies, *Prudent Practices in Laboratory-handling and management of chemical hazards.* The National Academies press. Washington D.C 2001 4. John O'M Bockris, Amulya K.. Reddy *Modern Electrochemistry 1 Ionics ,*2nd Edition, ,Publisher-Springer, UK 1989 5. John Kenkel, *Analytical chemistry for Technicians* 4th edition, CRC press, Tylor & Francis Group, Boca Raton, London, 2013
Course Outcome:	At the end of the course student will be able to- 1. implement necessary precaution while working in chemical laboratory 2. apply procedure of management, purchase and storage. 3. identify and classify common glassware and apparatus, prepare standard solutions and know the basics of Identify and classify different glasswares 4. Prepare solution of different strength/volume and know the different terms used for labeling concentration. 5. Identify and classify different types electrodes 6. Interpret hazard symbols and labels of supplied commercial chemicals

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHE-162 (Exit Course)**
Title of the course : **Basic Techniques in Qualitative and Quantitative Analysis**
Number of Credits : **1T+3P**
Effective from AY : **2024-25**

Prerequisites for the course	NIL	
Course Objectives:	1. To understand the various steps involved in common laboratory techniques of separation and purification. 2. To acquire knowledge of various concepts of volumetric analysis and inorganic qualitative analysis	
Content		**No. of hours**
	1. Common Laboratory Techniques Refluxing: Apparatus with interchangeable ground glass joints (Quick fit). Filtration: Techniques and filter media, filter paper, simple filtration. Recrystallization: Choice of solvent and precautions with flammable solvents. Distillation. Determination of Physical constants (melting and boiling points)	**05**
	2. Principles of Volumetric and Qualitative Analysis Purity of reagents, Primary and Secondary standards Types of Titrations: Acid base titration, Redox titration, Internal and External Indicators, Precipitation titration and Complexometric titration. Common Ion effect.	**10**
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature	
References / Readings	1. Svehla,G.,Vogel's textbook of Macro and semimicro qualitative Inorganic Analysis, 7th edition Longman Group Limited, London. 2012. 2. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C., Vogel's textbook of chemical quantitative analysis, 5th edition Longman Scientific & Technical, U K. 1989. 3. Ahluwalia,V. K., Aggarwal, R., Comprehensive Practical Organic Chemistry, Universities Press India limited, India. 2000. 4. Bansal,R. K., Laboratory Manual of Organic Chemistry, 5th revised edition New Age International Publishers, India. 2008. 5. Khosla, B. D., Garg, V.C., Gulati, A., Senior Practical Physical Chemistry, 9th edition , R. Chand & Co, India. 2019. 6. Pandey,O. P., Bajpai, D.N., Giri, S., Chemistry Practical,revised edition S. Chand Publishers, India. 2013. 7. Singh, J., Singh, R.K p., Singh, J., Yadav, LD.S., Siddhiqui, I.R., Srivastava, J., Advanced practical chemistry, latest edition, Pragati Prakashan, India.2016.	

Number of Credits: 03 (Practicals)

Course Objectives:	1. To acquire knowledge in different volumetric and inorganic qualitative analysis.

	2. To acquire skills in performing various methods of purification for organic compounds.	
Content		**No. of hours**
	1. To prepare 0.1 N NaOH and standardise it using 0.1N KHP.	**02**
	2. To determine the strength of HCl using standardised 0.1 N NaOH solution	**02**
	3. To determine the strength of acetic acid in vinegar using standardised 0.1 N NaOH solution.	**02**
	4. Purification of organic compounds by sublimation i) Anthracene ii) Acetanilide.	**04**
	5. Purification of organic compounds by recrystallization. Benzoic acid, β-Naphthol, m-nitroaniline, acetanilide	**06**
	6. Preparation of inorganic double salts, potash alum Ferrous ammonium sulphate and potassium ferric oxalate	**12**
	7. To separate and detect group II metal ions by paper chromatography.	**04**
	8. To separate and detect organic compounds by Thin layer chromatography.	**04**
	9. To prepare 0.1N $KMnO_4$ and standardise it using 0.1N $Na_2C_2O_4$.	**04**
	10. To determine the strength of (approx) 0.1N $FeSO_4$ using 0.1N sodium oxalate by the method of redox titration.	**04**
	11. To determine the salinity of sea water using 0.1N $AgNO_3$ by the method of precipitation titration using Mohr's method.	**04**
	12. To prepare 0.01M disodium salt of EDTA and standardise it using 0.01M $ZnSO_4$.	**04**
	13. To determine the amount of$MgSO_4.7H_2O$ by the method of complexometric titration using 0.01 M disodium salt of EDTA.	**04**
	14. To determine pH of fruit juices and soft drinks.	**02**
	15. To identify the cations present in the given mixture by semi micro qualitative analysis (two mixtures).	**04**
	16. To identify the anions present in the given mixture by semi micro qualitative analysis (two mixtures).	**04**
	17. To prepare acidic buffer and determine its buffer capacity.	**04**
	18. To prepare basic buffer and determine its buffer capacity.	**04**
	19. Identification of unknown organic compounds. (4 compounds: 2 solids and 2 liquid)	**08**
	20. Chemical tests to identify fats, carbohydrates and proteins.	**04**
	21. Purification of organic liquids by distillation (1 mixtures)	**02**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Svehla G., Vogel's textbook of Macro and semimicro qualitative Inorganic Analysis, 7th edition Longman Group Limited, London. 2012. 2. Jeffery, G.H., Bassett, J., Mendham, J., Denney, R.C., Vogel's textbook of chemical quantitative analysis, 5th edition Longman Scientific & Technical, U K. 1989.	

	3. Ahluwalia, V. K., Aggarwal, R., Comprehensive Practical Organic Chemistry, Universities Press India limited, India. 2000. 4. Bansal, R. K., Laboratory Manual of Organic Chemistry, 5th revised edition New Age International Publishers, India. 2008. 5. Khosla, B. D., Garg, V.C., Gulati, A., Senior Practical Physical Chemistry 18th edition, R. Chand & Co, India. 2018. 6. Pandey, O. P., Bajpai, D.N., Giri, S., Chemistry Practical, revised edition S. Chand Publishers, India. 2013. 7. Singh, J., Singh, R.K p., Singh, J., Yadav, LD.S., Siddhiqui, I.R., Srivastava, J., Advanced practical chemistry, latest edition Pragati Prakashan, India. 2016.
Course Outcome:	Students will be able to: 1. perform experiments using common laboratory techniques of separation and purification. 2. apply theoretical concepts of volumetric and inorganic qualitative analysis in experiments. 3. perform different types of volumetric and inorganic qualitative analysis. 4. perform purification of organic compounds using various methods. 5. perform roles of well trained Staff /Technicians /Assistants to work in chemistry labs, especially at the schools, Colleges, industries more efficiently and productively.

Semester V
Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC-300
Title of the course : Organic Chemistry II
Number of Credits : 3T+1P
Effective from AY : 2025-26

Prerequisites for the course	Students should have knowledge of organic reactions, stereochemistry, spectroscopy and natural products	
Course Objectives:	1. To predict aromaticity and mechanism for electrophilic aromatic substitution of benzene. 2. To understand the stereochemical reactions. 3. To acquire knowledge of carbohydrate and amino acid chemistry. 4. To understand and apply enolate chemistry. 5. To understand Infrared spectroscopy and solve problems based on it. 6. To understand mechanism of different name reactions and rearrangements.	
Content		**No. of hours**
	1. Aromaticity and electrophilic substitution reactions: Huckel's rule of Aromaticity (4n+2) Rule, 4n Rule for antiaromaticity, Electrophilic Aromatic substitution (w.r.t Benzene): Mechanism of Nitration, Sulphonation, Halogenation, Friedel – Crafts alkylation and acylation. Reactivity and orientation of activating, deactivating groups (ortho, para and meta effects) with examples.	**06**
	2. Stereochemical reactions Stereospecific and stereoselective reactions. Addition of bromine to 3-Hexene with mechanism. Regioselectivity in addition of hydrogen halides to alkenes: Markownikoff's and anti-Markownikoff's addition. Substitution reactions: SN1, SN2, SNi reactions with mechanisms. Elimination reactions: E1, E2, E1cb reactions with mechanism.	**07**
	3. Chemistry of Natural Products -I Amino Acids and Peptides: Terms: Zwitterion, Isoelectric point and Electrophoresis. Preparation of Amino Acids: Strecker synthesis, Gabriel's phthalimide. Synthesis of simple peptides (upto dipeptides) Bergmann's method. Carbohydrates: Classification and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, Osazone formation, Killiani Fischer synthesis.	**08**
	4. Infra-Red Spectroscopy in Organic Chemistry Principle of IR Spectroscopy (Hooke's law), types of molecular vibrations (Stretching and bending). Functional group region and Fingerprint region. Applications of IR Spectroscopy: Functional group analysis, detection of purity of sample, establishing the identity of an unknown molecule, Effect of H-bonding, conjugation, resonance and ring size on IR absorptions. To study	**06**

	the progress of a reaction. Problems based on IR spectroscopy (ketone, aldehyde, ester, acid & alcohol).	
	5. Chemistry of Enolates Chemistry of Enolates. Definition of enolate ion, acidity of carbonyl compounds, pka values, generation of enolate ion, role of bases in enolate ion formation, alkylation of carbonyl compounds with reference to cyclohexanone, acetone, ethylacetoacetate, malonic ester. Claisen condensation for preparation of ethylacetoacetate (reaction and mechanism). Keto-enol tautomerism of ethylacetoacetate. Malonic ester synthesis of carboxylic acids, ethylacetoacetate synthesis of ketones. Alkylation of 1,3-dithianes. Alkylation via enamine synthesis.	**10**
	6. Name Reactions and Rearrangements -I Reaction and mechanism of the following: Benzoin, Aldol, Knoevanagel, Michael addition. Rearrangement with mechanism: Beckmann, and Wolff. Reaction and two applications of Diekmann, Stobbe, Favorskii and Hofmann Rearrangement.	**8**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Kemp, W., *Organic spectroscopy*, 3rd ed., Palgrave Macmillan, New York, USA, 1991. 2. Pavia, D. L., Lampman, G. M. and Kriz, G. S., *Introduction to Spectroscopy*, 3rd ed., Thomson Learning, Fort Worth, USA, 2001. 3. Silverstein, R. M. and Webster, F., *Spectrometric Identification of Organic Compounds*, 5th ed., John Wiley & Sons, New York, USA, 2006. 4. Graham Solomons, T.W., Fryhle, C.B. and Snyder, S. A., *Organic chemistry*, 12th ed., John Wiley & Sons, New Jersey, USA, 2016. 5. McMurry, J., *Fundamentals of organic chemistry*, 7th ed., Cengage Learning India Edition, Noida, India, 2013. 6. Sykes, P., *A guidebook to mechanism in organic chemistry*, 6th ed., Longman Scientific & Technical, England, UK, 1985. 7. Finar, I. L., *Organic Chemistry* (Vol. I), 6th ed., Pearson Education, India, 1973. 8. Finar, I. L., *Organic Chemistry* (Vol. II), 3rd ed., Longmans, London, UK, 1964. 9. Morrison, R.T., Boyd, R.N. and Bhattacharjee, S. K., *Organic Chemistry*, 7th ed., Pearson, 2010. 10. Bahl, A. and Bahl, B.S., *Advanced Organic Chemistry*, S. Chand, New Delhi, India, 2012. 11. Carey, F., *Organic Chemistry*, 4th ed., McGraw Hill, New York, USA, 2000. 12. Bruice, P. Y., *Organic Chemistry*, 3rd ed., Pearson Education, Asia, 2014. 13. March, J., *Advanced Organic Chemistry*, 4th ed., John Wiley, New Jersey, USA, 2007. 14. Nasipuri, D., *Stereochemistry of Organic compounds - Principles and Applications*, 4th ed., New Academic Science, Kent, UK, 2012.	

	15. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 16. Potapov, V. M., *Stereochemistry*, Mir Publishers, Moscow, Russia,1979. 17. Kalsi, P. S., *Spectroscopy of Organic compounds*, 6th ed., New Age International Publishers, New Delhi, India, 2004.

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic preparation experiments. 3. To acquire hands on training in organic qualitative analysis.	
Content		**No. of hours**
	I. Organic preparations List of organic preparations to be performed. Purification by recrystallization, calculation of % yield and determination of melting point. (**Any 5)** a) Chalcone from acetophenone and benzaldehyde b) Benzoin from Benzaldehyde c) Cinnamic acid from benzaldehyde d) Acetanilide from acetophenone oxime e) Hippuric acid from glycine f) *m*-dinitrobenzene from nitrobenzene g) diazoaminobenzene from aniline	**15**
	II. Organic Estimations experiments (Any 3) a) Estimation of acid and amide. b) Estimation of acid and ester. c) Estimation of number of acetyl groups. d) Estimation of Saponification value of castor oil.	**12**
	III. Interpretation of Infra-Red Spectra (Any 5) Benzoic acid, *p*-nitroaniline, benzil, chalcone, cinnamic acid, ethanol, acetone, acetophenone, ethyl acetate.	**03**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5thed., Pearson Education Ltd., London, UK 2011. 2. Pasto, D., Johnson C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA,1992. 4. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2016.	
Course Outcome:	At the end of the course, students will be able to: 1. Identify aromatic, antiaromatic and non-aromatic compounds and explain stereochemistry of organic reactions. 2. Apply enolate chemistry in reaction mechanisms. 3. Write mechanism for name reactions and rearrangements.	

	4. Interpret Infrared spectra of organic compounds. 5. Synthesize some organic compounds. 6. Identify the functional groups present in organic compounds using Infrared spectroscopy. 7. Estimate organic compounds quantitatively. 8. Apply theoretical knowledge in understanding laboratory skills.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-301**
Title of the course : **Inorganic Chemistry - II**
Number of Credits : **3T+1P**
Effective from AY : **2025-26**

Pre-requisites for the Course	Student should have knowledge of periodic properties, solid state chemistry and coordination chemistry	
Course Objectives:	1. To study the preparations, chemical properties, structure and bonding of halogen compounds. 2. To understand fundamentals of the metal ligand bond in accordance with VBT and CFT. 3. To learn the fundamentals of solid-state chemistry, superconductivity and to study their applications. 4. To comprehend the concepts of acid bases and non-aqueous solvents.	
Content		**No of hours**
	1. Chemistry of halogens Introduction to Group 17: General methods of preparation, structure, bonding and chemical properties of: i) Interhalogens ii) Polyhalides ions iii) Oxoacids of halogens in different oxidation states	**08**
	1. Coordination Chemistry-I Valence Bond Theory: Hybridisation of the central metal orbitals sp^3, dsp^2, sp^3d/dsp^3, sp^3d^2/d^2sp^3 Inner and Outer orbital complexes (suitable examples), electroneutrality principle and limitations of Valence Bond Theory. Crystal field theory: Postulates, effect of crystal field on central metal valence orbitals in various geometries. splitting of *d* orbitals in octahedral and tetrahedral crystal fields. Crystal field splitting parameters Δ, factors affecting Δ, Spectrochemical series. Crystal Field Stabilization Energy (CFSE), calculation of CFSE, for octahedral complexes with d^1 to d^{10} metal ion configuration. Consequences of crystal field splitting on various properties such as ionic radii, hydration energy, lattice energy, enthalpies of formation, colour and magnetic properties. Limitations of CFT. Evidences for covalency in metal complexes: i) intensities of d-d transitions, ii) ESR spectrum of $[IrCl_6]^{2-}$, iii) Nephelauxetic effect iv) NMR spectra.	**15**
	3. Acid Bases and Non-aqueous Solvents Arrhenius theory, Lowry-Bronsted theory, Lux–Flood, Solvent systems and Lewis concept of Acids and Bases, HSAB Concept of Acids and Bases, Classification of solvents and importance of non-aqueous solvents. Supercritical carbon dioxide and ionic liquids as solvents. Levelling effect, reactions in non-aqueous solvents with respect to liquid NH_3, liquid SO_2 and liquid HF.	**08**
	4. Introduction to Solid State Chemistry Structures of Solids: Importance of solid-state chemistry, types of solids, crystal lattice, lattice points, unit cells and lattice constants. Close packing of rigid spheres (hcp, ccp), packing	**10**

	density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). Relationship between density of unit cell and lattice parameters (numerical problems expected). Tetrahedral and octahedral interstitial voids in ccp lattice, limiting radius ratios of different coordination numbers and their significance. Calculation of limiting radius ratio for coordination number	
	5. Superconductivity Discovery of Superconductivity. Explanation of terms: Superconductivity, Transition temperature and Meissner effect. Different types of superconductors viz, conventional superconductors, organic superconductors, alkali metal fullerides and high temperature superconductors.	**04**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / industrial visit, self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning	
References / Readings	1. P.L. Soni and Mohan Katyal, Textbook of Inorganic Chemistry by, Sultan Chand and Sons, 20th Edition (1997) 2. Puri, Sharma and Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing Co. (2018). 3. J.D. Lee, Concise Inorganic Chemistry by Chaman and Hall, 5th ed. (1996). 4. J.C. Kotz, Paul M. Treichel, Grabriela C. Weaver, Chemistry and Chemical Reactivity, 6th Edn. Thomson Books/Cole (2006). 5. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd Ed.; Wiley, (Reprint 2008). 6. N. N. Greenwood, A. Earnshaw, Chemistry of the Elements, Pergamon Press, 1st Ed.; (1984). 7. Glen E. Rodgers, Inorganic Chemistry, 3rd Edn. Brooks/Cole (2012). 8. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 3rd Edn. 9. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins, Inorganic Chemistry, 5th Ed.; Oxford Publications, (2009). 10. J.E. Huheey, E.A. Keiter, R.L. Keiter, U.K. Medhi, Inorganic Chemistry – Principles of structure and reactivity by, 1st impression (2006) Pearson Education Publishers. 11. K. V. S. Laxmi Devi, N. C. Patel, S.S. Dhume, A. Venkatachalam, S. P. Turakhia, Chhaya Dixit and R. A. Mirji, College Inorganic Chemistry for T.Y. B. Sc. 21st Edn, Himalaya Publishing House 12. Sharpe, Inorganic Chemistry, 3rd Edn. Pearson Education (2009). 13. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry- An Introduction, 3rd Edn. Taylor and Francis, (2005)	

Practical	**Credits: 01**	
Course objectives	1. To use various titrimetric techniques to estimate the analytes. 2. To perform gravimetric methods to estimate metal ions. 3. To prepare coordination compounds.	
Content		
	Volumetric Analysis	

	1. Determination of the strength of the given H_2O_2 solution using N/20 $KMnO_4$ solution. 2. Estimation of the amount of aluminium in the given aluminium sulphate solution by EDTA method (Back titration).	**2x4=8**
	Gravimetric Analysis 3. Estimation of iron as Fe_2O_3 and Ba as $BaSO_4$ from the given solution of ferric chloride, barium chloride and free HCl. 4. Estimation of barium as $BaCrO_4$ and Fe as Fe_2O_3 from the given solution of barium chloride**,** ferric chloride and free HCl. 5. Estimation of Zn as zinc pyrophosphate in the solution of zinc chloride containing free HCl. 6. Estimation of Ni as Ni-DMG in the solution of nickel chloride containing copper chloride and free HCl.	**4x4 = 16**
	Inorganic Preparations (ANY TWO) 7. Bis-(ethylenediamine)copper (II) sulphate. 8. Preparation of diaquabis-(acetylacetonato)nickel (II) 9. Preparation of tris-(ethylenediamine)nickel (II) thiosulphate	**2x3 = 6**
Pedagogy:	1. Students shall be given pre-lab and post-lab assignments 2. Theoretical concept underlying the experiments prior to each experiment. 3. Each student shall perform the experiments independently.	
References / Readings	1. Svehla G. Vogel's Qualitative Inorganic analysis. Seventh Edition. Pearson Education Ltd. 2. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edn. Pearson Education. 3. O. P. Pandey, D. N. Bajpai and S. Giri, Practical Chemistry, Revised Edn. S. Chand.	
Course Outcomes	At the end of the course, students will be able to: 1. explain the preparations, chemical properties, structure and bonding in halogen compounds. 2. apply and differentiate VBT and CFT approaches for Metal-ligand bonding. 3. explain the fundamentals of solid-state chemistry, superconductivity and their applications. 4. correlate the concepts of acid bases and non-aqueous solvents 5. perform the redox and complexometric titrations. 6. explain the chemistry behind the strategies used for the removal of interfering ions in gravimetric estimations. 7. develop experimental skills in inorganic preparations.	

Name of the Programme : B.Sc. Chemistry
Course Code : CHC – 302
Title of the course : Physical Chemistry II
Number of Credits : 3T+1P
Effective from AY : 2025-26

Pre-requisites for the Course	Students should have studied electrochemistry, quantum chemistry and spectroscopy	
Course Objectives:	1. To introduce the fundamentals of electrochemistry. 2. To understand and apply the concepts of quantum mechanics. 3. To learn the principles of vibrational and rotational spectroscopy.	
Content		**No of hours**
	1. Electrochemistry-I Conductivity: Equivalent and molar conductivity and the effect of dilution for weak and strong electrolytes. Arrhenius theory of ionisation, Ostwald dilution law. Debye-Hückel theory and its limitation. Debye Hückel-Onsager equation. Kohlrausch's law of independent migration of ions. Ionic mobility and factors affecting ionic mobility. Transference number and its experimental determination using moving boundary methods, Hittorf method. Applications of conductance measurements: hydrolysis and hydrolysis constant, solubility and solubility products of sparingly soluble salts, ionic product of water, conductometric titrations (only acid-base). EMF of a cell and its measurements, reversible cells and irreversible cells, types of reversible electrodes. Concentration cells (both electrodes and electrolytes) with and without transference, liquid junction potential and its measurements. (Numericals to be solved)	**15**
	2. Quantum Chemistry-I De-Broglie hypothesis, experimental verification of De Broglie Hypothesis, Heisenberg uncertainty principle, Derivation of Heisenberg's uncertainty principle, sinusoidal wave function, eigen value and eigen functions, physical significance of wave function. Terms involved in Quantum mechanics: Normalisation, orthogonality, observables, degeneracy, forbidden transitions and stationary state, Operators (linear, non-linear, Hermitian, non-Hermitian, Hamiltonian Operator) and commutation rules, Postulates of quantum mechanics, Schrödinger equation and its application to free particle and "particle in a box" (rigorous treatment), quantisation of energy levels, zero – point energy. (numericals to be solved).	**15**
	3. Molecular Spectroscopy -I Interaction of electromagnetic radiation with molecules and various types of spectra, Born-Oppenheimer approximation. a. Rotational Spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. b. Vibrational spectroscopy: Classical equation of vibration, computation of force constant, anharmonicity, Morse potential,	**15**

	dissociation energies, fundamental frequencies, overtones, hot bands, degree of freedom for polyatomic molecules, modes of vibration (H_2O and CO_2), concept of group frequencies. Vibration–rotation spectroscopy: Diatomic vibrating rotator, P, Q, R branches. c. Raman spectroscopy: Raman effect, qualitative treatment of Rotational Raman effect, Vibrational Raman spectra, Stokes and Anti-stokes lines, their intensity difference, Quantum and Classical theories of Raman effect, rule of mutual exclusion principle. (numericals to be solved)	
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations/ self-study or a combination of some of these can also be used. ICT modeshould be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. Banwell, C.N. & McCash, E.M., Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill, New Delhi, 2006. 2. Ira N. Levine, Quantum chemistry, 7th edition, Pearson India Education Pvt. Ltd., 2016, Noida. 3. Donald A. McQuarrie, John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd., 2018, Mumbai, 1st edition. 4. J.N. Gurtu, Physical Chemistry Vol-III, A Pragati Prakashan edition, 2020, Meerut, 9th edition. 5. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye, V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan, Girgaon, Mumbai, 5th edition, 1994. 6. Gurdeep Raj, Advanced Physical Chemistry Goel Publication 36th Edition, 2010, Meerut. 7. Chandra, A.K., Introductory Quantum Chemistry, Tata McGraw –Hill (2001), New Delhi, 4th edition. 8. J. E. House, Fundamentals of Quantum Chemistry, 2nd edition, Elsevier, USA, 2004. 9. Lowe. J.P. & Peterson., K., Quantum Chemistry, Academic Press, 2005, USA, 3rd edition.	

Practicals: Credits: 01

Course Objectives:	1. To understand the different techniques in electrochemistry. 2. To acquire knowledge of the types of spectra. 3. To obtain information on plotting wave functions.	
Content		**No of hours**
	1. To determine the cell constant using 0.1N and 0.02N KCl solution. 2. To verify Ostwald's dilution law using acetic acid. 3. To determine the percentage composition of acid mixture (strong acid and weak acid) by titrating against standard 0.1N NaOH. 4. To determine standard oxidation potential of Cu/Cu^{+2} and Zn/Zn^{+2} 5. To determine solubility product of AgCl using potentiometer. 6. To determine formal redox potential of Fe^{+2}/Fe^{+3} system using 0.1N $K_2Cr_2O_7$.	**2** **4** **4** **4** **4** **4**

	7. To plot the orthonormal wavefunctions of a particle in a one-dimensional box. 8. Using vibrational-rotational spectra of HCl and HBr molecules a) Assign the rotational lines to various transitions. b) Calculate: i) The value of B_0 and B_1, for R and P branches of spectra ii) Vibrational frequency and iii) Internuclear distance.	**4** **4**
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment. Pre- and post-laboratory assignments to be given. Each student performs the experiment individually.	
References / Readings, References for practicals	1. W. Rajbhoj and T.K. Chondhekar, Anjali Publication, Systematic experimental Physical Chemistry, 2000, Aurangabad, 2nd edition. 2. P. S. Sindhu, Practicals in Physical Chemistry, Macmillan India Publication, 2006, New Delhi, 1st edition. 3. B. Viswanathan and P.S Raghavan, Practical Physical Chemistry, Viva Books Private Ltd, 2005, Mumbai. 4. Khosla, B. D.; Garg, V. C. &Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co., New Delhi, 2018, 18th edition	
Course Outcome:	At the end of the course, students will be able to: 1. differentiate between the types of cells used in electrochemistry. 2. use quantum operators for solving numericals. 3. identify and predict structure of molecules using vibrational and rotational spectra. 4. perform conductometric and potentiometric measurements. 5. measure standard oxidation potentials of various metal/metal ion electrodes. 6. calculate internuclear distance of molecules from vibrational-rotational spectra.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-303**
Title of the course : **Green Chemistry Techniques**
Number of Credits : **2T**
Effective from AY : **2025-26**

Prerequisites for the course	Should have knowledge of chemical reactions	
Course Objectives:	1. To understand solvent-free and safer solvent organic reactions. 2. To demonstrate the role of green catalysis in organic reactions. 3. To acquire knowledge on modern green techniques.	
Content		**No of hours**
	Introduction to Green chemistry and 12 principles	**01**
	Mechanogrinding and safer solvents Solvent free reaction: Grinding Techniques-Aldol condensation between 3,4-dimethoxybenzaldehyde and 1-indanone. Procedure, advantages and drawbacks. Ball milling technique, Principle, instrumentation, working, advantages, disadvantages, one application. Water as green solvent with an example-Diels Alder reaction-Theory on how water works as solvent, advantages, disadvantages. Supercritical liquids: Procedure for extraction of D-limonene from orange peels. Advantages of using $ScCO_2$. Ionic liquids as designer solvent giving reasons. Preparation of [Bimim] BF_4^-, example giving reaction using ionic liquids-Green preparation of 1-acetyl ferrocene. Deep eutectic solvent- Properties and one application with example of choline chloride and urea.	**09**
	Green Catalysis Define catalysis. Types of catalysis, homogeneous and heterogeneous. Types of green catalysis Definition: Solid supported reagents- Advantages and disadvantages, examples $NaBH_4$- Alumina and PCC-silica giving one application of each. Biocatalyst or natural catalysts-Thiamine hydrochloride in benzoin condensation and L-Proline for enantioselective aldol reaction (only reaction to be given). Advantages of L-Proline and Thiamine HCl. Phase transfer catalysis: Definition, Phase Transfer catalyst, Mechanism of PTC, Advantages and application in Chemistry-Using 18-crown-6 ether or ammonium salt.	**10**
	Modern Green Techniques Microwave heating technique: Principle-Convection, dipolar ionisation, working, advantages and limitations. Green synthesis of metallophthalocyanine complexes with reaction and procedure. Ultrasonication technique: Principle-Acoustic Cavitation with diagram, working, advantages and limitations. Preparation of Grignard reagent by ultrasonication method. Photochemistry: Principle of photochemical reaction. Organic photochemical reactions with two examples. Role as a green technique-Advantages and drawback.	**10**

Issued on: 05/03/2025

	Electrochemistry: Principle of an electrochemical reaction. Electrochemical set up diagram. One application, advantages and limitations. Flow Chemistry: Principle, one application. Advantages over batch process.	
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Anastas, P. T., and Warner, J. K., *Green Chemistry-Theory and Practice*, Oxford University Press, UK, 2000. 2. Sharma, R. K., Sidhwani, I. T., and Chaudhari, M. K., *Green Chemistry Experiments: A monograph,* I. K. International Publishing House Ltd. New Delhi, 2012. 3. Ahluwalia, V. K., *Green Chemistry: Environmentally Benign Reactions*, Anne Books India, New Delhi, 2006. 4. Cann, M. C., and Connely, M. E., *Real-World cases in Green Chemistry*, American Chemical Society, Washington, 2000. 5. Waber, W. P., and Gokel, G. W., *Phase Transfer Catalysis in Organic Synthesis*, Springer Berlin, Heidelberg, 1977. 6. Ahluwalia, V. K., and Aggarwal, R., *Organic Synthesis-Special Techniques*, Narosa Publishing House, New Delhi, 2001. 7. Kappe, C. O., Stadler, A., and Dallinger, D., *Microwaves in Organic and Medicinal Chemistry,* Second revised edition, John Wiley & Sons, Darmstadt, Germany, 2012. 8. Ahluwalia V.K., and Kidwai M., *New trends in Green Chemistry*, Kluwer Academic Publishers, Dordrecht, The Netherlands, 2004. 9. Vacarro, L., *Sustainable flow chemistry: methods and Applications*, John Wiley and Sons Publishers, Weinheim, Germany, 2017. 10. Darvas, F., Hessel, V., and Dorman, G., *Flow Chemistry Vol 1 and II (Fundamentals and Applications)*, Walter de Gruyter GmbH & Co KG, Germany, 2014. 11. Desai, K. R., *Green Chemistry Microwave synthesis*, revised edition, Himalaya Publishing house, India, 2010. 12. Pletcher, D., *Guide to Electrochemical Technology for Synthesis, Separation and Pollution Control,* Electrosynthesis Company, Inc., Lancaster, NY,1999. 13. Rohatgi-Mukherjee, K. K., *Fundamentals of Photochemistry*, revised second edition, New Age International Publishers, New Delhi, 2006. 14. DuPay, C. H., and Chapman, O. L. *Molecular Reactions and Photochemistry*, Englewood Cliffs, N. J., Prentice-Hall, Englewood Cliffs NJ, 1972. 15. Crow, D. R., *Principles and Applications of Electrochemistry*, Fourth Edition, CRC Press, Boca Raton, FL, USA, 1994.	
Course Outcome:	At the end of the course, students will be able to 1. Apply the knowledge of safer solvents in designing synthesis of organic compounds. 2. Demonstrate the role of catalysis in organic synthesis 3. Apply the knowledge of modern green techniques in organic synthesis.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-321 (Minor Vocational-2)**
Number of Credits : **3T+1P**
Title of the course : **CHEMISTRY OF FOOD AND NUTRIENTS**
Effective from AY : **2025-26**

Pre-requisites for the course	NIL	
Course Objectives:	1. To acquaint students with the chemical constituents of food, their interactions during processing, and evaluation of varied characteristics of food. 2. To familiarize students with the classification of foods and nutrients, and their metabolism in the human body. 3. To understand adulterants in food and their characteristics. 4. To familiarize with the laws and regulations on food adulteration.	
Content		**No. of Hours**
	Unit 1: Basic concept on Food, Nutrition and Nutrients Definition of nutrition, nutrients, adequate, optimum and malnutrition, Classification of Food, Classification of Nutrients. and Functions	**04**
	Unit 2: Carbohydrates & Lipids Carbohydrates: Definition, classification, structure and properties, sources, daily requirements, functions. Effects of too high and too low carbohydrates on health. Lipids : Classification, nomenclature, saturated, unsaturated fatty acids, food sources, functions of fats. Definition, classification & properties, daily requirements, role and nutritional significances of PUFA, MUFA, SFA and W-3 fatty acid.	**10**
	Unit 3: Proteins Definition, Classification, Structure & properties. Effect of too high - too low proteins on health. Assessment of Protein quality (BV, PER, NPU), denaturation of proteins Amino acids: Classification, types, functions. Proteins - Sources, daily requirements, functions.	**05**
	Unit 4 : Fats and Oils Introduction, structure, rancidity, reversion, factors leading to rancidity and reversion, prevention of rancidity, effect of heat on fats and oils, polymerization, extraction of fats and oils, refining, hydrogenation of oils.	**05**
	Unit 5 : Vitamins, Minerals & Trace Elements Classification, sources and functions, water soluble and fats soluble vitamins, bio-chemical and physiological role, bio-availability & requirements, sources, deficiency & excess of Vitamins and minerals (calcium, sodium, potassium phosphorus, iron, fluoride, zinc, selenium, iodine, chromium).	**08**
	Unit 6: Water Types of water, hydrogen bonding in water, water and ice properties, functions of water in food functions, daily requirements, water balance	**04**
	Unit 7: Food adulteration, Food Laws & Regulations	**09**

Issued on: 05/03/2025

	Adulteration: definition, types-intentional, incidental, metallic and packaging hazard. Causes and methods of food adulteration. General impact on human health. Detection and prevention of food adulteration. Nature of adulterants, methods of detection of food adulterants and toxic constituents in foods, common food adulterants & their detection. Food additives: Definition, classification, role of additives in processed foods. Safe levels of additive uses and the institutions involved in the process. Food Laws & Regulations: Role of FDA, Prevention of Food Adulteration Act 1954, Food Safety and Standards Act (2006), Food Safety and Standards Authority of India (FSSAI), BIS, FPO, APEDA.	
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Agarwal A and Udipi SA. Textbook of Human Nutrition. Jaypee Brothers Medical Publishers (P) Ltd. New Delhi, 2014. 2. Bamji MS, Krishnaswamy K, and Brahmam GNV. Textbook of Human Nutrition. 3rd Edition. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi, 2009. 3. Sunetra Roday, Food Science and Nutrition,1st edition, Oxford Higher Education, New Delhi, 2008 4. Belitz H.-D, Grosch W, and Schieberle P. Food Chemistry.4th Edition. Springer.New York 2009. 5. Damodaran S and Parkin K. Fennema's Food Chemistry. 5th . CRC Press, Boca Raton. 2017. 6. A.Y. Sathe, First course in Food Analysis, New Age International (P) Ltd., 1st New Delhi,1999. 7. Siva Kiran, R.R. Manual for Detection of Common Food Adulterants, 1st Edition, Banglore, IAPEN. (2012). 8. Battershal, J.P. Food Adulteration and its detection, General Books LLC.NewYork (2013). 9. Jaiprakash Bhatnagar, shailendra Kumar Awasthi, Prevention of Food Adulteration Act, FSSAI, 4th Edition, Ashoka Law House,New Delhi, 2002.	
PRACTICALS (30 hours)		
Practical Course Objectives:	1. To introduce students to basic chemistry involved in analysis of different components of food. 2. To develop skill to analyze nutrients and minerals in different types of food. 3. To distinguish between the pure and adulterated food. 4. To analyse the adulterants in food.	
Content		**No. of hours**

	1. Estimation of acid value of fat/ oil. 2. Estimation of iodine value of fat. 3. Estimation of saponification value of fats. 4. Quantitative estimation of sugars by titrimetric method 5. Determination of calcium and magnesium in leafy vegetables by EDTA titration. 6. Determination of iron in leafy vegetables by redox method. 7. Estimation of amount of salt in butter by Mohr titration 8. Estimation of Vitamin C in citrus fruits by acid base titrimetric method. 9. Estimation of iodine in iodized common salt using iodometry. 10. Quantitative estimation of proteins by Folin-Lowry method. 11. Separation of amino acids by Thin Layer Chromatography. 12. Detection of adulterants in food items. a) Turmeric powder b) Black pepper c) Sugar /dextrose from Honey	02 02 02 02 04 04 02 02 02 02 02 04
References / Readings	1. S. Suzanne Nielsen, Food Analysis Manual, 2nd Edition Publisher Springer, UK 2015. 2. The Food Chemistry Laboratory: A Manual for Experimental Foods, Dietetics, and Food Scientists by Connie M. Weaver and James R. Daniel, 2nd edition, CRC Press, New York, 2003 3. Anil J. Elias. A Collection of General Chemistry Experiments, Universities Press, Revised Edition, Hydrabad, 2007 4. Manual Of Methods of Analysis of Foods (Milk and Milk Products)- Directorate General of Health Services Ministry of Health and Family Welfare Government of India New Delhi, 2005, 5. (FSSAI)Manual of methods of analysis of foods honey& other bee hive products New Delhi, India 6. Manual of methods of analysis of foods food safety and standards authority of India ministry of health and family welfare government of India new Delhi 2015 7. Food Adulteration Testing Manual (14th Revised Edition) –Consumer Guidance Society of India (CGSI) Mumbai-2019 8. Meyer LH. Food Chemistry. CBS Publishers and Distributors, New Delhi, 2004	
Course Outcome:	At the end of the course, students will be able to: 1. Recognise the role of various types of chemical bonding on physicochemical properties of food. 2. Propose or hypothesise mechanisms for the distribution of nutrients on consumption of complex food items. 3. Debate the fortification of foods on the basis of their composition and functional properties. 4. Explain the laws and regulations related to food adulteration. 5. explain the theory involved in chemical analysis of food. 6. analyse minerals and nutrients in different types of food and food product. 7. suggest the analysis method and identify adulterants in common foods and explain their adverse impact on health.	

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-361 (Internship-2)**
Number of Credits : **2**
Title of the course : **Internship**
Effective from AY : **2025-26**

Pre-requisites for the course	Student should have basic knowledge of Chemistry	
Course objectives	1. To learn the use of instruments and techniques in industry or research institution. 2. To keep abreast with recent developments in research and industry. 3. To learn the work culture and ethics.	
Content		**60 Hrs**
1	**Training in Industry/Institute** The student shall be required to undertake training in an Industry, Institute for a minimum period of 2 weeks or its equivalent and submit a certificate of attendance signed by the Training Coordinator of the respective organization.	
2	**Report writing**	
3	**Presentation and/or group discussion**	
Pedagogy	Hands on training/ Literature review/presentation	
References / Readings	Reading material provided by the industry/institute.	
Course Outcomes	At the end of the course, students will be able to: 1. evaluated the use of specialized instruments for application in chemical analysis. 2. carried out planning of experiments and protocols on the basis of recent advancements in the field. 3. compiled analysis reports and present the document.	

Issued on: 05/03/2025

Semester - VI
Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC-304
Title of the course : Advanced Organic Chemistry I
Number of Credits : 3T+1P
Effective from AY : 2025-26

Prerequisites for the course	Students should have knowledge of spectroscopy, natural products and organic reactions	
Course Objectives:	1. To acquire knowledge of natural product chemistry and heterocyclic chemistry. 2. To understand NMR spectroscopy and solve problems on structure elucidation. 3. To understand mechanism of name reaction and rearrangements.	
Content		**No. of hours**
	1. Chemistry of Heterocyclic compounds Definition of heterocyclic compounds: Organic compounds containing oxygen, sulphur, nitrogen. Classification with examples for three, four, five and six membered heterocycles. Structure, resonance, stability and industrial source of furan, pyrrole, thiophene and pyridine. Preparation of furan, pyrrole and thiophene using Paal Knorr Synthesis. Reactivity of furan, pyrrole and thiophene: Electrophilic substitution at 2/5 position. (Nitration, Friedel-Crafts acylation, Sulphonation, Halogenation). Preparation of pyridine using Hantzsch synthesis. Reactivity of pyridine: Basicity order of pyrrole, pyridine and piperidine. Electrophilic substitution at 3 position. Nucleophilic substitution at 2/4 position. Definition of bicyclic heterocycles with examples. Structure, resonance, stability and industrial source of indole, quinoline, isoquinoline. Preparation of indole using Fischer indole synthesis. Reactivity of Indole: Electrophilic substitution at 3 position. Skraup synthesis of quinoline and Bischler Napieralski synthesis of isoquinoline. Electrophilic substitution at 5 and 8 positions.	**15**
	2. NMR Spectroscopy of Organic Compounds Basic Principles of ^{1}HNMR spectroscopy, Number of signals, Position of signals, Chemical shift: Reference standard, Solvent effect, Shielding and deshielding effect, anisotropic effects in alkenes, alkynes, aldehydes, aromatic compounds, factors affecting chemical shift. Intensity of signals: Peak area and proton counting. Spin-Spin coupling: Coupling constant (J). Interpretation of NMR spectra of simple compounds. (acetone, acetaldehyde, toluene, ethyl bromide, anisole, acetic acid, *t*-butylbenzene, 2- butanone, propene). Simple problems based on NMR spectral data for identification of molecule. Carbon-13 Nuclear Magnetic Resonance Spectroscopy	**12**

Issued on: 05/03/2025

	Principle of ^{13}C spectroscopy. Number of signals: Proton coupled and decoupled spectra (off-resonance). Position of signals. Factors affecting position of signals (hybridisation). Combined Problems based on UV, IR, $^{1}HNMR$ and $^{13}CNMR$ spectroscopy.	
	3. Chemistry of Natural Products -II Terpenes: General classification of terpenes, isoprene rule, special isoprene rule. General methods of structure elucidation. Structure elucidation of α-Terpineol. Synthesis of Terebic acid and terpenylic acid. Synthesis of *α* –Terpineol from *p*-toluic acid. Alkaloids: General methods of structure elucidation. Ziesel's Method, Herzig-Meyer's method, Hoffman's exhaustive methylation method. Structure elucidation of Nicotine. Synthesis of Nicotine from Succinimide. Vitamins and Hormones: Structure elucidation of Vitamin A and Adrenaline. Synthesis of Vitamin A from *β*-ionone and Adrenaline from Catechol.	**12**
	4. Name Reactions and Rearrangements -II Reaction and mechanism of the following: Wittig and Darzens Glycidic ester. Rearrangement with mechanism: Claisen, Curtius. Reaction and two applications of Baeyer Villiger, Appel. Comparison of Clemmensen reduction and Wolff-Kishner reduction with two examples.	**06**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Kemp, W., *Organic spectroscopy*, 3rd ed., Palgrave Macmillan, New York, USA, 1991. 2. Pavia, D. L., Lampman, G. M. and Kriz, G. S., *Introduction to Spectroscopy*, 3rd ed., Thomson Learning, Fort Worth, USA, 2001. 3. Silverstein, R. M. and Webster, F., *Spectrometric Identification of Organic Compounds*, 5th ed., John Wiley & Sons, New York, USA, 2006. 4. Graham Solomons, T.W., Fryhle, C.B. and Snyder, S. A., *Organic chemistry*, 12th ed., John Wiley & Sons, New Jersey, USA, 2016. 5. McMurry, J., *Fundamentals of organic chemistry*, 7th ed., Cengage Learning India Edition, Noida, India, 2013. 6. Sykes, P., *A guidebook to mechanism in organic chemistry*, 6th ed., Longman Scientific & Technical, England, UK, 1985. 7. Finar, I. L., *Organic Chemistry* (Vol. I), 6th ed., Pearson Education, India, 1973. 8. Finar, I. L., *Organic Chemistry* (Vol. II), 3rd ed., Longmans, London, UK, 1964. 9. Morrison, R.T., Boyd, R.N. and Bhattacharjee, S. K., *Organic Chemistry*, 7th ed., Pearson, Bangalore, India, 2010. 10. Bahl, A. and Bahl, B.S., *Advanced Organic Chemistry*, S. Chand, New Delhi, India, 2012. 11. Carey, F., *Organic Chemistry*, 4th ed., McGraw Hill, New York, USA, 2000.	

	12. Bruice, P. Y., *Organic Chemistry*, 3rd ed., Pearson Education, Asia, 2014. 13. March, J., *Advanced Organic Chemistry*, 4th ed., John Wiley, New Jersey, USA, 2007. 14. Nasipuri, D., *Stereochemistry of Organic compounds - Principles and Applications*, 4th ed., New Academic Science, Kent, UK, 2012. 15. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 16. Potapov, V. M., *Stereochemistry*, Mir Publishers, Moscow, Russia,1979. 17. Kalsi, P. S., *Spectroscopy of Organic compounds*, 6th ed., New Age International Publishers, New Delhi, India, 2004. 18. Dyer, J. R., *Applications of Absorption Spectroscopy of Organic compounds*, Prentice Hall of India, New Delhi, India, 1974. 19. Parikh, V.M., *Absorption spectroscopy of organic Molecules*, Addison Wesley Publishing Company, Massachusetts, USA,1974. 20. Williams, D.H and Fleming, I., *Spectroscopic methods in organic chemistry*, 7th ed., Springer Nature, Switzerland, 2019. 21. Joule, J. A. and Mills, K., *Heterocyclic chemistry*, 5th ed., Wiley-Blackwell, New Jersey, USA, 2010. 22. Ahluwalia, V. K. and Parashar, R.K., *Organic Reaction Mechanisms*, 3rd ed., Alpha science International, Oxford, UK, 2006.

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic preparation. 3. To acquire hands on training in organic qualitative analysis.	
Content		**No. of hours**
	I) Binary mixture separation (7 mixtures to be done) a) Solid-solid mixture (3) water insoluble+ water insoluble (2). water soluble +water insoluble (1). b) Solid-liquid mixture (2) c) Liquid-liquid mixture (2)	**28**
	II) Interpretation of ^{1}H and ^{13}C NMR Spectra (Any 2 compounds) (benzoic acid, acetone, benzaldehyde, ethanol, toluene, ethyl acetate, isopropyl benzene).	**02**
Pedagogy	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5thed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA,1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2016.	

Course Outcomes	At the end of the course, students will be able to: 1. Explain the chemistry of simple heterocyclic compounds. 2. Interpret NMR spectra and elucidate structure of organic compounds. 3. Explain chemistry of selected natural products. 4. Write mechanism for selected name reactions and rearrangements. 5. Analyse and identify the structure of organic compounds using NMR spectroscopy. 6. Separate unknown organic mixture and identify the compounds. 7. Apply theoretical knowledge in understanding laboratory skills.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC-305**
Title of the course : **Advance Inorganic Chemistry - I**
Number of Credits : **3T+1P**
Effective from AY : **2025-26**

Pre-requisites for the Course	Students should have studied coordination chemistry and solid-state chemistry	
Course Objectives:	1. To study the theories of metal-ligand bonding in coordination compounds 2. To comprehend the different electronic transitions, ground state terms, and term symbols. 3. To learn about the organometallic compounds and metal complexes in biological systems 4. To study the properties and applications of nanomaterials.	
Content		**No of hours**
	1. Co-ordination Chemistry II Ligand Field Theory (Adjusted Crystal Field Theory), Molecular Orbital Theory (MOT) of Coordination Compounds: Identification of central metal orbitals and their symmetry suitable for formation of σ-bonds with ligands orbitals. Construction of ligand group orbitals. Construction of σ-molecular orbitals for an ML_6 complex. Molecular orbitals diagrams of $[Ti(H_2O)_6]^{+3}$, $[Fe(CN)_6]^{-3}$, $[FeF_6]^{-3}$ and $[Co(NH_3)_6]^{+3}$ complexes. Effect of π - bonding on splitting parameter. Comparison of the CFT and MOT. Thermodynamic stability and kinetic stability of complexes with examples. Stability constants: Stepwise and overall stability constants and their inter-relationship. Factors affecting thermodynamic stability.	**10**
	Organometallic Chemistry General characteristics of various types of organometallic compounds, viz, ionic, sigma-bonded and electron-deficient compounds. EAN rule, 18 electron rule. Metal carbonyls: Preparation, properties, structure and bonding in mononuclear metal carbonyls. Polynuclear metal carbonyl: Preparation and structures of $Mn_2(CO)_{10}$, $Co_2(CO)_8$ $Fe_2(CO)_9$ and $Fe_3(CO)_{12}$. Metallocenes: Introduction, Ferrocene: synthesis, properties, structure and bonding on the basis of VBT and MOT.	**10**
	3. Magnetism and Electronic Spectra of Coordination Compounds A) Magnetism: Introduction, types, origin of magnetism, spin-only formula and calculation of magnetic moment, determination of magnetic susceptibility by Guoy's method, applications of magnetic moment data for 3d complexes. B) Electronic Spectra: Origin**,** types of electronic transitions in coordination compounds: intra–ligand, charge transfer and intra-metal transitions**.** Selection rules: Spin and Laporte selection rules and intensities of spectra. Electronic	**15**

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	configuration, microstates, Ground state terms, and Term symbols. Coupling of spin momenta (Ms), orbital momenta (M_l), and spin-orbit coupling or Russell-Saunders coupling. Orgel Diagrams for d^1/d^9 and d^2/d^8 electronic configurations in octahedral coordination compounds.	
	4. Bioinorganic and Medicinal Chemistry Metal coordination in biological systems: Enzymes, apoenzymes and coenzymes. Biological role of carboxypeptidases, catalases and peroxidases. Metal complexes in medicine: carboplatin, oxaliplatin and gold complexes. Inorganic radiopharmaceuticals: Introduction, diagnostic and therapeutic uses with reference to Mo, Tc, I, Lu isotopes.	**05**
	5. Nanomaterials Introduction and importance of nanomaterials, quantum confinement and surface effects. Chemical methods of synthesis of nanomaterials. Characterization of nanomaterials (UV, XRD, TEM techniques). Dimensions and forms of nanomaterials: nanofilms, nanolayers, nanotubes, nanowires, and nanoparticles. Properties and applications of nanomaterials.	**05**
Pedagogy	1. Lectures and Tutorials. 2. Seminars/Term papers/Assignments/Applicative Quiz sessions/ Presentations. 3. Industry visits/self-study or a combination of some of these can be used. 4. ICT mode will be preferred. 5. Sessions should be interactive in nature to enable peer group discussions and learning.	
References / Readings	1. J.D. Lee, Concise Inorganic Chemistry by, Chaman, and Hall, 5th ed. (1996). 2. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd Ed.; Wiley, (Reprint 2008). 3. N. N. Greenwood, A. Earnshaw, Chemistry of the Elements, Pergamon Press, 1st Ed.; (1984). 4. Glen E. Rodgers, Inorganic Chemistry, 3rd Edn., Brooks/Cole (2012). 5. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 3rd Edn. Wiley Eastern Ltd., (1993) 6. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th Ed.; Oxford Publications, (2009). 7. J.E. Huheey, E.A. Keiter, R.L. Keiter, U.K. Medhi, Inorganic Chemistry – Principles of structure and reactivity by, 1st impression (2006) Pearson Education Publishers. 8. K. V. S. Laxmi Devi, N. C. Patel, S.S. Dhume, A. Venkatachalam, S. P. Turakhia, Chhaya Dixit and R. A. Mirji, College Inorganic Chemistry for T.Y. B. Sc. 21st Edn, Himalaya Publishing House 9. A. Sharpe, Inorganic Chemistry, 3rd Edn. Pearson Education (2009). 10. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry- An Introduction, 3rd Edn. Taylor and Francis, (2005) 11. B. Douglas, D. Mc. Daniels, J. Alexander, Concepts, Models of inorganic chemistry by, Mohan Wiley & Sons 3rd Edn (2007).	

	12. R. L. Dutta, A. Syamal, Elements of Magnetochemistry, 2nd Ed.; Affiliated East-West Press, New Delhi (1993) 13. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt, Ltd. (2002). 14. Ajay Kumar and G.R. Chatwal, Bio-inorganic and Supramolecular Chemistry, 1st edn. Himalaya Publishing House (Reprint 2022). 15. Brechignac, P. Houdy, M. Lahmani, Nanomaterials and Nanochemistry, Springer (2006) 16. A.H. Beckett, J.B. Stenlake, Practical Pharmaceutical Chemistry (Part 2), 1st edn. CBS Publishers and Distributors, New Delhi (Reprint 2005). 17. Sibaprasad Bhattacharyya, Inorganic Pharmaceuticals for Imaging and Therapy: Current Trends and Future Directions, Encyclopaedia of Inorganic and Bioinorganic Chemistry, John Wiley and Sons (2016) doi.org/10.1002/9781119951438.eibc2464 18. Valerie Carroll, Dustin W. Demoin, Timothy J Hoffman and Silvia S Jurisson, Inorganic chemistry in nuclear imaging and radiotherapy: current and future directions, Radiochim Acta. 2012 August; 100 (8-9): 653–667. doi: 10.1524/ract.2012.1964	
Practicals: Credits: 01		
Course Objectives:	**1.** To prepare inorganic coordination compounds. **2.** To use various titrimetric techniques to estimate the analytes.	
Content		**30hr**
	1. Preparation of tetraamminecopper (II) sulphate 2. Preparation of tris-(acetylacetonato)iron (III) 3. Estimation of Fe(III) by dichromate method in the given solution of ferric alum by using $SnCl_2$. 4. Estimation of nitrite present in the given $NaNO_2$ solution by using ceric ammonium sulphate. 5. Determination of the strength (grams/litre) of $AgNO_3$ solution using N/30 NaCl solution by Mohr's Method. 6. Estimation of magnesium content in talcum powder by complexometric titration (EDTA method). 7. Determination of acetic acid in commercial vinegar by titrating with approx. 0.05N NaOH solution. 8. Estimation of copper from tetraaminecopper (II) sulphate complex by iodometry. 9. Estimation of sodium carbonate content of washing soda. 10. Determination of hardness of water from given sample by complexometric method.	**10 x3 =30**
Pedagogy	1. Students shall be given pre-lab and post-lab assignments. 2. Theoretical concept underlying the experiments prior to each experiment. 3. Each student shall perform the experiments independently.	
References / Readings	1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, 6th edn., Pearson Education. 2. O. P. Pandey, D. N. Bajpai and S. Giri, Practical Chemistry, Revised Edn., S. Chand. 3. George Brauer, Handbook of Preparative Inorganic Chemistry Vol. 2, 2nd Edition, Academic Press (1964)	

Course outcomes	At the end of the course, students will be able to: 1. explain the electronic spectra, magnetism, and thermodynamic/ kinetic stability of coordination compounds and the biological significance of metal complexes. 2. explain the properties of nanomaterials with their bulk counterpart. 3. construct the molecular orbital diagram for coordination compounds. 4. apply EAN and 18 electron rule to explain the stability of organometallic compounds. 5. prepare normal and molar solutions of a substance. 6. calculate the amount of substance in given solutions. 7. perform volumetric experiments to determine unknown concentrations. 8. estimate metal ion contents from given samples.

Name of the Programme : **B.Sc. (Chemistry)**
Course Code : **CHC – 306**
Title of the course : **Advanced Physical Chemistry-I**
Number of Credits : **3T+1P**
Effective from AY : **2025-26**

Pre-requisites for the course	Students should have studied surface chemistry, colloids and electrochemistry	
Course Objectives:	1. To empower the students with applied physical chemistry skills for industrial applications. 2. To introduce heterogeneous catalysis and its importance in chemical industry. 3. To understand the principles and applications of energy sources.	
Content		**No of hours**
	1. Catalysis and Surface chemistry General Introduction: Catalysis and activation energy. Homogeneous vs Heterogeneous catalysis with suitable examples. Catalytic activity, selectivity and stability. Steps in a heterogeneous catalysis reaction. Adsorption vs absorption, cause of adsorption, striking and sticking probability. Freundlich and Langmuir adsorption isotherms and their application in waste water purification. Types of catalyst. Precipitation and combustion method of catalyst synthesis. Metal catalysed reactions (Haber-Bosch process of NH_3 synthesis), solid acid and solid base catalysts in industrial reactions (alkylation, dehydration, amination and xylenol production reactions). Introduction to zeolites and zeolite catalyzed industrial reactions (examples with illustrations to be discussed).	**10**
	2. Colloids and surfactant technology General introduction to colloids, classification and types, electrical double layer, DLVO theory, colloidal stability, surfactants and reduction of surface tension, charged colloids, electrokinetic phenomena and zeta potential of colloids. Preparation of colloids: hot injection method for synthesis of colloidal semiconductor nanocrystals/ quantum dots. Industrial methods of colloid synthesis. Applications of colloids: (i) Colloids as drug delivery agents in the form of liposomes, (ii) thin film processing of colloidal nanocrystal for their applications in LEDs, biological imaging.	**10**
	3. Electrochemistry II **a.** Applications of emf measurements-(i) determination of pH using hydrogen electrode, quinhydrone electrode, glass electrode, (ii) determination of solubility and solubility product of sparingly soluble salts, (iii) determination of ionic product of water (iv) determination of transport number. Polarisation; elimination of polarization; decomposition potential; measurement of decomposition potential; overvoltage and types of overvoltage; measurement of overvoltage; factors affecting overvoltage; Tafel plot. Buffer solution, types, buffer action, buffer capacity, and mechanics of buffer action, Henderson equation for acidic and	**15**

	basic buffer. Debye Hückel theory of strong electrolytes. Variation of activity coefficient with concentration, ionic strength, Debye Hückel limiting law.	
	b. Energy sources: i) Batteries: Introduction to batteries, primary and secondary battery, basic principles; rating and shelf life. Leclanché and Lead acid battery, Lithium ion batteries and rechargeability. ii) Supercapacitors: Introduction to Supercapacitors, types of Supercapacitors, EDLC and Pseudocapacitors. Advantages and limitations of supercapacitors. iii) Photovoltaics: Solar cell, construction, working, advantages and disadvantages of silicon solar cell. iv) Fuel cells; H_2-O_2 fuel cell, molten carbonate fuel cell, proton exchange membrane fuel cell, solid-oxide fuel cell. (numericals are expected)	**10**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT modeshould be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. J. O. M. Bockris & A. K. N. Reddy, Modern Electrochemistry, Springer India Pvt. Ltd, 2000, Vol.1, 2 and 3., New Delhi, 2nd edition. 2. A. Vincent & B. Sacrosati, Modern Batteries, John Wiley, NewYork,1997, 2nd edition. 3. J. O. M. Bockris & S. Srinivasan, Fuel cells: Their Electrochemistry, McGraw-Hill Book Co., 1969, New York. 4. B. A. J., Stratmann M. and Licht D, Encyclopedia of Electrochemistry, Semiconductor Electrodes and Photoelectrochemistry, Wiley-VCH, 2002 New Jersey. 5. K. S. Birdi, Surface and Colloid Chemistry: Principles and Applications, Taylor & Francis Group, 2010, UK, 1st edition. 6. V. Lesnyak, M. Yarema, S. Miao, Colloidal Semiconductor Nanocrystals: Synthesis, Properties and Applications, Frontiers Media SA, 2020 Switzerland. 7. B. E. Conway, Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications, Springer, New York, 1999. 8. M. S. Halper and J. C. Ellenbogen, Supercapacitors: A Brief Overview, March 2006, MP 05W0000272 MITRE Nanosystems Group, Virginia. 9. B. Vishwanathan, S. Sivasanker and A. V. Ramaswamy, Catalysis: Principles and Applications, Narosa Publishing House, 2002, New Delhi, Illustrated Edition. 10. P. S. Farinas, A. L. Doimo, M. A. R. da Silva, and I. F. Teixeira, Journal of Chemical Education, 2020, 97 (10), 3771-3777. 11. J. N. Gurtu, Physical Chemistry, Vol-III, Pragati Prakashan, 2020, 9th edition, Meerut. 12. N. B. Laxmeshwar, S. M. Malushte, A. S. Mulye and V. N. Kulkarni, Concepts of Physical Chemistry, Chetana Prakashan, Mumbai, 5th ed,1994. 13. G. Raj, Advanced Physical Chemistry, Goel Publication, 36th edition, 2010, Meerut. 14. A. Bahl and G.D. Tuli, S., Essentials of Physical Chemistry, Chand Publication, 2019, New Delhi, 26th edition.	

	15. Puri Sharma and Pathania, Principles of Physical Chemistry, Vishal Publishing Co., 2018, Jalandhar, New-Delhi,1st edition 16. R. L Madan, Chemistry for degree students, S Chand publications, 2017, New Delhi, 1st edition. 17. P. C. Jain, Engineering Chemistry, Dhanpat Rai Publishers, 17th edition, New Delhi, 2020.

Practicals: Credit: 01

Course Objectives:	1. To use the theoretical concepts in performing the experiments. 2. To acquire knowledge on the types of electrodes used in potentiometry. 3. To calculate dissociation constant of mono basic acids	
Content		**No of Hours**
	1. Verification of Debye –Hückel Onsager equation using dilute solution of KCl by conductometric method.	**2**
	2. To determine the strength of mixture containing weak acid (CH_3COOH) and salt of weak base (NH_4Cl) by titrating against standard 0.1N NaOH solution conductometrically.	**4**
	3. To determine hydrolysis and hydrolysis constant of Sodium Acetate /NH_4Cl.	**4**
	4. To determine potentiometrically the equivalence point of strong acid v/s strong base using quinhydrone and amount of acid present.	**4**
	5. To determine the percentage composition and the amount of halides from a mixture (any two halides) using standard 0.1N $AgNO_3$.	**4**
	6. To determine dissociation constant of a weak monobasic acid (CH_3COOH) by titrating against standard 0.1N NaOH using pH meter.	**4**
	7. To study the adsorption of oxalic acid by charcoal and verifying Freundlich adsorption isotherm.	**4**
	8. To detect the ultralow concentration of Cu^{2+} ions by silver colloids using colloid destabilization method.	**4**
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment. Pre and post laboratory assignments to be given. Each student performs the experiment individually.	
References / Readings, References for practicals	1. W. Rajbhoj, T.K. Chondhekar, Anjali Publication, Systematic experimental Physical Chemistry, 2000, Aurangabad, 2nd edition. 2. P.S. Sindhu, Practicals in Physical Chemistry, Macmillan India Publication, 2006, New Delhi, 1st edition. 3. B. Viswanathan, P.S Raghavan, Practical Physical Chemistry, Viva Books Private Ltd, Mumbai, 2005. 4. B. D. Khosla,; Garg, V. C. & A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi, 18th Edition, 2018 5. P. S. Farinas, A. L. Doimo, A. R. da Silva, and I. F. Teixeira, Synthesis and Application of Ag Nanoparticles for an Undergraduate Laboratory: Ultrasensitive Method to Detect Copper (II) Ions, J. Chem. Educ. 2020, 97, 10, 3771–3777	

Course Outcome:	At the end of the course, students will be able to: 1. select catalysts for industrial and environmental applications. 2. predict the colloidal systems for surfactant industry. 3. differentiate efficiencies of various energy sources. 4. distinguish between different halides based on their solubility. 5. determine pH of various solution using different electrodes. 6. distinguish the type of colloid formed.

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Name of the Programme : B.Sc. (Chemistry)
Course Code : CHC – 307 Major
Title of the course : Project
Number of Credits : 04
Effective from AY : 2025-26

Pre-requisites for the Course:	Knowledge of chemistry is essential	
Course Objectives:	1. To develope the ability to formulate research problems based on existing knowledge gaps. 2. To understand and apply various research methodologies and ethics to design and collect data 3. To apply critical analysis to interpret and discuss research results. 4. Present research findings in the APA format in an organized and coherent manner.	
Content		**No of Hours**
	This course is designed for students pursuing graduation in Chemistry to develop their research skills through research-based project. Emphasis will be placed on literature review, critical thinking, research design and data interpretation. Students would be required to adhere to the latest APA style guidelines of report writing,	**60**
Pedagogy	1. Designing a problem: The project guide will assist students in designing a research problem that aligns with their interests. 2. Research Methodology: The project guide will ensure that the students follow proper research methodology relevant to their chosen topics. 3. Project writting: The project guide will assist and guide students to articulate the research data analysis and interpretation in the final project.	
References / Readings, References for practicals	Research articles and reviews from journals and books.	
Course Outcome:	At the end of the course, students will be able to: 1. finalise new areas for a research project. 2. design a discipline specific research methodology. 3. interprete the raw data and draw conclusions. 4. develop analytical skills and gain expertise in scientific writin	

Courses for SEM-VI
Name of the Programme : B.Sc. (Honors) Chemistry
Course Code : CHC- 322 (Minor Vocational – 3)
Title of the course : Instrumentation and analysis
Number of Credits : 3T+1P
Effective from AY : 2025-26

Pre-requisites for the course	Students should have knowledge about instrumental techniques	
Course Objectives:	1. To classify different types of chromatographic techniques and understand the principles and applications of chromatographic techniques. 2. To study the principles and instrumentation of X-ray, Mass spectroscopy, Turbidimetry, Nephelometry and Thermal methods. 3. To describe the basic components of instruments of electroanalytical methods. 4. To discuss the applications of different chromatographic techniques and electroanalytical methods.	
Content:		**No of Hours**
	Unit 1: Thermal Analysis Principle, instrumentation and applications of thermogravimetric analysis (TGA), differential thermal analysis (DTA) and differential scanning calorimetry (DSC). Numericals based on TGA.	**06**
	Unit 2: Chromatography - I Introduction, Classification of chromatographic techniques: A) Column chromatography: Principle, Height Equivalent to a Theoretical Plate (HETP), van Deemter equation., experimental details, theory of development, factors affecting column efficiency and applications. B) Paper and thin layer chromatography: Principle, techniques and applications of paper and thin layer chromatography. C) Ion exchange chromatography: Principle, classification of ion exchange materials, nature of exchanging ions, ion exchange capacity, applications in analytical chemistry.	**08**
	Unit 3: Mass spectrometry Introduction, basic principle, Instrumentation, Ionisation methods : Electron ionization (EI), Chemical ionization (CI), Electrospray ionization (ESI), Matrix-assisted laser desorption ionization (MALDI). Analysers : Schematic diagram of single focussing, double focusing, quadrupole mass analyser and Time-of-Flight mass analysers, Advantages of Quadrupole Mass Spectrometer, spectrum resolution. Interpretation of mass spectra: Nitrogen rule, ring plus double bond rule, even electron rule, rule of 13. Applications of mass spectrometry in identification of pure compounds, analysis of mixtures, quantitative determinations.	**09**
	Unit 4: X-ray diffraction methods Introduction to X-rays, X-ray diffraction of crystals, Bragg's law, Single Crystal and Powder X-ray diffraction: Instrumentation and applications. Interpretation of powder X-ray diffraction pattern.	**07**

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	Unit 5: Atomic spectrometric methods Atomic absorption Spectroscopy (AAS): Introduction, principle, instrumentation, applications and limitations. Flame photometry: Introduction, principle, instrumentation and applications, limitations. Differences between flame photometry and atomic absorption spectroscopy. Fluorimetry: principles of fluorescence, chemical structure and fluorescence. Relationship between concentration & fluorescence intensity, instrumentation and applications. (numerical problems are expected to be solved)	**10**
	Unit 6: Turbidimetry and Nephelometry Scattering of radiations, factors affecting scattering of radiation: concentration, particle size, wavelength and refractive index. Instrumentation and applications of Turbidimetry and Nephelometry.	**05**
Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive and practical oriented in nature to enable peer group learning	
References:	1. B. K. Sharma. *Instrumental Methods of Chemical Analysis* Goel Publishing House, Meerut. 2004 2. K. Raghuraman, D. V. Prabhu, C. S. Prabhu and P. A. Sathe, *Basic principles in Analytical Chemistry*, 1st edition, Shet Publications Pvt. Ltd , Mumbai, 2016 3. G. Chatwal and S. Anand, *Instrumental Methods of Chemical Analysis*, 5th edition Himalaya publication. India, 2003 4. H.Willard, L. Meritt and J.A. Dean, Settle *Instrumental Methods of Analysis*, 7th edition, CBS publication, India , 2004 5. D.A. Skoog and J.J. Leary, *Principles of Instrumental analysis*, 4th Edition, Saunders College Publication. Forth Worth1992 6. G. D. Christian, *Analytical Chemistry*, 6th edition, Wiley publication, NewYork, 2004 7. John Kenkel, Analytical chemistry for Technicians 4th edition, CRC press, Tylor & Francis Group, Boca Raton, London, 2002	
	Practicals (Credits-01)	
Course Objectives:	1. To understand and develop the problem-solving skills and hands on experience with instrumental methods with reference to concepts studied in theory. 2. To interpret given XRD and TG /DTA curves patterns of solids 3. To learn different chromatographic technique 4. Use spectroscopic methods for estimation.	
Content:		**No. of Hours**
	1. Interpretation of spectra and Curves 1. Interpretation and indexing of X–ray powder diffraction pattern of NiO or $MgAl_2O_4$ *(d value, (h, k, l) and unit cell parameters)* by graphical/mathematical method. 2. Interpret the given TG/ DTA thermogram for decomposition of $CaC_2O_4.H_2O$ and $CuSO_4.5H_2O$.	**4**

	2. Chromatography: 1. Determination of ion exchange capacity of the given cation/anion exchange resin. 2. Zn^{2+} /Mg^{2+} separation by an anion exchanger & volumetric estimation of Magnesium with standard EDTA. 3. Estimation of Na^{+} in NaCl by cation exchange resin using standard NaOH. 4. Separation and detection of any two metal ions (Cu^{2+}, Cd^{2+}, Pb^{2+}) using paper chromatography. Separation and detection of any two metal ions (Cu^{2+}, Cd^{2+}, Pb^{2+}) using paper chromatography. 5. Separation of chlorophyll and xanthophyll from plant extract by paper Chromatography /Thin Layer Chromatography.	**16**
	3. Spectrophotometric method: 1. Estimation of sulphate in the given solution using turbidimeter. 2. Estimation of Na and K in given common salt solution using flame photometer. 3. Determination of composition of Bi and Cu in a given mixture with EDTA by spectrophotometry. 4. Determination of nitrite in water by colorimetry.	**10**
Pedagogy:	Students should be given suitable explanation, with revision of theoretical aspects of experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References:	1. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 2. 3. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, England 2000 3. Anil J. Elias, *Collection of Interesting chemistry experiments*, University Press(India) private limited, Hyderabad 2002 4. John Kenkel, Analytical chemistry for Technicians 4th edition, CRC press, Tylor & Francis Group, Boca Raton, London ~~NewYork~~ 2002.	
Course outcome:	At the end of the course, students will be able to 1. Categorise different chromatographic techniques based on their principles. 2. explain basic principles and scope of different chromatographic, spectrocophic, instrumental and electoanalytical methods of separation and analysis. 3. describe the instrumentation and application of different methods of separation and analysis 4. use different techniques for qualitative and quantitative estimation 5. interpret basic information from X-ray diffraction pattern and TG-DTA thermograms. 6. perform separation and estimation using different chromatographic technique 7. use spectroscopic methods for estimation.	

SEM-VII

Name of the Programme : **B.Sc. Semester VII (Chemistry)**

Course Code : **CHC-400**

Title of the course : **Advanced Organic Chemistry II**

Number of Credits : **3T+1P Major (16)**

Effective from AY : **2024-25**

Pre-requisites for the course	Students should have knowledge of stereochemistry and organic reactions	
Course Objective:	1. To understand the concepts of topicity, prostereoisomerism and chemo-, regio- and stereoselectivity in organic reactions. 2. To understand the mechanistic aspects of various type of reactions in organic synthesis. 3. To study various oxidising and reducing agents in organic synthesis.	
Content		**No. of hours**
	1. Stereochemistry a. Chirality in molecules with two and more chiral centres. b. Conformational analysis of open chain compounds (Butane, 2, 3-butane diol, 2,3-dibromobutane etc.). *Erythro* and *threo* nomenclature. c. Topicity and Prostereoisomerism: Topicity of ligands and faces-homotopic, enantiotopic and Cram's rule /diastereotopic ligands and faces. d. Introduction to chemoselective, regioselective and stereoselective reactions. e. Stereochemistry of *cis*- and *trans*-decalins, conformation and reactivity of cyclohexane and substituted cyclohexanes, cyclohexene / cyclohexanone. Conformational isomerism and analysis in acyclic and simple cyclic systems –substituted ethanes, cyclopentane, cyclohexane cycloheptane, cyclooctane and decalins.	12
	2. Aliphatic Nucleophilic substitution The concept of the following in nucleophilic substitutions giving an example: The Neighbouring Group Participation (NGP)/ Anchimeric assistance: General approach to various NGP processes; NGP by unshared/lone pair of electrons; NGP by π-electrons; NGP by aromatic rings (formation of phenonium ion intermediate); NGP by sigma bonds with special reference to bornyl and nor-bornyl system (formation of nonclassical carbocation).	06
	3. Elimination reactions a. The E2, E1 and E1cB mechanisms and comparison with respect to reactivity. Orientation of the double bond, Saytzeff and Hofmann rule. b. Effects of changes in the substrate, base, leaving group and medium on i. Overall reactivity ii. E1 vs. E2 vs. E1cB	10

	iii. Elimination vs substitution, Mechanism and orientation in pyrolytic *syn* elimination (various examples involving cyclic and acyclic substrates to be studied).	
	4. Oxidation and Reduction a. Oxidation reactions: Oxidation of organic compounds using Oppenauer oxidation, Swern oxidation. Other methods of oxidation such as PCC, PDC, MnO_2, Ozonolysis, selenium dioxide, $Pb(OAc)_4$, HIO_4, OsO_4, RuO_4, DMSO (Swern) sodium bromate / CAN & NaOCl, DDQ, Prevost's reagent and Woodward Conditions; Catalytic oxidation over Pt, Photosensitised oxidation of alkenes, oxidation with molecular oxygen, aromatization, silver based reagents. b. Reduction reactions: Reduction of organic compounds using hydride-transfer reagents and related reactions: MPV reduction, Trialkylborohydrides, LAH, DIBAL-H, diborane, $NaBH_4$, mixed LAH-$AlCl_3$ reagents, enzymatic reduction involving liver alcohol dehydrogenase/NADH & Bakers' yeast, catalytic hydrogenation, dissolving metal reductions including acyloin condensation, other methods of reduction: Raney Ni desulphurisation, di-imide.	17
Pedagogy	Mainly lectures and tutorials. Seminars/term papers /assignments /presentations /self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References/ Readings	1. Caruthers, W. and Coldham, I., *Modern Methods of Organic Synthesis*, 4th ed., Cambridge University Press, Cambridge, UK, 2004. 2. Smith, M. B., *Organic Synthesis*, International edition, McGraw–Hill, New York, USA, 1994. 3. Clayden, J., Greeves, N. and Warren, S., *Organic Chemistry*, 2nd ed., Oxford University Press, New York, USA, 2012. 4. Bruckner, R., *Advanced Organic Chemistry – Reaction Mechanisms*, Harcourt Academic Press, San Diego, USA, 2002. 5. Fuhrhop, J. and Penzlin, G., *Organic Synthesis – Concepts, Methods, Starting Materials*, 2nd ed., VCH Publishers Inc., New York, USA, 1994. 6. House, H. O., *Modern Synthetic Reactions*, 2nd ed., W. A. Benjamin, Inc., California, USA, 1972. 7. Nogradi, M., *Stereoselective Synthesis*, 2nd ed., VCH Publishers, Weinheim (Federal Republic of Germany), 1987. 8. Carey, F. A. and Sundberg, R. J., *Advanced Organic Chemistry*, 5th ed., Springer Science + Business Media, LLC, New York, USA, 2007. 9. Laue, T. and Plagens, A., *Named Organic Reactions*, 2nd ed., John Wiley and Sons, Ltd., West Sussex, England 2005. 10. Nasipuri, D., *Stereochemistry of Organic compounds, Principles and applications*, 4th ed., New Age International Pvt. Ltd, New Delhi, India, 2021. 11. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 12. Kalsi, P.S., *Stereochemistry: Conformation and Mechanism*, 7th ed., New Age International Pvt. Ltd, New Delhi, India, 2008.	

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To understand laboratory safety rules. 3. To acquire hands on training in organic laboratory techniques. 4. To acquire skills in organic preparations.	
Content		**No. of hours**
	1. Introductory Organic Experiments a. Safety Aspects in Organic Laboratory (Presentation and discussion). (Risk Management, Safety techniques, Accident prevention, storage, waste disposal, PPE, Hazards, first aid, fire extinguishers). b.Introduction to laboratory equipment.	**03**
	2. Purification techniques a. Simple Distillation **(Any one)** i. Chlorobenzene and acetone. ii. Nitrobenzene and methyl acetate. b. Steam Distillation **(Any one)** i. Piperine from pepper. ii. Clove oil from cloves. iii. Cinnamaldehyde from cinnamon. c. Recrystallisation **(Any two)** i. Salicylic acid using boiling water. ii. Acetanilide using boiling water. iii. *p*-nitrobenzaldehyde using ethanol. iv. *p*-nitrotoluene using ethanol. d. Sublimation **(Any one)** i. Succinic acid ii. Naphthalene iii. Camphor e. Thin layer chromatography **(Any one)** i. Mixture of benzoin and benzil. ii. Mixture of *o*-and *p*-nitroaniline. iii. Mixture of *o*- and *p*-nitrophenol.	**12**
	3. Simple organic synthesis experiments **(Any 5)** i. Preparation of pyridinium chlorochromate-silica or MnO_2-silica or I_2-silica. ii. Bromination of acetophenone to phenacyl bromide. iii. Nitration of naphthalene to 1-nitronaphthalene. iv. Nitration of benzaldehyde to 3-nitrobenzaldehdye. v. Cyclohexanol to cyclohexanone using Jones reagent. vi. Reduction of *o*-nitroaniline to *o*-phenylenediamine using Sn/HCl. vii. Reduction of *p*-nitro benzaldehyde to *p*-nitrobenzyl alcohol using $NaBH_4$.	**15**

	viii. Bromination of an alcohol using CBr_4/ triphenylphosphine. ix. Cannizzaro reaction using 4-chlorobenzaldehyde as substrate.	
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson, C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA,1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Williamson, K. L. and Masters, K. M., *Macroscale and Microscale Organic Experiments*, 6th ed., Cengage Learning, USA, 2011. 5. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2016. 6. Delvin, S., *Green Chemistry*, Sarup& Sons, Delhi, India, 2005. 7. Rodig, O.R., Bell Jr. C.E. and Clark, A.K., *Organic Chemistry Laboratory Standard and Microscale Experiments*, 3rd ed., Saunders College Publishing, Philadelphia, 2009. 8. Mohan, J., *Organic Analytical Chemistry*, Reprint, Narosa Publishing House, New Delhi, India, 2014.	
Course Outcomes:	At the end of the course, students will be able to 1. propose plausible mechanism of various types of organic reactions. 2. apply various reagents for desired organic transformations. 3. apply various concepts in stereochemistry to understand stereochemical outcome in a reaction. 4. calculate stoichiometric requirements during organic syntheses. 5. follow safe and good laboratory practices, handling laboratory glassware, equipment and chemical reagents. 6. apply the practical knowledge to perform experiments involving common organic chemistry laboratory techniques. 7. apply theoretical knowledge in understanding laboratory skills.	

Name of the Programme : **B.Sc. Semester VII (Chemistry)**
Course Code : **CHC-401**
Title of the course : **Advance Inorganic Chemistry-II**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the course	Students should have studied atomic structure, inner transition elements and organometallic chemistry	
Course Objectives:	1. To understand advancement in atomic and molecular structure with examples 2. To study concepts of inner transitions elementsTo learn the fundamentals of organometallic chemistry 3. To understand aspects of environmental chemistry	
Content		**No. of Hours**
	1. Atomic and Molecular Structure: Bohr model of atom, wave mechanics, Schrodinger wave equation, spectroscopic terms and Zeeman effect, vector model and term structure for polyelectron atom, penetration & shielding. Spectroscopic terms. Brief introduction to atomic properties (atomic radii, ionic radii, ionization energy, electron affinity, electronegativity, polarizability). Molecular models: Valence bond (Pauling Slater) theory, molecular geometry and hybridizations, isoelectronic molecules, VSEPR theory, Lewis-Langmuir atomic charges, hydrogen bond, weak interactions. Polyatomic molecules, hypervalence, molecular orbital theory for polyatomic species: LCAO-MO applied to triatomic species: H_3^+ and H_3 (correlation between bond angle and molecular orbitals). Molecular orbital approach for bonding in AB_2 molecules. Application of symmetry concepts for linear and angular species considering sigma-bonding only (examples like: BeH_2, H_2O). Terms such as Walsh correlation diagram: Symmetry Adapted Linear Combinations (SALCs), Ligand Group orbitals (LGOs), transformation of atomic orbitals into appropriate symmetry types. Metallic bonding: Band theory, explanation of electrical properties of conductors, insulators and semiconductors, intrinsic and extrinsic semiconductors.	**15**
	2. Chemistry of Inner transition elements Introduction: Definition, position in the periodic table, and electronic configuration of lanthanoids and actinoids. Chemistry of lanthanoids: lanthanoid contraction, oxidation states, magnetic and spectral properties, occurrence, extraction and separation of lanthanoids by solvent extraction, applications of lanthanoids. Chemistry of actinoids: Comparison between lanthanoid and actinoids, chemistry of uranium with reference to occurrence and isolation (solvent extraction method) properties and applications of uranium.	**10**

	3. Organometallic Chemistry Introduction to organometallic chemistry, nomenclature, stability and inert gas rules (neutral atom and donor pair electron count methods). Ligands: CO & phosphines, homoleptic carbonyls, its synthesis and properties, oxidation-reduction of carbonyls, metal carbonyl basicity, reactions of CO ligand, IR spectroscopic properties of metal carbonyls. Oxidative addition and reductive elimination reactions. Structure and bonding in organo-metallic compounds – isolobal analogies, metal carbonyls, carbenes and N-Heterocyclic carbene complexes, olefin and acetylene complexes, alkyls and allyl complexes, metallocenes (other than ferrocene). Major reaction types – oxidative addition, reductive elimination, insertion, isomerization and rearrangement reactions. Catalytic reactions: metathesis, hydrogenation, allylic activation, C-C coupling reactions, C-X coupling, hydride elimination.	**10**
	4. Environmental Chemistry a. Air Pollution: Classification of air pollutants and photochemical reactions in the atmosphere. Common air pollutants (e.g. CO, NO_x, SO_2, hydrocarbons and particulates) (a) sources (b) physiological and environmental effect (c) monitoring, (d) various remedial & technological measures to curb pollution. Air quality standards. b. Water pollution: Importance of buffer & buffer index in waste water treatments. Chemical, physical & biological characteristics of water pollution, specific and non-specific characterization of water. Dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), and chlorine demand, typical water treatment and waste water treatment (Municipal). Impact of plastic pollution and its effects.	**10**
Pedagogy	1. Lectures and Tutorials, Seminars/Term papers/Assignments/Applicative Quiz sessions/ Presentations. 2. Industry visits/self-study or a combination of some of these can be used. 3. ICT mode will be preferred. 4. Sessions should be interactive in nature to enable peer group discussions and learning.	
Reference Books	1. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th Ed.; Oxford Publications, 2009. 2. J. E. Huheey, E. A. Kieter, R. L. Kieter, O. K. Medhi, Inorganic Chemistry: Principles of Structure & Reactivity, 4th Ed.; Pearson, 2011. 3. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd Ed.; Wiley, 2008 (reprint). 4. J. D. Lee, *Concise Inorganic Chemistry, 5th Edn.*; Wiley India, (2003). 5. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 3rd Ed.; Wiley, Eastern, 2001. 6. N. N. Greenwood, A. Eranshaw, Chemistry of the Elements, Elsevier, 2012. 7. B. E. Douglas and D. H. McDaniel, *Concepts & Models of Inorganic Chemistry,* Oxford, 1970.	

	8. M. C. Day and J. Selbin, *Theoretical Inorganic Chemistry*, ACS Publications, 1962. 9. L. Pauling, The Nature of The Chemical Bond, 3rd Ed.; Cornell University Press, 1960. 10. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 2017 11. A. V. Salker, Environmental Chemistry: Pollution and Remedial Perspective, 1st Ed.; Narosa Publication, 2017. 12. A.K. De, Environmental Chemistry, 3rd Ed.; New Age Intl. Publishers, 2005. 13. A. C. Stern, R. W. Boubel, D. Bruce turner, D. L. Fox, Fundamentals of Air Pollution, 1st Ed.; Academic Press, 1984. 14. R. A. Horne, Chemistry of Our Environment, 1st Ed.; John Wiley, 1978.	
	Practicals	**No. of Hours**
Course Objectives:	1. To train students to prepare Inorganic metal compounds. 2. To acquire the skill of converting waste into wealth. 3. To analyse metal ions by volumetry. 4. To understand metal ion determination using colorimetry /spectrophotometry.	
	I. Inorganic Preparations (Any 4) 1. Preparation of potassium hexathiocyanato-*k*N-chromate tetrahydrate. 2. Preparation of potassium trioxalatoaluminate trihydrate. 3. Preparation of potash alum from scrap aluminum. 4. Preparation of hexaminecobalt(III) chloride. 5. Preparation of hexaamminenickel(II) chloride.	**4 x 4 = 16**
	II. Volumetric Estimations: (Any 3) 6. Estimation of nickel in $[Ni(NH_3)_6]Cl_2$ by complexometric titration. 7. Estimation of cobalt in $[Co(NH_3)_6]Cl_3$ by complexometry. 8. Estimation of chromium in chrome alum by redox titration. 9. Estimation of oxalate in $K_3[Al(C_2O_4)_3]\cdot xH_2O$	**3 x 4 = 12**
	III. Colorimetric/spectrophotometric determinations (Any 1) 10. Colorimetric/Spectrophotometric determination of nickel 11. Colorimetric/Spectrophotometric determination of chromium 12. Estimation of manganese by colorimetric / spectrophotometry method.	**1 x 2 = 2**
Pedagogy	Pre-labs, hands on training, demonstrations, ISA/ term exam/oral.	
Reference Books	1. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 & 2, 1963. 2. G. Pass & H. Sutcliffe, Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods, 2nd Ed.; Chapman & Hall, 1974. 3. W. L. Jolly, The Synthesis & Characterization of Inorganic Compounds, Prentice-Hall, INC, 1970. 4. A. J. Elias, General Chemistry Experiments, Revised Ed.; UniversityPress, 2008.	

	5. J. Mendham, R. C. Denny, J. D. Barnes & M. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed.; Pearson Education Asia, 2002. 6. G. Marr & B. W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold Company, London, 1972.
Course Outcomes	At the end of the course, students will be able to: 1. interpret the atomic and molecular aspects. 2. explain the electronic structures and properties of inner transition metals. 3. write the reaction mechanisms of organometallic compounds. 4. explain the different types of pollution. 5. apply synthetic procedures for preparations of other inorganic compounds 6. determine the metal content by titrimetry. 7. demonstrate the estimation of metal ions using instrumental techniques.

Name of the Programme : **B.Sc. Semester VII, Chemistry (Major)**
Course Code : **CHC – 402 Major - 18**
Title of the course : **Advanced Physical Chemistry-II**
Number of Credits : **3T +1P**
Effective from AY : **2024-25**

Pre-requisites for the course	Students should have studied quantum chemistry, thermodynamics, chemical kinetics and electrochemistry	
Course Objectives:	1. To understand the applicability of tools of quantum mechanics in Chemistry. 2. To study the applicability of laws of thermodynamics to binary and ternary systems. 3. To evaluate the kinetic rates of various classes of reactions. 4. To describe electrode-electrolyte interfaces and understand electrode kinetics.	
Content		**No of Hours**
	1. Quantum Chemistry-II a. Basic tools of quantum mechanics: properties of operators, adjoint and Hermitian operators, eigenfunctions/eigenvalues, matrix formulations, the Uncertainty Principle and time evolution of observables. b. Postulates of quantum mechanics, Born interpretation, position and momentum representations, the time dependent and time independent Schrödinger Equations. c. Exact solutions of Schrödinger Equations: free particle, particle in one-dimensional box, particle in two-dimensional and three-dimensional box (quantization, separation of variables, degenerate wave functions) c. Hydrogen-like atoms, Schrödinger equation and its solutions, atomic orbital wave functions and interpretation. Introduction to Quantum Tunneling. d. Hückel MO theory, Secular equations, Secular determinant, pi-bond order, free valence, applications to C_2H_4, C_3H_5 (radical), C_4H_6, C_4H_4, C_6H_6, C_6H_8.	**12**
	2. Thermodynamics-II a. Important terminologies in Thermodynamics, Thermodynamic state functions, work & heat, work expansion, Mathematical interlude exact and inexact differentials. Cyclic rule, partial derivatives. Relationship between Q_p & Q_v, Heat capacities C_p & C_v, Laws of Thermodynamics. b. Joule-Thomson effect and production of low temperature, adiabatic demagnetization, Joule-Thompson coefficient, inversion temperature. Enthalpy of a system, Enthalpy of a reaction, Thermochemical equations, Heat of reaction or enthalpy of reactions, Hess's law of constant heat summation, Applications of Hess's law, measurements of the heat of reactions, properties of the internal energy and Gibbs energy. c. Concept of entropy, entropy change for an ideal gas; entropy of mixing of ideal gas and the Gibbs paradox; Physical significance of	**12**

	entropy. Maxwell Relation. The third law of thermodynamics. Need for the third law. Apparent exceptions to third law. d. Thermodynamics and Phase diagram, its application to Binary (Ag-Pb) system and Ternary (Mg_2SiO_4 - $MgAl_2O_4$ - $KAlSi_2O_6$) system. The stabilities of phases, phase boundaries, experimental determination of transition points, critical points, boiling points, melting point & triple points. Impact on engineering and technology: supercritical fluids.	
	3. Chemical Kinetics-II a. General introduction to formulation of reaction rates, factors affecting reaction rates, various types of order of reaction including fractional order and their graphical analysis (derivations not required, numericals are expected). Arrhenius temperature dependent and independent activation energy and its significance. Generalized kinetic theory and extended collision theory. Concept of collisional number, collisional frequency factor, collisional cross section, steric factor, Maxwell Boltzmann distribution of energies of colliding molecules and microscopic rate constant. Assumptions and limitations of collision theory. b. Lindemann-Hinshelwood theory of thermal unimolecular reactions. Conventional transition state theory, equilibrium hypothesis and derivation of reaction rates. Van't Hoffs equation and thermodynamic formulation of transition state theory. Assumptions and limitations of transition state theory. c. Introduction to reversible and irreversible reactions and analysis of Gibbs free energy of equilibrium reactions. Reaction Mechanisms: elementary reactions, consecutive reactions, steady state approximation and its applications to complex reactions such as reaction between H_2 and Br_2. (Derivations and numerical problems are expected). d. Collisional kinetics in solution, effect of solvent polarity, solvent cohesion energy and introduction to fast reactions in solution.	**13**
	4. Electrochemistry-III a. Introduction to aqueous electrolytes: True and potential electrolytes, Born model of solvation of ions, Debye-Hückel limiting law and its modifications considering ions of finite size, determination of ionic strength, Debye length and activity coefficient of strong electrolytes. b. Fundamentals of electrode-electrolyte interfaces: Polarizable and non-polarizable electrode-electrolyte interfaces, measurement of potential difference at electrified interfaces using outer potential, surface potential and inner potential. c. Introduction to electrode kinetics: Disturbing the electrode/electrolyte equilibrium and significance of overpotential. Determination of exchange current density for hydrogen electrode reactions using Butler-Volmer equation, Nernst equation as a special case of Butler-Volmer equation at equilibrium. d. Introduction to electroplating, electroless plating and electrosynthesis.	**8**

	(numericals to be solved)	
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT modeshould be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. I. N. Levine, Quantum chemistry, 7th edition, Pearson India Education Pvt. Ltd, 2016, New Delhi. 2. D. A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach, Student Edition, Viva Books Pvt. Ltd, 2018, Mumbai, 1st edition 3. P. K. Ghosh, P. K. Shukla, Atomic Electronic Structure Atomic Orbitals, Prentice Hall of India learning Pvt. Ltd, 2016, New Delhi. 4. R. G. Baughman, Hydrogen-like atomic orbitals an undergraduate exercise, J. Chem. Educ. 1978, 55, 5, 315. 5. P. Atkins and J. Paula, Physical Chemistry, 8th edition, W. H. Freeman and Company, 2006, New York 6. J. O. M. Bockris & A. K. N. Reddy, Modern Electrochemistry, Springer India, Pvt.Ltd, 2000, Vol.1,2 and 3, 2nd edition, New Delhi. 7. K. Laidler, Chemical Kinetics, 3rd edition, Pearsons Educ. Inc., 2007, New Jersey, U.S.A. 8. J. P. Lowe and K.A. Peterson, Quantum Chemistry, Elsevier, 2006, 3rd edition, Pennsylvania, U.S.A. 9. G. C. Schatz and M.A. Ratner, Introduction to Quantum Mechanics in Chemistry, Prentice Hall, 2001 ,1st edition, New Jersey, U.S.A.	

Practicals: Credits: 01

Course Objectives:	1. To apply theoretical knowledge to carry out the experiments. 2. To acquire knowledge of instrumental and non-instrumental techniques. 3. To learn the use of computers for visualising orbitals and wave functions.	
Content		**No of Hours**
	1. To obtain the solution for hydrogen atom and graphically visualize the results.	**2**
	2. To construct and graphically visualize hybrid orbitals.	**4**
	3. To understand the origin of colours using particles in a box.	**4**
	4. To measure and compare the calorific value of polyethylene glycol, polymethyl methacrylate, and cellulose acetate using bomb calorimeter.	**4**
	5. To investigate base hydrolysis of ethyl acetate at three different temperatures and determine the a) Energy of activation b) Entropy of activation and c) Free energy change.	**4**
	6. To study the three-component system such as acetic acid, chloroform and water and obtain tie line.	**4**
	7. To determine formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} system, obtain derivative plot to get equivalence point.	**4**
	8. To determine the Avogadro's number by electroplating method.	**4**
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment. Pre- and post-laboratory assignments to be given. Each student performs the experiment individually.	

References / Readings, References for practicals	1. I. N. Levine, Quantum chemistry, 7th edition, Pearson India Education Pvt. Ltd, 2016, New Delhi. 2. D. A. McQuarrie and John D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Pvt. Ltd, 2018, 1st edition, Mumbai. 3. P. K. Ghosh and P. K. Shukla, Atomic Electronic Structure-Atomic Orbitals, Prentice Hall of India learning Pvt. Ltd, 2016, Delhi. 4. R. G. Baughman, Hydrogen-like atomic orbitals an undergraduate exercise, J. Chem. Educ. 1978, 55, 5, 315. 5. D. Rubenstein, W. Patterson, I. Peng, F. Schunk, A. Mendoza-Garcia, M. Lyu and L-Q. Wang, Introductory Chemistry Laboratory: Quantum Mechanics and Color, J. Chem. Educ. 2020, 97, 12, 4430–4437 6. A. Finlay & J.A. Kitchener, Practical Physical Chemistry, Longman. Prentice Hall Press, New Jersey, USA, 8th edition, 2000. 7. F. Daniels & J.H. Mathews, Experimental Physical Chemistry, 2nd edition, McGraw-Hill, New York, 2002. 8. A. M. James, Practical Physical Chemistry, Longman Publisher, New York, 1974. 9. D. P. Shoemaker & C.W. Garland, Experimental Physical Chemistry, 8th edition, McGraw-Hill, 2008, New York.
Course Outcome:	At the end of the course, students will be able to: 1. apply the Schrödinger's equation and its solution to simple molecules. 2. explain different phase diagrams and predict physical properties of systems. 3. apply steady state hypothesis to chemical mechanisms and deduce rate laws. 4. explain the electrode kinetics of electrochemical reactions. 5. calculate thermodynamic parameters using chemical kinetics. 6. determine formal redox potential of reversible electrodes. 7. estimate Avogadro's number experimentally by electroplating method

Name of the Programme : **B.Sc. Semester VII (Chemistry)**
Course Code : **CHC-403**
Title of the course : **Molecular Symmetry and Spectroscopy**
Number of Credits : **4 credits**
Effective from AY : **2024-25**

Pre-requisites for the course	Students should have knowledge of molecular symmetry and spectroscopy	
Course Objectives:	1. To understand concepts of symmetry elements, symmetry operations, point groups and group theory application. 2. To understand crystal symmetry and space groups 3. To study IR, NMR, EPR and Mossbauer Spectroscopy 4. To solve problems on IR/NMR/EPR and Mossbauer spectra	
Content		**Hrs**
	1. Molecular symmetry **I)** Symmetry elements and symmetry operations, symmetry planes and symmetry reflections, inversion center, proper axes and proper rotations, improper axis and improper rotations, point groups.	**6**
	II) Products of symmetry operations, equivalent symmetry elements and equivalent atoms, relations among symmetry elements and operations, symmetry elements and optical isomerism, symmetry point groups, symmetries with multiple high order axes, classes of symmetry operations, procedure for symmetry classification of molecules. Systematic procedure for symmetry classification of molecules with illustrative examples, dipole moment, optical activity and point groups.	**7**
	III) Group and it's defining properties, order of the group, examples of group, group multiplication table, cyclic group, acyclic group, abelian group, non-abelian group. Sub groups, classes, properties of conjugate elements.	**5**
	IV) Some properties of matrices and vectors, the great orthogonality theorem, reducible and irreducible representations, irreducible representations and their characters, character tables. Standard reduction formula, Direct products of representations and its applications Quantum Chemistry and spectroscopy: Vanishing of integrals, Selection rules. Applications of group theory for hybridization of atomic orbitals. Bases for irreducible representations, direct product. Symmetry Adapted Linear Combinations and its applications. Cage and cluster compounds, metal sandwich compounds. MO treatment (within Huckel Molecular Orbital Theory) of large molecules with symmetry. Applications of group theory to Infra-red and Raman spectroscopy.	**6**
	V) Crystal symmetry and Space Groups. Symmetry elements, Schoenflies, and Hermann Mauguin notation, Representation of point groups and space groups, point symmetry, space symmetry, glide plane, helical screw axis	**6**

	2. Spectroscopy **I) IR and Raman Spectroscopy** a. Principle of Fourier Transform (FT) spectroscopy, Fourier Transform infrared spectroscopy (FTIR): Theory, instrumentation and applications. b. Quantum theory of Raman effect, Raman shift, instrumentation, Resonance Raman spectroscopy, complimentary nature of IR and Raman spectroscopy in structure determination, applications. **II) NMR Spectroscopy** a. Basic principles of NMR, b) Solid state NMR, magic angle spinning (MAS), dipolar decoupling and cross polarization, applications of solid-state NMR, c) Double resonance, NOE, spin tickling, solvent and shift reagents, structure determination by NMR. NMR spectral interpretation of a few nuclei like ^{19}F, ^{29}Si, ^{31}P. **III) Electron Spin Resonance (ESR)** a. Theory and experimental techniques, Identification of odd-electron species (methyl and ethyl free radicals) and radicals containing hetero atoms. Anisotropic system, number of expected ESR signals for one electron paramagnetic species, zero field splitting and Kramer's degeneracy, spin energy levels of octahedral Mn(II) complexes, nuclear quadrupole interaction, ESR spectra of some transition metal compounds, Electron delocalization. b. Spin trapping and isotopic substitution, spin densities and McConell relationship, double resonance techniques. **IV) Mössbauer spectroscopy** Mössbauer effect, Mössbauer principle, Recoilless emission and absorption spectral line widths, Doppler shift, experimental arrangement of Mössbauer spectroscopy, chemical shift (isomer shift), quadrupole splitting, magnetic hyperfine interaction, discussion of selected Mössbauer nuclei like ^{57}Fe, ^{129}I.	**8** **7** **7** **8**
Pedagogy	1. Lectures and Tutorials. 2. Seminars/Term papers/Assignments/Applicative Quiz sessions/ Presentations. 3. Industry visits/self-study or a combination of some of these can be used. 4. ICT mode will be preferred. 5. Sessions should be interactive in nature to enable peer group discussions and learning.	
Text/ Reference Books/ Reading material	1. F. A. Cotton, Chemical Applications of Group theory, 3rd Ed.; John Wiley,1990 2. J. E. Huheey, E. A. Keiter, R.L. Keiter, Inorganic Chemistry: Principles of structure and reactivity, 4th Ed.; Pearson, 1993. 3. R. L. Dutta, A. Syamal, Elements of Magnetochemistry, 2nd Ed.; Affiliated East-West Press, New Delhi, 1993. 4. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed.; Tata McGraw Hill, New Delhi, 1994.	

	5. G. Aruldhas, Molecular structure and spectroscopy, Prentice Hall of India, 2001 6. P. Atkins, J. De Paula, J. Keeler, Atkins' Physical Chemistry, International Ed.; Oxford University Press, 2018. 7. M. Weller, T. Overton, J. Rourke, F. Armstrong, Inorganic Chemistry, International Ed.; Oxford University Press, 2018. 8. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part A: Theory and Applications in Inorganic Chemistry, 6thEd.; Wiley, 2009. 9. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, Part B: Applications in Coordination, Organometallic and Bioinorganic Chemistry, 6thEd.; Wiley, 2009. 10. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 2017 11. G. C. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Ed.; Pearson, 2004 12. K. V. Raman, Group Theory and its applications to chemistry, Tata McGraw-Hill, New Delhi, 1999 13. W. Kemp, NMR in Chemistry a multinuclear introduction, Macmillan, 1986. 14. R.S. Drago, Physical Methods in Chemistry, W.B. Saunders Company, 1977.
Course Outcomes	At the end of the course, students will able to: 1. explain the basic concepts of symmetry and mathematical aspects of group theory. 2. apply group theory concepts in spectroscopy. 3. explain the applications of IR, NMR, EPR and Mössbauer techniques. 4. solve the problems on IR, NMR, EPR and Mössbauer spectroscopy.

Name of Programme : **B.Sc. semester-VII (Chemistry)**
Title of the course : **Advanced analytical techniques-I**
Course Code : **CHC-411, Minor**
Number of Credits : **4 (Theory 3 + Practical 1)**
Effective from AY : **2024-25**

Pre-requisites for the course	Student should have studied instrumental techniques	
Course Objectives:	1. Introduction to the various chemical and Instrumental methods of analysis 2. To study details of underlying principle of chemical and Instrumental methods, advantages and limitations. 3. To study the advance chromatographic techniques of separation and estimation 4. To comprehend advance applications of the analytical tools	
Contents		**No. of Hours**
	1. Electroanalytical methods-II A) Polarography: Introduction, basic principles of instrumentation, Deposition potential, dissolution potential, Polarisation of electrode, Polarographic wave, Ilkovic equation, Supporting electrolytes, Interference of oxygen, Applications of polarography – inorganic and organic. B) Amperometric titration: Introduction, principle, apparatus used for amperometric titration, technique of titration, titration with two electrodes, advantages, disadvantages and application	**07**
	2. Nuclear magnetic resonance (NMR) Principle, instrumentation- sample holder, permanent magnet, magnetic coils, sweep generator, radio frequency generator, radio frequency receiver, readout system. Types of NMR spectra, environmental effects of NMR Spectra, the chemical shift Application of proton NMR - Qualitative analysis, Quantitative analysis, structure determination of inorganic compound	**06**
	3. Clinical methods of analysis a. Composition of Blood; Collection and Preservation of Samples. b. Immunoassay: Radioimmunoassay: principle and applications, instrumentation for radio bioassay. c. Clinical application of the radioimmunoassay of insulin, estrogen and progesterone, receptor techniques of breast cancer. d. Enzyme- linked immunosorbent assay, principles, practical aspects, applications. e. Blood gas analyzer f. Trace elements in the body	**08**
	4. Gas Chromatography (GC): Instrumentation, selection of operating condition, carrier gases, stationary phases, choices of GC column, temperature selection, sampling techniques, methods to prepare derivatives of samples (silylation, acylation, alkylation), factors affecting separation, working principle of GC detectors such as TCD, ECD, FID, quantification methods such as normalizing peak	**10**

	area, internal standard, external standard, standard addition, advances in GC, hyphenated techniques; GC-FTIR, GC-MS. Analysis of data obtained using GC chromatogram.	
	5. Liquid-Liquid Partition Chromatography: HPLC, Introduction, selection of stationary and mobile phase, types of bonded phase chromatography-NPC and RPC and stationary phases used, reversed phase partition chromatography, steps in HPLC method development in partition chromatography, elution techniques (isocratic and gradient), ion pairing agents, buffer agents, organic modifiers, optimization of capacity factor, gradient selectivity factor and column plate numbers, numericals on method development using Snyder's polarity index, advances in LC, Preparative vs analytical HPLC, Chiral chromatography- Pirkle stationary phases, examples of enantiomer separation such as ibuprofen, calculation of enantiomeric excess. Choosing detectors- working principle of RI, UV-Vis, conductivity and ELSD, hyphenated techniques; LC-MS. Analysis of chemical data obtained using HPLC chromatogram, LC-MS. application of HPLC method development in food analysis/drugs, etc.	**14**
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
Reference:	1. H.Willard, L. Meritt and J.A. Dean, Settle *Instrumental Methods of Analysis*, 7th edition, CBS publication, India , 2004 2. D.A. Skoog and J.J. Leary, *Principles of Instrumental analysis*, 4th Edition, Saunders College Publication. Forth Worth1992 3. G. D. Christian, *Analytical Chemistry*, 6th edition, Wiley publication, NewYork, 2004 4. John Kenkel, *Analytical chemistry for Technicians* 4th edition, CRC press, Tylor & Francis Group, Boca Raton, Londn NewYork, 2013 5. D. A. Skoog, D. M. West & F. J. Holler, *Fundamentals of Analytical Chemistry*, 6th th Ed., Sounders College publishing, USA 1992. 6. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, 2000. 7. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 8. D. Harvey, *Modern analytical chemistry*, 1st Ed., The McGraw-Hill, India,2000. 9. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis*,5th edition, Himalaya publishing house, Mumbai, 2013 10. C.N. Banwell and E.M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw- Hill, New Delhi, 4th Ed.	
	Practicals	
Course objective:	1. Application of chemical and instrumental methods for qualitative and quantitative analysis 2. Learn using electroanalytical and spectrophotometry techniques for quantitative estimation. 3. Apply chromatography technique for separation and estimation.	

	I. **Colorimetric / U.V visible spectrophotometric and flame photometric** 1. Estimation of phosphoric acid in cola drinks by molybdenum blue method. 2. Estimation of KNO_3 and $K_2Cr_2O_7$ by UV-Visible spectrophotometry. 3. Simultaneous determination and verification of law of additively by absorbance ($K_2Cr_2O_7$ and $KMnO_4$) by UV-Visible spectrophotometry 4. Extraction of Cu as copper dithiocarbamate (DTC) using solvent extraction and estimation by spectrophotometry 5. Flame photometry- Estimation of Na and K in commercial and natural common salt sample.	**14 Hrs**
	II. **Electroanalytical methods** 1. Analysis of Benzbromaron by potentiometric technique. 2. Analysis of ascorbic acid by titration using pH meter.	**04 Hrs**
	III. **Chromatographic method** 1. Separation and estimation of chloride and bromide by ion exchange chromatography	**02 Hrs**
	IV. **Comparative study of volumetric and gravimetric method** 1. Estimation of sulphates by complexometric titrations using EDTA and by gravimetric method as $BaSO_4$ 2. Estimation of Calcium in cement by volumetric method and gravimetric method as Calcium Oxalate	**10 Hrs**
References:	1. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 2. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, England, 2000 3. Anil J. Elias, *Collection of Interesting chemistry experiments*, University Press (India) private limited, Hyderabad, 2002 4. R.A. Day & A.L. Underwood, Quantitative analysis,6th Edition, Prentice Hall, New Delhi, 2001. 5. John Kenkel, *Analytical chemistry for Technicians* 4th edition, CRC press, Tylor & Francis Group, Boca Raton, Londn NewYork, 2013	
Course Outcomes:	At the end of the course student will be able to: 1. explain the basic principle and chemistry involved in different conventional method of analysis. 2. summarize the Advance chromatographic technique of separation and estimation. 3. describe basics analytical tools of clinical analysis. 4. judge the limitation of method of analysis and will be in a position to choose an appropriate chemical method for particular analysis. 5. select instrumental techniques like potentiometry/pH metry/flame photometry/UV-Visible spectroscopy for quantitative analysis.	

Name of the Programme : **B.Sc. Semester VII (Chemistry)**
Course Code : **CHC-412 Minor (3)**
Title of the course : **Advanced Pharmaceutical Chemistry and Analysis I**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have knowledge about diseases and drugs	
Course Objectives:	1. To understand the concepts of physicochemical properties, drug dosage forms and drug metabolism 2. To define and classify the drugs 3. To analyse the drugs using thermal and chromatographic methods	
Content		**No of hours**
	1. Physicochemical properties, Drug dosage forms, drug metabolism Brief introduction to physicochemical properties of drug: solubility, partition coefficient, ionisation constant, hydrogen bonding, surface activity, chelation, geometrical isomerism. Drug dosage forms-Types-solid oral, liquid-oral, liquid-semisolid, parenteral-types, topical -types, enemal-suppositories. Routes of drug administration: Oral, Parenteral and Enemal with advantages and disadvantages. Drug Metabolism- definition. Types-Phase I reactions, oxidation, reduction, hydrolysis. Phase II reactions-Conjugation. One example of each type of phase reactions. Factors affecting drug metabolism.	**08**
	2. Definition and Classification with structure of the following drugs: **Anti Infective agents:** Antiseptics and Disinfectants: Alcohols, substituted phenols, DDT, Halazone. **Synthesis, use and side effects of DDT and Halazone**. Antimycobacterial agents (Antitubercular and Antileprotic drugs) Aminosalicylic acid, Pyrazinamide, Ethambutol, Dapsone. **Synthesis, use and side effects of Isoniazid and Dapsone.** Antimalarials: Quinine, Mefloquine, Chloroquines. Antiamoebics: Metronidazoles, Diloxanides. Anthelmintics: Piperazine, Niclosamide, Mebendazoles, Praziquantels. **Synthesis, use and side effects of Mefloquine**. Antifungal: Tolnaflates, Clotrimazoles. Antivirals including drugs acting on HIV: Idoxuridines, Amantadine Hydrochlorides. **Synthesis, use and side effects of Tolnaflate and Idoxuridines.** Sulfonamides: Sulfonamides, Sulfacetamide, Sulfamethoxazole, Newer antibacterial agents: Quinoline carboxylic acids such as Ciprofloxacin, **Synthesis, use and side effect of Sulfamethoxazole. Mechanism of action of Mefloquine. SAR of Clotrimazole.**	**08**

	3. Definition and Classification with structure of the following drugs Antineoplastics, Hypoglycemics, Diagnostic agents, Diuretics and antihistaminics. Antineoplastics: 6-Mercaptopurines, Thiotepa, Chlorombucils, Cis-platin. Insulin and various sulfonyl ureas like tolbutamide, Metformin, Saccharin. Diagnostic agents-aminohippuric acid. Diuretics– Ethacrynic acid, Theophylline. **Synthesis, use and side effects of thiotepa and theophylline** Antihistaminics and antiemetics and antiulcer drugs: Chlorpheniramine, Promethazine, Omeprazole. **Synthesis, use and side effects of Chlorpheniramine and Promethazine.** Central Nervous System Drugs. a] Hypnotics and sedatives: Phenobarbital. b] Drugs acting as anticonvulsants: Phenytoin, Carbamezepine. c] Psychotherapeutic agents: Phenothiazines such as Chloropromazine, Diazepam. d] CNS stimulants: Nikethamide, Caffeine. **Synthesis, use and side effects of Phenytoin, Nikethamide**. **Mechanism of action of Chlorpheniramine, SAR of Promethazine**	**08**
	4. Analysis of drug in solid state: Concepts of particle size, size distribution shown as cumulative undersize curve. Thermal methods of analysis: Basic principles of differential thermal analysis (DTA) and Differential Scanning Calorimetry (DSC), Differential Thermal Analysis - apparatus and methodology, factors affecting DTA results, quantitative DTA, interpretation of results. Applications to detect polymorphism and pseudopolymorphism in pharmaceuticals by DSC or DTA.	**06**
	1. Assay of drugs and chromatographic analysis Active pharmaceutical ingredient (API). Assay, potency of drug. Chemical assay- Examples: Titrimetric assay of aspirin and ibuprofen, Instrumental assay of Paracetamol and Isoniazid. Comparison between titrimetric and instrumental assay. Chromatographic techniques in drug analysis- Classification of chromatography methods. Gas chromatography: Basic principles of GSC and GLC. Terms involved: Distribution equilibria, rate of travel, retention time, retention volume, relative retention, Height Equivalent to a Theoretical Plate (HETP), Van Deemter equation. Instrumentation: carrier gas, column, injections systems, explanations of factors affecting separation, thermal conductivity and flame ionization detectors. Qualitative and Quantitative analysis: internal standards, determination of peak area. HPLC: Instrumentation, description of pumps, detector choice (UV absorption and refractive index detectors), columns, injection system, packing materials, applications. Introduction to hyphenated techniques: Basic principles of GC-MS and LC-MS. HPLC v/s HPTLC.	**15**

Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References / Readings	1. Patrick, G.L., *Introduction to Medicinal Chemistry*, 7th ed., Oxford University Press, UK, 2023. 2. Singh, H. and Kapoor, V. K. *Medicinal and Pharmaceutical Chemistry*, 3rd ed., Vallabh Prakashan, Pitampura, New Delhi, 2012. 3. Foye, W.O. Lemke, T.L. William, D.A., *Principles of Medicinal Chemistry*, 7th ed., B. I. Waverly Pvt. Ltd., New Delhi, 2012. 4. Beale, J. H. and Blocks, J. H., *Wilson and Gisvold's Textbook of Organic, Medicinal and Pharmaceutical Chemistry*, 12th ed., Lippinkott Williams and Wilkins, Philadelphia, USA, 2011. 5. Lednicer, D. and Meischer, L. A., *Organic Chemistry of Drug Synthesis*. Vol. I to III. John Wiley & Sons, New Jersey, USA, 2005. 6. Sriram, D. and Yogeshwari, P., *Medicinal Chemistry*, 1st ed., Pearson Education, London, 2007. 7. Sriram, D. and Yogeshwari, P., *Medicinal Chemistry*, 2nd ed., Pearson Education, London, 2010. 8. Wolff, M. E., *Burger's Medicinal Chemistry and Drug Discovery*, 5th ed., John Wiley & Sons, New Jersey, USA, 1997. 9. Chatwal, G.R., *Medicinal Chemistry*, 2nd ed., Himalaya Publishing house, Mumbai, 2002. 10. Sharma, B.K., *Instrumental Methods of Chemical Analysis*, Goel Publishing House, Meerut, 2014. *11.* Raghuraman, K.; Prabhu, D. V.; Prabhu, C. S.; and Sathe, P. A., *Basic principles in Analytical Chemistry*, 5th ed., Shet Publications pvt. ltd, Mumbai, 2014. 12. Chatwal, G. R. and Anand, S., *Instrumental Methods of Chemical Analysis*, 5th ed., Himalaya publications, Mumbai, 2003. 13. Willard, H. H. Meritt, L.L. Dean, J.A. and Settle, F.A., *Instrumental Methods of Analysis*, 7th ed., Balmond Wadsworth, California, 1988. 14. Skoog, D. A. and Leary, J. J., *Principles of Instrumental analysis*, 4th ed., Saunders College Publication, USA, 1992. 15. Connors, K. A., *Text book of Pharmaceutical analysis*, 3rd ed., Wiley Interscience Publication, London, 1999. 16. Christian, G. D., *Analytical Chemistry*, 6th ed., John Wiley & Sons, New Jersey, USA, 2001.

Practicals

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in spectrophotometric and chromatographic technique. 3. To acquire hands on training in preparation of bioactive compounds.	
Content		**No of hours**

	a) Qualitative and Quantitative tests of (Any 1) (1) Purified Water as per IP Monograph (2) Aspirin as per IP Monograph **b) Spectrophotometric assay (bulk or tablets) (Any 2)** Allopurinol, Bisacodyl, Chlorpheniramine Maleate, Metronidazole, Ibuprofen **c) Titrimetric assay of bulk drug/ tablet (Any 2)** Chlorpheniramine maleate, Benzyl penicillin, nitrazepam, sulphamethoxazole **d) HPLC analysis: (Any 1)** Paracetamol, Diclofenac sodium **e) Synthesis of bioactive compounds (Any 5)** Phenothiazine, p-bromobenzalacetone, 2,3-diphenyl quinoxaline, Fluorescein, Schiff's base of 2-amino phenol and p nitrobenzaldehyde, 2'hydroxy chalcone, 3-acetylcoumarin, hexamine, benzothiazole from 2-aminothiol and p-chlorobenzaldehyde. **f)** TLC identification of analgesic/sulpha drugs comparison of bulk drugs with branded drugs.	**06** **04** **04** **04** **10** **02**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, 2011. 2. Pasto, D. Johnson, C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1991. 3. Fieser, L.F. and Williamson, K.L., *Organic Experiments*, 7th ed., D. C. Heath, Massachusetts, USA, 1992. 4. Bansal, R.K., *Laboratory Manual in Organic Chemistry,* 5th ed., New Age International private limited, New Delhi, 2016. 5. Indian Pharmacopoeia, Latest edition. 6. Siddique, A.A., *Laboratory Manual-Selected experiments in pharmaceutical analysis*, 2nd ed., CBS Publishers, New Delhi, 2020. 7. Mondal, P. and Mondal, S., *Handbook of Practical, Pharmaceutical Organic, Inorganic and Medicinal Chemistry*, Educreation Publishing, New Delhi, 2019. 8. Singh, R., *Handbook of practical pharmaceutical chemistry (A systematic approach to titrimetric analysis*), Shivalik College of Pharmacy, Punjab, 2016.	
Course Outcomes	At the end of the course, students will be able to: 1. Explain concepts of physicochemical properties, drug dosage forms and drug metabolism. 2. Classify the drugs based on uses. 3. Demonstrate role of thermal and chromatographic methods in drug analysis.	

	4. Refer Pharmacopoiea and apply in laboratory experiments. 5. Synthesize drugs and drug like compounds. 6. Demonstrate chromatographic methods in drug analysis.

SEMESTER-VIII

Name of the Programme : B.Sc. Semester-VIII Chemistry
Course Code : CHC-404
Title of the course : Research Methodology
Number of Credits : 4T (60 Hrs)
Effective from AY : 2024-25

Prerequisites for the course	NIL	
Course Objectives:	1. To introduce various aspects of research methodology, academic writing and publishing. 2. To perceive ethics & scientific conduct. 3. To comprehend importance of safety and good laboratory practices. 4. To understand databases used in published journals and usefulness of various softwares in plotting the experimental data collected.	
Content		**No. of Hours**
	1. Introduction to Research Methodology Term Research, General Characteristic of research, Function of Research, objectives of research, classification of Research, Types of research: Descriptive, Analytical, Applied, Basic, Conceptual and Non scientific methods. Significance of research, Research and scientific methods, Criteria of good Research, Research Process- formulating the research problem, developing the working hypothesis, research design, Types of qualitative and quantitative research design, Types of experimental research design, Characteristics of research design, sample design, collection of the data; execution of the project, analysis of data, testing of hypothesis, generalizations and interpretation, and preparation of the report or presentation of the results & conclusions.	**15**
	2. Scientific publications and Ethics **a. Scientific conduct** Research ethics, Definition, Ethical theories and framework, Human research ethics, basic Principles of human research ethics, Types of ethical issues, Anonymity, Confidentiality, nature of moral judgments and reactions, Ethics with respect to science and research, Ethics of animal research, Intellectual honesty and research integrity, Scientific conduct and misconducts: Falsification, Fabrication, and Plagiarism (FFP). **b. Academic writing** Introduction, Types, importance of Academic writing, Structure of scientific articles, Academic articles, Abstract, selecting keywords, Introductions, Methods, Result & discussions, Acknowledgements, Foot notes, References, Bibliography, Conflicts of interest. Tables: constructing & presenting tables, plotting graphs: Pie, Bar, Line. Writing: Books, Thesis, Literature,	**5** **7**

	Reviews and Conference papers: reading versus speaking, Presentations: Powerpoint, Poster. Book reviews. Letters to the publishers, choosing where to publish. **c. Publication ethics** Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, violation of publication ethics, authorship and contributor ship, identification of publication misconduct, complaints and appeals, predatory publishers and journals, peer review, responsibilities of reviewers, responsibilities of authors, Copyright: meaning, misconceptions, transferring copyrights. Online publishing. Authorship issues: exclusion from authorship, Gift authorship, Authorship by coercion, Unsolicited authorship, Salami, Imalas. Redundant publications: duplicate and overlapping publications, Selective reporting and misrepresentation of data.	**8**
	3. Data bases and research metrics Databases What are data bases, Types of databases, Indexing databases, Citation databases: Web of Science, Scopus, UGC-Care List, Google Scholar, IEE explorer, Microsoft academic, Jstore, Semantic scholar. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score, Metrics: h-index, g index, i10 index etc.	**05**
	4. Safety aspects in Chemistry & Good laboratory practices What are the safety do's and don'ts, chemistry laboratory safety rules, chemical hygiene plan, chemical tracking system, handling of various chemicals, solvents & glassware, fires and fighting with fires. Hazardous substances, strategies to reduce amount/toxicity of chemical waste generated in laboratory, General guidelines to follow in case of chemical accident/spill, classification and handling Safety Data Sheet, Good laboratory practices (GLP), Elements of GLP, OECD Principles of GLP, Factors influencing implementation and maintenance of GLP in QC laboratory, laboratory infrastructure, reference standard, Analytical reagents and chemicals, volumetric glassware, preparation of standard solutions and reagents, validation of analytical procedures, calibration of equipments and instruments, types of calibration, training, documentation and records, safety, checklist of GLP implementation.	**10**
	5. Softwares in Chemistry Data plotting Structure Drawing Reference management software Chem sketch, Chemdraw (for drawing chemical structures), Chem plot, Mendeley – Reference management software, Crystal Maker (X-ray crystallography) Cambridge Structural Database (CSD) System. Originlab, Microsoft excel for plotting graphs. Google sheets, Tableau, MATLAB, R Python (with libraries like Matplotlib and Seaborn), Graph lab software, JMP data analysis software for industry.	**10**

Pedagogy	Mainly lectures and tutorials. Seminars /term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References / Readings	1. C. R. Kothari, Research Methodology: Methods & Techniques, New Age International Pvt. Ltd., India, 2004. 2. Y. K. Singh, Fundamentals of Research Methodology & Statistics, New Age International Pvt. Ltd., India, 2006. 3. US consumer product safety commission, School chemistry safety guide, United States, October 2006. 4. S. B. Chidambaram, M. M. Essa, M.W. Qoronfleh, (2022) Introduction to Toxicological Screening Methods and Good Laboratory Practices, Springer, Singapore. https://doi.org/10.1007/978-981-16-6092-4_1ISBN978-981-16-6092-4. 5. The Norwegian National Ethics Commitees, Guidelines for Research Ethics in Science and Technology, 2nd edition, Norwegia, June 2016. ISBN: 978-82-7682-075-1. 6. V. Rajaraman, Computer Programming in Fortran 90 And 95, PHI Learning Pvt. Ltd., India, 2013. 7. G. D. Christian, P. K. Dasgupta & K. A. Shug, Analytical Chemistry, 7th Ed.; Wiley India Pvt. Ltd. New Delhi, 2020. 8. Prudent Practices in the Laboratory Handling and Disposal of Chemicals, National Academy Press, Washington, D.C.1995. 9. The ACS, Style Guide, Effective Communication of Scientific Information Editors Anne M. Coghill, Lorrin R. Garson. American Chemical Society Washington, DC Oxford University Press, New York Oxford 2006.
Course Outcome:	At the end of this course students will be able to: 1. explain research methodology concepts. 2. apply information technology to solve their research problems in chemistry and apply software's to the data collected experimentally. 3. write manuscript of research work. 4. do indexing and find out citations, impact factor of different journals.

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-405**
Title of the course : **Advances in Organic Synthesis**
Number of Credits : **3T+1P Major (16)**
Effective from AY : **2024-25**

Prerequisites for the course:	Students should have knowledge of organic reactions and their mechanisms	
Course Objective:	1. To study various concepts related to carbon-carbon bond formation. 2. To understand designing of organic synthesis to make molecules of interest. 3. To plan total synthesis based on protection-deprotection strategy. 4. To understand chiral pool strategies for organic synthesis.	
Content		**No. of hours**
	1. Introduction to enols and enolates Keto-enol tautomerism; Introduction, acidity, basicity concepts & pKa scale, neutral nitrogen and oxygen bases. Formation of enols by proton transfer, mechanism of enolization by acids & bases, types of enols & enolates, kinetically & thermodynamically stable enols, stability of enolates, preparation and reactions of enol ethers. Hard and Soft Acid Base (HSAB) concept & Factors affecting it, effect of structure & medium on acid and base strength; Concept of superacids and superbases; Electrophilicity & nucleophilicity, examples of ambident nucleophiles & electrophiles.	**06**
	2. Formation and reactions of enolates Formation of Enolates; Introduction, preparation & properties, non-nucleophilic bases, E / Z geometry in enolate formation, kinetic vs. thermodynamic controlled enolates, other methods for the generation of enolates, issue of enolate ambidoselectivity. Reactions of enolates: i. Alkylation of enolates. ii. Reactivity of carbonyl groups. iii. alkylation involving nitriles and nitroalkanes. Types of electrophiles for alkylation: i. Lithium enolates of carbonyl compounds and alkylation. ii. Alkylation of *β*-dicarbonyl compounds. iii. Reaction of enolates with aldehydes and ketones; Introduction, aldol reaction including cross & intramolecular version, enolisable substrates which are not electrophilic in nature. Acylation at carbon; Introduction, acylation of enolates by esters, directed C-acylation of enols and enolates & acylation of enamines.	**12**

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	iv.Conjugate addition of enolates; Introduction, thermodynamic control vs. conjugate addition, utility of various electrophilic alkenes in conjugate addition.	
	3. Applications of selected condensation reactions in organic synthesis. Mukaiyama reaction, Perkin reaction, Diekmann condensation, Michael addition, Robinson annulation, Sakurai reaction, Darzen, Pechmann condensation.	**05**
	4. Synthetic utility of important name reactions / methodology a. Mannich Reaction, Nef Reaction, Mitsunobu and Appel Reaction, Baylis Hillman reaction, Mc. Murry coupling, vicarious nucleophilic substitution, Steglich and Yamaguchi esterification. b. Grubb's various generation, Grubbs-Hoveyda, Schrock catalysts. Ring closing and cross metathesis**.**	**06**
	5. The Ylides in Organic Synthesis a. Phosphorus Ylides; Nomenclature and Preparation. Wittig olefination: mechanism, stereoselectivity, cis- and trans selective reactions, Wittig reagents derived from α-halo carbonyl compounds. b. Modified Wittig, Horner – Wadsworth – Emmons, Peterson reaction, Julia Olefination. c. Sulfur Ylides; Sulfonium &sulfoxonium ylides in synthesis, diphenylcyclopropyl sulfonium ylides & their reactions with carbonyl compounds / Michael acceptors.	**05**
	6. Protecting Groups in Organic Synthesis a. Introduction and effective use of protecting groups, umpolung of reactivity. b. Common protective groups namely acetals & ketals, dithio acetal/ketals, trialkylsilyl, TBDMS, THP, MOM, MEM, SEM & benzyl ether, methyl ether, benzyl amine, Cbz, t-Boc, Fmoc, t-butyl ester and methods for deprotection. Some examples of multistep synthesis using protection-deprotection procedures.	**04**
	7. Asymmetric synthesis Asymmetric induction methods– substrate, reagent, and catalyst-controlled reactions. Determination of enantiomeric and diastereomeric excess, use of chiral auxiliaries, chiral reagents and catalysts, asymmetric hydrogenation, asymmetric epoxidation and asymmetric dihydroxylation. Chiral auxiliary approach; Oxazolidinone & norephedrine-derived chiral auxiliary controlled Diels-Alder reaction and alkylation of chiral enolates and aldol reaction, Chiral pool (chiron approach) examples (−) α-santonin and sclareolide. Chiral Reagents - Use of (-)-sparteine. Optical and kinetic resolution. Organocatalyzed aldol reaction (Use of proline).	**07**
Pedagogy	Mainly lectures and tutorials. Seminars/term papers/ assignments/ presentations/ self-study or a combination of some of these can also be	

	used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.
References / Readings	1. Smith, M. B., *Organic Synthesis*, International edition, McGraw–Hill, New York, USA, 1994. 2. Smith, M. B. and March, J., *Advanced Organic Chemistry: Reactions, Mechanisms and Structure*, 6th ed., John Wiley & Sons, Inc., New Jersey, USA, 2007. 3. Nasipuri, D., *Stereochemistry of Organic compounds, Principles and application*s, 4th ed., New Age International Pvt. Ltd, New Delhi, India, 2021. 4. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 5. Caruthers, W. and Coldham, I., *Modern Methods of Organic Synthesis*, 4th ed., Cambridge University Press, Cambridge, UK, 2004. 6. Clayden, J., Greeves, N. and Warren, S., *Organic Chemistry*, 2nd ed., Oxford University Press, New York, USA, 2012. 7. Finar, I. L., Organic Chemistry, vol. 2: *Stereochemistry and the Chemistry of Natural Products*, 5th ed., Dorling Kindersley India Pvt. Ltd., Licensees of Pearson Education in South Asia, New Delhi, India, 2009. 8. Gould, E.S., *Mechanism and Structure in Organic Chemistry*, Holt, Reinhart and Winston, USA, 1959. 9. Carey, F. A. and Sundberg, R. J., *Advanced Organic Chemistry*, 5th ed., Springer Science + Business Media, LLC, New York, USA, 2007. 10. Norman, R. and Coxon, J. M., *Principles of Organic Synthesis*, 3rd ed., Blackie Academic and Professional, Glasgow, UK, 1993. 11. House, H. O., *Modern Synthetic Reactions*, 2nd ed., W. A. Benjamin, Inc., California, USA, 1972. 12. Kalsi, P.S., Stereochemistry: Conformation and Mechanism, 7th ed., New Age International Pvt. Ltd, New Delhi, India, 2008.

Practicals

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To understand laboratory safety rules. 3. To acquire hands on training in organic laboratory techniques. 4. To acquire skills in organic preparations.	
Content		**No. of hours**
	1. Synthesis of organic compounds (Any 5) a. Aniline to Quinoline by Skraup Synthesis. b. Sucrose to Ethyl alcohol using Baker's yeast. c. Assymmetric reduction of EAA by using Baker's yeast. d. Anthranilic acid to 2-Iodobenzoic acid. e. Aniline to Acetanilide using acetic acid. f. 7-Hydroxy -3-methyl flavone from 2-hydroxyacetophenone via Baker-Venkatraman reaction. g. 4-Chlorobenzaldehyde to 4-Chlorobenzalacetone (Aldol condensation).	**16**

	h. Diels Alder reaction between 9-anthracenemethanol and *N*-methylmaleimide. **2. Two step organic synthesis (Any 2)** a. Benzaldehyde → Benzalacetophenone → Epoxide. b. 4-Nitro toluene → 4-nitro benzoic acid → 4-Amino benzoic acid. c. *o*-nitroaniline → *o*-phenylene diamine → Benzimidazole. d. Phenylacetate ⟶ *o*-Hydroxyacetophenone⟶ Chromone -2-carboxylic acid. **3. Extraction of Organic compounds from Natural sources. (Any 1)** 1. Isolation of lactose from milk . 2. Isolation of β-Carotene from carrots. 4. Isolation of citronella oil from lemongrass.	**10** **04**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson, C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA,1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Williamson, K. L. and Masters, K. M., *Macroscale and Microscale Organic Experiments*, 6th ed., Cengage Learning, USA, 2011. 5. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2016. 6. Delvin, S., *Green Chemistry*, Sarup& Sons, Delhi, India, 2005. 7. Rodig, O.R., Bell Jr. C.E. and Clark, A.K., *Organic Chemistry Laboratory Standard and Microscale Experiments*, 3rd ed., Saunders College Publishing, Philadelphia, 2009. 8. Mohan, J., *Organic Analytical Chemistry*, Reprint, Narosa Publishing House, New Delhi, India, 2014. 9. Ahluwalia, V. K. and Aggarwal, R., *Comprehensive practical organic chemistry*, Sangam Books Ltd., 2001.	
Course Outcomes	At the end of the course, students will be able to: 1. Explain how a carbon-carbon bond can be constructed along with the selectivity in bond formations. 2. Apply knowledge of various reactions in constructions of simple to complex organic molecules. 3. Design protecting group strategies for synthesis of organic molecules. 4. Apply chiral pool strategies for organic synthesis. 5. Understand the organic preparations. 6. Apply the practical knowledge to perform organic reactions.	

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-406**
Title of the course : **Materials Chemistry**
Number of Credits : **2 Credits**
Effective from AY : **2024-25**

Prerequisites for the course:	Students should have studied Semester I to VII Courses	
Course Objectives:	1. To explain the basic concepts of materials chemistry. 2. To understand various synthesis of materials. 3. To study properties and applications of materials.	
Content		**No. of hours**
	1. **Structure and Bonding in Solid materials:** **a. Introduction to Materials**: Basic concepts, properties, structures, and applications of materials. **b. Different Types of Solids**: Molecular, Metallic, Covalent & Ionic solids, X-ray diffraction technique, structural classification of binary and tertiary compounds, Spinel and Perovskite structures.	**6**
	2. **Preparation Techniques for Materials Synthesis** **a**. **Broad Classification of methods**: Ceramic method and Wet chemical methods. **b**. **Types of Materials and methods of Preparation**: **I. Types of Materials:** Powder bulk materials, Single crystal and thin films, Amorphous materials and Nanomaterials. **II. Methods of preparation:** **i**. **Powder Materials:** Solid state method, Co-precipitation method, Precursor method, Combustion method, Precursor-combustion method, Sol-gel method, Spray roasting method, Freeze drying method. **ii. Single Crystals**: (a) Growth from melt (b) Growth from solution (c) Growth using Flux method (d) Epitaxial growth of single crystal thin films Using Chemical and Physical methods (e) Chemical vapor transport (f) Hydrothermal method (g) Dry high-pressure method, Electrochemical reduction method. **iii**. **Amorphous Materials**: Types of amorphous materials (Zeolites & Aluminosilicates), their synthesis & applications. Nanomaterials: Synthesis, Structural, Optical and Magnetic properties, Applications of Nanomaterials.	**14**
	3. **Material Properties:** **a**. **Electrical properties and Semiconductor devices**: Electrical conductivity, Free electron theory, Band Theory, Insulators, Semiconductors and Conductors. Diodes and Transistors, Junction Field Effect Transistors (JFET) **b**. **Dielectric and Magnetic Properties**: Ferroelectric Materials and their applications, Piezoelectric Materials. Ferromagnetic materials- Their magnetization properties and applications,	**10**

	Anti-ferromagnetism and Ferrimagnetism, Superparamagnetism.	
Pedagogy	Lectures/tutorials/assignments / problem solving/ self-study/tests/ discussions/use of models/ ICT/combination of some of these.	
Reference Books	1. A.R. West, SolidState Chemistry and Its Applications, 1st Ed., John Wiley & Sons, Singapore, 1984 (reprint 2007). 2. L.V. Azaroff, Introduction to Solids, 1st Ed., Tata McGraw Hill, (33rd Reprint), USA, 2009. 3. D. K. Chakraborty, Solid State Chemistry, 2nd Ed.; New Age International Publisher, New Delhi, 2010. 4. H. V. Keer, Principles of the Solid State, 1st Ed., New Age International (P) Ltd., (Wiley Eastern Ltd,), USA, 1993, (Reprint 2008). 5. W. D. Callister, Materials Science and Engineering: An Introduction, 7th Ed.; John Wiley, USA, 2007. 6. B. D. Fahlman, Materials Chemistry, 2nd Ed.; Springer, USA, 2011. 7. H. R. Allcock, Introduction to materials chemistry, 1st Ed.; John Wiley & Sons, USA, 2011.	
Course Outcomes	At the end of this course, students will be able to: 1. Discuss the basic concepts of Materials Chemistry. 2. Apply various synthetic methods for the preparation of materials. 3. Explain the various properties of materials. 4. Illustrate the structure-property relations and applications of materials.	

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-407**
Title of the course : **Organic Spectroscopy, Pericyclic and photochemical reactions**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course:	Students should have studied spectroscopic techniques	
Course Objective:	1. To understand UV and IR spectroscopic techniques through problem solving. 2. To understand the introductory aspects of commonly used 2D NMR techniques. 3. To learn interpretational aspects of spectral data pertaining to UV, IR, PMR, CMR and MS. 4. To introduce various concepts in pericyclic chemistry based on molecular orbital theory and apply for solving pericyclic reactions. 5. To learn mechanistic aspects of pericyclic & photochemical reactions in organic synthesis.	
Content		**No. of hours**
	1. Problem solving in UV and IR spectroscopy Woodward-Fieser rule for conjugated dienes and dienones. IR spectroscopy in structural elucidation of organic compounds. Interpretation of IR spectra.	**04**
	2. Advances in NMR spectroscopy-I Brief overview of NMR spectroscopy. Interpretation of PMR spectra. (Coupling constants and AB, A2B2/A2X2, AMX and ABX spin systems). Nuclear Overhauser Effect and its applications. ^{13}C- chemical shifts effects (α-, ß-, γ-, δ-substituent effects, π-conjugation, heavy atom effect and ring size effects). Proton coupled and proton decoupled ^{13}Cspectra. Off- resonance decoupling, APT & DEPT techniques.	**07**
	3. Mass spectrometry Molecular Formulae Index (D.B.E), Molecular ion peak, base peak, metastable ions, Nitrogen rule, effect of isotopes. Prediction of molecular formulae based on relative abundance. Rules for fragmentation, McLafferty rearrangement, and mass spectra of some chemical classes (Ketones, alcohols, acids, esters). Combined UV, IR, NMR and Mass spectroscopic problems.	**08**
	4. Theory and applications of pericyclic reactions i. Frontier Molecular Orbital (FMO) theory. ii. Transition state aromaticity (Mobius-Huckel theory) concept Types of Pericyclic recations with examples: Electrocyclic, cycloaddition, sigmatropic rearrangements. Stereochemistry of Diels Alder reactions. [3, 3]-Shifts; Claisen and Cope, aza-Cope-, oxy-Cope Rearrangements.	**14**

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	[2,3]-Sigmatropic rearrangements such as Sommelet-Hauser rearrangement, Sulfonium ylide rearrangement, Wittig rearrangement, ene reaction.	
	5. Concepts and applications of photochemical reactions. Photochemical reactions of alkenes, dienes, carbonyl compounds and arenes including the following: Paterno-Buchi reaction; Norrish Type cleavages; Di-pi methane rearrangement; bicycle rearrangement. Photochemistry of aromatic compounds, cycloaddition reaction of benzene, naphthalene, pyrrole and indoles with alkenes and alkynes. Reactions involving singlet and triplet oxygen: Photooxygenation reactions, examples of [2+2] and [4+2]- Applications: Barton reaction, and Hofmann-Loffler-Freytag reaction.	**12**
Pedagogy	Mainly lectures and tutorials. Seminars/term papers/ assignments /presentations/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Kalsi, P. S., *Spectroscopy of Organic compounds*, 6th ed., New Age International (P) Ltd. Publishers, New Delhi, India, 2004. 2. Silverstein, R. M., Webster, F. X., Kiemle, D., Bryce, D., Samant, S. and Nadkarni, V. S., *Spectrometric Identification of Organic compounds, An Indian Adaptation*, 8th ed., John Wiley & Sons Inc., New Delhi, India, 2022. 3. Pavia, D. L., Lampman, G. M., Kriz, G. S. and Vyvyan, J. R., *Introduction to Spectroscopy*, 5th ed., Cengage Learning, Stamford, USA, 2015. 4. Silverstein, R. M., Webster, F. X. and Kiemle, D., *Spectrometric Identification of Organic compounds,*7th ed., John Wiley & Sons, Hoboken, New Jersey, USA, 2005. 5. Parikh, V. M., *Absorption Spectroscopy of Organic Molecules*, Addison Wesley Longman Publishing Co., Michigan, 1974. 6. Williams, D. H. and Fleming, I., *Spectroscopic Methods in Organic Chemistry*, 6th ed., Tata Mcgraw Hill Education, Switzerland, 2011. 7. Kemp, W., *Organic spectroscopy*, 3rd ed., Palgrave Macmillan, New York, USA, 1991. 8. Kemp, W., *NMR in Chemistry: A Multinuclear Introduction*, Macmillan Press Ltd., London, 1986. 9. Dyer, J. R., *Applications of Absorption Spectroscopy of Organic compounds*, Prentice Hall of India, New Delhi, India, 1987. 10. Field, L. D., Li, H. L. and Magill, A. M., *Organic Structures from 2D NMR Spectra*, Wiley Publishers, New Delhi, India, 2015. 11. Dinda, B., *Essentials of Pericyclic and Photochemical Reactions*,1st ed., Springer, Switzerland, 2017. 12. Kumar, S., Kumar, V. and Singh, S. P., *Pericyclic Reactions: A Mechanistic and Problem-Solving Approach*, Academic Press, London, UK, 2016. 13. Lehr, R. E. and Marchand, A. P., *Orbital Symmetry: A Problem-Solving Approach*, Academic Press, London, UK, 1972.	

	14. Woodward, R. B. and Hoffmann, R., The *Conservation of Orbital Symmetry*, 1st ed., Verlag Chemie GmbH Academic Press Inc., Weinheim/Bergstr., Germany, 1971. 15. Fleming, I., *Frontier Orbitals and Organic Chemical Reactions*, 1st ed., John Wiley & Sons, London, 1991. 16. Gilchrist, T. L. and Storr, R. C., *Pericyclic Reactions*, Cambridge Univ. Press, Great Britain, 1972. 17. Turro, N., Ramamurthy, V. and Scaiano, J. C., *Modern Molecular Photochemistry of Organic molecules*, University Science Books, California, 2010. 18. De Pay, C. H., *Molecular Reactions and Photochemistry*, Prentice Hall (I) Ltd, New Delhi, India, 1972. 19. Kopecky, J., *Organic Photochemistry- A Visual Approach*, VCH Pub., New York, USA, 1992.

Practicals

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic laboratory techniques. 3. To acquire skills in organic preparations.	
Content		**No. of hours**
	1. Synthesis of organic compounds (Any 5) a. Phenylhydrazone to Indole by Fischer Indole Synthesis. b. Glucose to Glucose pentaacetate. c. Barbituric acid from malonic ester. d. *p*-Toluidine to 4-Chlorotoluene. e. Benzopinacolone from benzopinacol using iodine catalyst. f. Benzophenone to 4-methylbenzophenone using Friedal Crafts reaction. g. Benzyl alcohol to benzaldehyde using hydrogen peroxide. h. Diels Alder reaction between Anthracene and maleic anhydride.	**12**
	2. Two step organic synthesis (Any 2) a. Benzpinacolone to Benzopinacol to Benzophenone. b. *o*-Chlorobenzoic acid to *N*-PhenylAnthranillic acid to Acridone. c. Benzyl alcohol to Benzaldehyde to *m*-nitrobenzaldehyde. d. Acetanilide to 4-bromoacetanilide to 4-bromoaniline.	**08**
	3. Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & M).	**04**
	4. Extraction of Organic compounds from Natural sources (Any 2) a. Isolation of caffeine from tea leaves. b. Isolation of casein from milk. c. Isolation of lycopene from tomatoes. d. Isolation of Eugenol from cloves.	**06**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments	

	prior to the conduct of each experiment. Each of the experiments should be done individually by the students.
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson, C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Williamson, K. L. and Masters, K. M., *Macroscale and Microscale Organic Experiments*, 6th ed., Cengage Learning, USA, 2011. 5. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2016. 6. Delvin, S., *Green Chemistry*, Sarup & Sons, New Delhi, India, 2005. 7. Rodig, O.R., Bell Jr. C.E. and Clark, A.K., *Organic Chemistry Laboratory Standard and Microscale Experiments*, 3rd ed., Saunders College Publishing, Philadelphia, 2009. 8. Mohan, J., *Organic Analytical Chemistry*, Reprint, Narosa Publishing House, New Delhi, India, 2014. 9. Ahluwalia, V. K. and Aggarwal, R., *Comprehensive practical organic chemistry*, Sangam Books Ltd., 2001.
Course Outcomes	At the end of the course, students will be able to: 1. Deduce structures of simple to moderately complex molecules by combining the spectral data obtained using two or more spectral techniques. 2. Differentiate various spectroscopic techniques. 3. Propose plausible mechanism of pericyclic/photochemical reactions and explain applications of photochemistry. 4. Apply various concepts in organic spectroscopy (PMR, CMR, MS and 2D NMR) and analyse/ predict PMR, CMR, MS and 2D NMR spectral data based on given structures of simple molecules. 5. Interpret spectroscopic data of unknown compound. 6. Apply the practical knowledge to perform organic reactions.

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-408**
Title of the course : **Essentials of Stereochemistry**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course:	Students should have studied stereochemistry	
Course Objective:	1. To study various principles of stereochemistry. 2. To understand the importance of chirality in organic syntheses. 3. To learn stereoselective reactions.	
Content		**No. of hours**
	1. Stereochemistry: Conformations, stability and reactivity Configurational (R/S) nomenclature in appropriately substituted allenes, alkylidenecycloalkenes, spiranes, adamantoids, biaryls, trans-cycloalkenes, cyclophanes and ansa compounds. Atropisomerism in biphenyls. Fused bicyclic systems with small and medium rings: cis- and trans- decalones and decalols, Fused polycyclic systems: Perhydrophenanthrenes, Perhydroanthracenes, Perhydrocyclopentenophenanthrene system (steroids). Conformations and reactivity towards esterification, hydrolysis, chromium trioxide oxidation, ionic additions of halogen (X_2) to double bonds, formation and opening of epoxide ring, epoxidation by peroxy acids.	**16**
	2. Conformation of bridged ring compounds Bicyclo [2.2.1] heptane (norbornane): Geometry and topic relationship of hydrogens, solvolysis of bicycle [2.2.1]heptyl systems, formation, stability and reactivity of norbornylcation, relative stability and the rate of formation of endo and exo isomers in both bornane and norbornane systems.	**10**
	3. Dynamic Stereochemistry: Stereoselective Reactions a. **Stereoselectivity:** classification, terminology and principle. Selectivity in chemistry– substrate and product selectivity. b. **Stereoselective reaction of cyclic compounds**: Introduction, reactions of four, five and six-membered rings. c. **Diastereoselectivity:** Introduction, making single diastereoisomers using stereospecific reactions of alkenes. d. **1,2-Addition to carbonyl compounds**: Predicting various addition Outcomes using different predictive models such as, Cram Chelate, Cornforth, Felkin-Anh. Specific reactions: allylation/crotylation by Brown, Roush, BINOL catalyzed. e. **Stereoselective reaction of acyclic alkenes**: The Houk model.	**14**
	4. Asymmetric catalysis CBS catalyst, Ruthenium catalyzed chiral reductions of ketones, Catalytic asymmetric hydrogenation of alkenes, Asymmetric	**05**

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	epoxidation (Sharpless and Jacobson), Sharpless asymmetric dihydroxylation reaction.	
	Total	**45 hrs**
Pedagogy	Mainly lectures and tutorials. Seminars/term papers/assignments/ presentations/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Smith, M. B. and March, J., *Advanced Organic Chemistry: Reactions, Mechanisms and Structure*, 6th ed., John Wiley & Sons, Inc., New Jersey, USA, 2007. 2. Nasipuri, D., *Stereochemistry of Organic compounds, Principles and applications*, 4th ed., New Age International Pvt. Ltd, New Delhi, India, 2021. 3. Eliel, E. L., *Stereochemistry of Carbon Compounds*, Tata McGraw-Hill, New York, USA, 1962. 4. Caruthers, W. and Coldham, I., *Modern Methods of Organic Synthesis*, 4th ed., Cambridge University Press, Cambridge, UK, 2004. 5. Clayden, J., Greeves, N. and Warren, S., *Organic Chemistry*, 2nd ed., Oxford University Press, New York, USA, 2012. 6. Finar, I. L., Organic Chemistry, vol. 2: *Stereochemistry and the Chemistry of Natural Products*, 5th ed., Dorling Kindersley India Pvt. Ltd., Licensees of Pearson Education in South Asia, New Delhi, India, 2009. 7. Gould, E.S., *Mechanism and Structure in Organic Chemistry*, Holt, Reinhart and Winston, 1959, USA. 8. Carey, F. A. and Sundberg, R. J., *Advanced Organic Chemistry*, 5th ed., Springer Science + Business Media, LLC, New York, USA, 2007. 9. Norman, R. and Coxon, J. M., *Principles of Organic Synthesis*, 3rd ed., Blackie Academic and Professional, Glasgow, UK, 1993. 10. House, H. O., *Modern Synthetic Reactions*, 2nd ed., W. A. Benjamin, Inc., California, USA, 1972. 11. Potapov, V. M., *Stereochemistry*, Mir Publishers, Moscow, Russia,1979. 12. Morris, D. G., *Stereochemistry*, Wiley-Interscience, RSC, New York, USA, 2002. 13. Greeves, C. and Wothers, W., *Organic Chemistry*, 2nd ed., Oxford University Press, New York, USA, 2002. 14. Nogradi, M., *Stereoselective Synthesis*, 2nd revised., VCH Publishers, Inc., USA, 1994. 15. Kalsi, P.S., Stereochemistry: Conformation and Mechanism, 7th ed., New Age International Pvt. Ltd, New Delhi, India, 2008.	

Practicals

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in organic laboratory techniques. 3. To acquire skills in organic preparations.	
Content		**No. of hours**

	1. Synthesis of organic compounds (Any 3) a. Pinacol to pinacolone. b. p-Toluidine to p-Chloroaniline. c. Benzophenone to 4-acetylbenzophenone using Friedel Crafts reaction. d. Grignard synthesis of benzoic acid e. Dichromate Oxidation of 4-Methylcyclohexanol f. Reduction of Cinnamaldehyde using $NaBH_4$ **2. Two step organic synthesis (Any 4)** a. *p*-toluidine to *p*-methyl acetanilide to *p*-aminobenzoic acid. b. Trans-stilbene to meso-2,3-dibromostilbene to diphenylacetylene. c. *p*-Chlorobenzaldehyde to bis-Chlorobenzalacetophenone to Epoxide. d. Acetanilide to 4-Nitroacetanilide to 4-nitroaniline. e. Borneol to Camphor to Isoborneol. f. Salicylic acid to 5-nitrosalicylic acid to 5-nitro acetylsalicylic acid. g. Phthalic acid to Phthalic anhydride to Rhodamine B. **3. Stereochemical synthesis (Any 2)** a. Asymmetric reduction of Acetophenone by using Baker's yeast. b. Diels Alder reaction between furan and maleic anhydride. c. Bromination of Cinnamic acid. d. S (-) Phenylalanine to S (+) or S (-) Phenyl lactic acid. e. From Racemic to Enantiomeric Ibuprofen.	**08** **16** **06**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5th ed., Pearson Education Ltd., London, UK, 2011. 2. Pasto, D., Johnson, C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA,1992. 3. Fieser, L. F. and Williamson, K. L., *Organic Experiments*, 7th ed., D. C. Heath and Company, Massachusetts, USA, 1992. 4. Williamson, K. L. and Masters, K. M., *Macroscale and Microscale Organic Experiments*, 6th ed., Cengage Learning, USA, 2011. 5. Bansal, R. K., *Laboratory Manual of Organic Chemistry*, 5th ed., New Age International Publishers, New Delhi, India, 2016. 6. Delvin, S., *Green Chemistry*, Sarup & Sons, New Delhi, India, 2005. 7. Rodig, O.R., Bell Jr. C.E. and Clark, A. K., *Organic Chemistry Laboratory Standard and Microscale Experiments*, 3rd ed., Saunders College Publishing, Philadelphia, 2009. 8. Mohan, J., *Organic Analytical Chemistry*, Reprint, Narosa Publishing House, New Delhi, India, 2014.	

	9. Ahluwalia, V. K. and Aggarwal, R., *Comprehensive practical organic chemistry*, Sangam Books Ltd., 2001. 10. McCullagh, J. V., *The Resolution of Ibuprofen, 2-(4'-Isobutylphenyl)propionic acid*, J. Chem Educ., 2008, 85, 941. **http://pubs.acs.org/doi/suppl/10.1021/ed085p941**.
Course Outcomes	At the end of the course, students will be able to: 1. explain stereochemistry and organic transformations. 2. apply stereoselective reactions for the synthesis of chiral organic molecules. 3. describe conformations of bridged ring compounds. 4. predict stereochemical outcome in a reaction. 5. evaluate stereochemical aspects in an organic synthesis. 6. apply the practical knowledge to perform different organic reactions.

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-409**
Title of the course : **Advanced Inorganic Chemistry-III**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Pre-requisites for the course	Students should have studied coordination chemistry, s-block chemistry and spectroscopy	
Course Objectives:	1. To know the advanced concepts in coordination chemistry. 2. To understand Orgel diagram and Tanabe-Sugano (T-S) diagrams. 3. To calculate the magnitude of Δo from UV-Vis spectra. 4. To gain in depth knowledge of s-block elements and their compounds. 5. To learn the medicinal applications of Inorganic compounds.	
Content		**No. of Hours**
	1. Advanced Coordination Chemistry a. Different geometries of coordination compounds (other than octahedral and tetrahedral): Crystal field splitting diagrams of square planar, square pyramidal, trigonal bipyramidal, linear geometries. Jahn-Teller theorem and applications. Molecular orbital diagram for square planar compounds. **b. Electronic spectroscopy** The determination of micro states and terms symbols for s^1, s^2, p^1 to p^6 and d^1-d^{10} electronic configurations of free metal ions. Identification of other terms and arranging them in the order of their increasing energies. Correlation diagrams and application of selection rules. Electronic spectrum of $[Mn(H_2O)_6]^{2+}$. Transformation of free metal ion/atoms terms into new terms in octahedral and tetrahedral geometries. Orgel Diagrams for d^1, d^2, d^3, d^4(hs), d^6(hs), d^7(hs), d^8, d^9 octahedral and tetrahedral compounds. Hole formalism, non-crossing rule. Tanabe-Sugano (T-S) diagrams: fundamentals, T-S diagram for any two electronic configurations (d^2, d^8). Racah parameters, determination of Δo from the electronic spectra of Ni^{2+}, V^{2+}, Cr^{3+} octahedral compounds. Interpretation of spectra and elucidation of Δo from T-S diagrams. Difference between Orgel diagrams and T-S diagrams. **c. Magnetic properties of coordination compounds** Magnetic moments, spin ross over phenomenon, variation of magnetic moment of $[Fe(phen)_2(NCS)_2]$, variation of magnetic susceptibility with temperature.	**18**
	2. Main group Chemistry **i) s-block elements and their compounds:** a. Hydrogen and hydrides: Electronic structure, position in periodic table, abundance, preparation, properties, isotopes, ortho and para hydrogen. Classification of hydrides, preparation &	**17**

	properties of hydrides; hydrogen ion, hydrogen bonding and its influence on properties. b. Group 1 elements: Introduction, abundance, extraction, physical and chemical properties, solubility and hydration, alkali metals in liquid ammonia, complexes, crown ethers and cryptands, electrides, alkalides, c. Group 2 elements: Introduction, abundance, extraction, physical and chemical properties, alkaline earth metals in liquid ammonia, complexes, preparation and properties of Grignard reagent.	
	3. Inorganic medicinal chemistry Anticancer agents; Platinum and Ruthenium complexes as anticancer drugs, Cancer chemotherapy, phototherapy, radiotherapy using borane compounds. b. Chelation therapy. c. Gadolinium and technetium complexes as MRI contrast agents, X-ray contrast agents. d. Anti-arthritis drugs.	**10**
Pedagogy	For Theory: Lectures/ tutorials. Seminars / term papers /assignments / presentations /self-study or a combination of some of these.	
References	1. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th Ed.; Oxford Publications, 2009. 2. J. E. Huheey, E. A. Kieter, R. L. Kieter, O. K. Medhi, Inorganic Chemistry: Principles of Structure & Reactivity, 4th Ed.; Pearson, 2011. 3. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd Ed.; Wiley, 2008 (reprint). 4. J. D. Lee, *Concise Inorganic Chemistry, 5th Edn.*; Wiley India, (2003). 5. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 3rd Ed.; Wiley, Eastern, 2001. 6. D. Banerjee, Coordination Chemistry, 1st Ed.;Tata McGraw Hill, New Delhi, 1994. 7. N. N. Greenwood & A. Earnshaw, Chemistry of the Elements, Pergamon Press, Exeter, 1984. 8. G. Rodgers, Introduction to coordination, solid state, and descriptive Inorganic chemistry, 1st Ed.; McGraw Hill,1994. 9. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., 2017	
	Practicals Credit = 1	
Course objectives	1. To acquire skills in preparation of coordination compounds. 2. To learn the estimation of metal ions by different methods. 3. To perform qualitative analysis of inorganic mixtures. 4. To acquire basic laboratory skills.	
Content		**No. of Hours**
	I. Preparations / Estimation of Inorganic Compounds (Any 5): i. Preparation of Potassium trioxalatochromate(III) trihydrate ii. Estimation of iron and oxalate by redox titration	**20**

	iv. Estimation amount of zinc present in given sample by gravimetric method. v. Estimation of barium by complexometric titration method. vi. Estimation of manganese in presence of iron by complexometric titration method. **II. Colorimetry /spectrophotometry (Any 1)** i. Estimation of manganese by colorimetric / spectrophotometry method. ii. Estimation of iron by colorimetric / spectrophotometry method. **III. Semi-micro qualitative analysis of cation and anion in a given inorganic mixture (Any 2):** Mixture containing total six cations and/or anions. Cations: Pb^{2+}, Cu^{2+}, Cd^{2+}, Sn^{2+} , Fe^{2+} , Fe^{3+}, Al^{3+}, Cr^{3+} , Zn^{2+} , Mn^{2+}, Ni^{2+}, Co^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, $(NH_4)^+$, K^+ Anions: Cl^- , Br^- , I^- , NO_2^- , NO_3^- , SO_3^{2-}, CO_3^{2-}, SO_4^{2-}, PO_4^{3-}, S^{2-}	**02** **08**
Pedagogy	Pre-labs, hands on training, demonstrations, ISA/ term exam/oral.	
Reference books	1. J. Mendham, R. C. Denny, J. D. Barnes & M. Thomas, Vogel's Textbook of Quantitative Chemical Analysis, 6th Ed.; Pearson Education Asia, 2002. 2. G. Marr & B. W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold Company, London, 1972. 3. Svelha, G., Vogels Qualitative Inorganic Analysis 7Th Edition by Svehla G, PEARSON INDIA	
Course Outcomes	At the end of the course, students will be able to: 1. apply crystal field theory to square planar and other geometries 2. use Orgel diagrams and T-S diagrams to deduce the electronic spectra of transition metal compounds 3. describe chemistry of s-block elements and their applications 4. explain the importance of inorganic compounds in medicinal chemistry 5. prepare inorganic coordination compounds. 6. determine the concentration of metal ions by titrimetry. 7. use colorimetry and spectrophotometry in analysis of metal ions. 8. perform advanced inorganic qualitative analysis.	

Name of the Programme : **B.Sc. Semester VIII, Chemistry (Major)**
Course Code : **CHC – 410 Major – 20**
Title of the course : **Advanced Physical Chemistry-III**
Number of Credits : **3L+1P**
Effective from AY : **2024-25**

Pre-requisites for the course	Students should have studied quantum chemistry, thermodynamics, chemical kinetics and electrochemistry	
Course Objectives:	1. To understand the concepts of molecular symmetry and quantum mechanics. 2. To introduce the laws of non-equilibrium and statistical thermodynamics. 3. To study the kinetics of enzymatic, oscillatory, fast reactions and introduce reaction dynamics. 4. To introduce spectro-electrochemistry and electrochemical corrosion concepts.	
Content		**No. of Hours**
	1. Quantum Chemistry-III a. Basic tools of quantum mechanics: Properties of operators, Eigenvalues and Eigen functions, degeneracy and average values. b. Exact solutions of Schrödinger Equations: Harmonic oscillator, particle on a ring of fixed radius, the Born–Oppenheimer Approximation and solution to the H_2^+ molecular ion. c. Molecular Symmetry: Symmetry Elements and Operations, Symmetry Point Groups and Term symbols d. System with two or more electrons: I) The helium atom: Introduction to spin, the Pauli's exclusion principle, Slater determinants. II) Approximation methods: Introduction to Variation method and Perturbation theory (1^{st} order correction to energy) (numericals and derivations are expected)	**12**
	2. Thermodynamics-III a. Non-Equilibrium Thermodynamics: Concept of internal entropy and spontaneity of a process in relation to free energy. Chemical affinity and extent of a reaction. Phenomenological Laws and Onsager's reciprocal relations; Conservation of mass and energy in closed and open system. Postulates of non-equilibrium thermodynamics. Entropy production in heat flow and entropy flow in open system. Validity of application of irreversible thermodynamics to biological systems, application to thermo-electric and electrokinetic phenomena. (numericals and derivations are expected) b. Statistical Thermodynamics: The language of statistical thermodynamics: Probability, ensemble, microstate, degeneracy, permutations and combinations. The molecular partition function: Its interpretation and its relation uniform energy levels.	**12**

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	Translational, Rotational, Vibrational and Electronic partition functions for diatomic molecules. Law of Equipartition energy. (numericals and derivations are expected)	
	3. Chemical Kinetics-III a. Kinetics of Homogeneous reactions: Enzymatic reactions and Michaelis-Menten kinetics, Lineweaver-Burk and Eadie analysis, autocatalytic reactions. (numericals and derivations are expected) b. Composite reactions & Oscillatory reactions: Types of composite mechanisms, kinetics of parallel and consecutive reactions. Oscillatory reactions. The significance of bi-stability in the Belousov-Zhabotinskii reaction. (numericals and derivations are expected) c. Fast Reactions: Photochemical fast reactions, Pulsed laser photolysis, and its use in monitoring fast reactions. d. Reaction Dynamics: Introduction to potential energy surfaces, description of H_2O and HF potential energy surface.	**13**
	4. Electrochemistry-IV a. Molten Electrolytes: Fundamentals of ionic liquids and thermal loosening of ionic lattice. Ionic liquids in surface electrochemistry, electrode/electrolyte interfacial processes in ionic liquids. b. Electrode kinetics and corrosion: Fundamentals of impedance spectroscopy; determining exchange current densities and rate constants from impedance plots. Principles of electrochemical corrosion, Pourbaix diagram for corrosion of iron. c. Photo-electrochemistry: Light absorption and carrier generation at the electrode, photo induced charge transfer, semiconductor/electrolyte interface, band edge and band bending, photo-electrochemical water splitting. (numericals to be solved)	**8**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings, References for practicals	1. I. N. Levine, Quantum chemistry, 7th edition, Pearson India Education Pvt Ltd, 2016, New Delhi. 2. D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Pvt. Ltd, 2018, 1st edition, Mumbai. 3. P. K. Ghosh, P. K. Shukla, Atomic Electronic Structure Atomic Orbitals, Prentice Hall of India learning Pvt. Ltd, 2016, New Delhi. 4. R. G. Baughman, Hydrogen-like atomic orbitals an undergraduate exercise, J. Chem. Educ., 1978, 55, 5, 315. 5. P. Atkins and J. Paula, Physical Chemistry, 8th edition, W. H. Freeman and Company, 2006, New York 6. J. O. M. Bockris & A. K. N. Reddy, Modern Electrochemistry, Springer India Pvt.Ltd, 2000, Vol.1,2 and 3, 2nd edition, New Delhi. 7. K. Laidler, Chemical Kinetics, 3rd edition, Pearsons Educ. Inc., 2007, New Jersey, U.S.A. 8. J. P. Lowe and K. A. Peterson Quantum Chemistry, Elsevier, 2006, 3rd edition, Pennsylvania, U.S.A.	

	9. G.C. Schatz and M.A. Ratner, Introduction to Quantum Mechanics in Chemistry, Prentice Hall, 2001, 1st edition, New Jersey, U.S.A.

Practicals:

Course Objectives:	1. To apply theoretical knowledge for performing experiments. 2. To understand the computer program for determining equivalence point. 3. To acquire knowledge of various methods on reaction kinetics.	
Content		**No. of hours**
	1. To generate a plot for a given function such as solutions of 1-D box, harmonic oscillator, H-like atom wave functions.	**2**
	2. To write a computer program to obtain equivalence point in pH metry experiments (derivative method).	**4**
	3. To determine the instability constant of the reaction $[Ag(NH_3)_2]^+ \rightarrow Ag^+ + 2NH_3$ potentiometrically.	**4**
	4. To investigate the autocatalytic reaction between potassium permanganate and oxalic acid.	**4**
	5. To study the kinetics of reaction between H_2O_2 and KI (clock reaction).	**4**
	6. To investigate the reaction kinetics between potassium per sulphate and potassium iodide colorimetrically.	**4**
	7. To determine the degradation rate of the polymers using thermogravimetric methods.	**4**
	8. To study the variation in catalytic activity of three different metal oxides for H_2O_2 decomposition reaction.	**4**
	9. To determine the concentration of Fe^{2+} ions by titrating with potassium dichromate conductometrically.	**4**
	10. To determine the mass of acetaminophen in a given sample using electrochemical method.	**4**
	(Note: Experiment No. 1 is compulsory, from experiment No. 2 to 10, perform any seven)	
Pedagogy	Students should be given suitable explanation revising the theoretical aspects prior to the conduct of each experiment. Pre- and post-laboratory assignments to be given. Each student performs the experiment individually.	
References / Readings, References for practicals	1. I. N. Levine, Quantum chemistry, 7th edition, Pearson India Education Pvt. Ltd. 2016, New Delhi. 2. D. A. McQuarrie, J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Pvt. Ltd, 2018, 1st edition, Mumbai. 3. P. K. Ghosh, P. K. Shukla, Atomic Electronic Structure-Atomic Orbitals, Prentice Hall of India learning Pvt. Ltd., 2016, New Delhi. 4. R. G. Baughman, Hydrogen-like atomic orbitals an undergraduate exercise, J. Chem. Educ. 1978, 55, 5, 315. 5. P. Atkins and J. Paula, Physical Chemistry, 8th edition, W. H. Freeman and Company, 2006, New York 6. D. Rubenstein, W. Patterson, I. Peng, F. Schunk, A. Mendoza-Garcia, M. Lyu and Li-Qiong Wang, Introductory Chemistry Laboratory: Quantum Mechanics and Color, J. Chem. Educ. 2020, 97, 12, 4430–4437 7. A. Finlay & J.A. Kitchener, Practical Physical Chemistry, Longman. Prentice	

	Hall Press, New Jersey, USA, 8th edition, 2000. 8. F. Daniels & J.H. Mathews, Experimental Physical Chemistry, Second edition, McGraw-Hill, New York, 2002. 9. A. M. James, Practical Physical Chemistry, Longman Publisher, New York, 1974. 10. D. P. Shoemaker & C.W. Garland, Experimental Physical Chemistry, 8th edition, McGraw-Hill, 2008, New York.
Course Outcome:	At the end of the course, students will be able to: 1. apply the Schrödinger's equation and its solution to complex molecules. 2. explain concepts of non-equilibrium and statistical thermodynamics. 3. deduce rate equations of complex and fast reactions. 4. demonstrate electrochemical corrosion effects and explain principles of photovoltaics. 5. determine instability constant by potentiometric method. 6. compare catalytic activity of different metal oxides for H_2O_2 decomposition.

Name of Programme : **B.Sc. (Honors) Chemistry**
Title of the course : **Advanced analytical techniques-II**
Course Code : **CHC-413, Minor**
Number of Credits : **4 (Theory 3, Practical 1)**
Effective from AY : **2024-25**

Pre-requisites for the course	Student should have studied semester I to VII courses	
Course Objective:	1. Provide basic knowledge about data handling. 2. Introduce the principles and applications of optical analytical and emission spectroscopic techniques. 3. Develop concepts in various electroanalytical techniques and Karl Fischer titration. 4. Acquaint the students to the basic principles, instrumentation and working of ESR and radioanalytical techniques.	
Contents		**No. of Hours**
	1. Data Handling : Confidence limit, Test of significance: Students t, F test, Rejection of the results: 2.5 d & 4 d rule and Q test, F-Test, Null Hypothesis, Linear least squares and Method of averages. *(Numerical problems are expected to be solved)*	**04**
	2. Emission Techniques: Introduction, principles and applications of Atomic Emission Spectroscopy (AES). Excitation techniques, electrodes and their shapes, Quantitative and qualitative application, brief introduction to ICP-MS, ICP-OES.	**07**
	3. Electroanalytical techniques: Brief introduction to electroanalytical techniques. a. Electro gravimetric analysis: Introduction, principle, instrumentation, electrolysis at constant current, apparatus, determination of copper by constant current electrolysis. b. Coulometry: Introduction, constant current measuring device, Hydrogen-Oxygen coulometer, Silver coulometer. General characteristics of coulometric method, applications of coulometry in neutralization, complexation, precipitation and redox titrations. c. Amperometric titrations: Introduction, instrumentation, titration curves, advantages. d. Voltametry and polarography, cyclic voltametry, stripping voltammetry. e. sensors, types of sensors including electrochemical sensors, evaluation and calculation. f. Impedance spectroscopy, Nyquist plots.	**12**
	4. Electron spin resonance spectroscopy: Basic principle, comparison between NMR and ESR: instrumentation- source, circulator (Magic-T), sample cavity, magnet system, crystal detector, auto amplifier, recorder.	**06**

	Working, application: structure determination, inorganic compounds, analytical application.	
	6. Radioanalytical techniques: Theory and principles of radio analytical technique, detection of nuclear radiation, radiation detectors, pulse height analysis, counting error, analytical application of radioisotopes, neutron activation analysis and isotope dilution analysis.	**06**
	7. Chromatographic Methods: a. Size Exclusion Chromatography: Principle, types, stationary phases in gel chromatography, physical and chemical characteristics of gel, mechanism of gel permeation chromatography (GPC), instrumentation of GPC, applications of GPC: determination of molecular weight of polymer with numericals. b. Supercritical-Fluid Chromatography: Introduction, important properties of supercritical-fluids, instrumentation and variables, SFC column vs other columns, applications and data analysis. c. Affinity Chromatography: Principle, affinity matrix, ligands, mobile phase, separation mechanism, application in the separation of proteins, etc.	**10**
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning	
Reference :	1. H. Willard, L. Meritt and J.A. Dean, Settle *Instrumental Methods of Analysis*, 7th edition, CBS publication, India , 2004 2. D.A. Skoog and J.J. Leary, *Principles of Instrumental analysis*, 4th Edition, Saunders College Publication. Forth Worth1992 3. G. D. Christian, *Analytical Chemistry*, 6th edition, Wiley publication, NewYork, 2004 4. John Kenkel, *Analytical chemistry for Technicians* 4th edition, CRC press, Tylor & Francis Group, Boca Raton, Londn NewYork, 2013 5. D. A. Skoog, D. M. West & F. J. Holler, *Fundamentals of Analytical Chemistry*, 6th th Ed., Sounders College publishing, USA 1992. 6. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, England, 2000. 7. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 8. D. Harvey, *Modern analytical chemistry*, 1st Ed., The McGraw-Hill, India,2000. 9. Gurdeep R. Chatwal, Sham K. Anand, *Instrumental Methods of Chemical Analysis*,5th edition, Himalaya publishing house, Mumbai, 2013 10. C.N. Banwell and E.M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw- Hill, New Delhi; 4th Ed.	

Practicals		
Course objective	1. To train students to use different techniques of separation and estimation 2. Apply the knowledge for chemical and pharmaceutical analysis 3. Familiarize student to understand the spectral data and to interpret the information.	
Content		**No of Hours**
	I. Estimations: (Any Four) 1. To separate organic mixture (acid +base+neutral) by solvent extraction. 2. Colorimetric estimation of iron in supplements (capsules) by thiocyanate method. 3. Purification and estimation of paracetamol from commercial tablets by column chromatography. 4. Separation and estimation of Cadmium and Zinc ion exchange chromatography. 5. Separation of a mixture of benzoin and benzyl on silica gel column. 6. Spectrophotometric determination of aspirin/phenacetin/ in APC tablet using solvent extraction.	**16**
	II. DATA interpretation 1. Data Interpretation of H^1 and C^{13} NMR spectra of Ethyl acetate and Ethyl methyl ketone. 2. Data Interpretation of Mass spectra of Ethyl acetate and Ethyl methyl ketone. 3. Data Interpretation of HPLC chromatogram: Separation of enantiomers of Ritalin by HPLC with a chiral stationary phase. **(a)** From t_r and $w_{1/2}$, find N for each peak. **(b)** From t_r and $w_{1/2}$, find the resolution. 4. Data Interpretation GC chromatograph: From a gas chromatogram of a mixture of toluene and ethyl acetate. **(a)** Use the width of each peak (measured at the base) to calculate the number of theoretical plates in the column. Estimate all lengths to the nearest 0.1 mm. **(b)** Using the width of the toluene peak at its base, calculate the width expected at half-height.	**14**
References:	1. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, 5th Ed., John Wiley, New York, 1989. 2. J. Mendham, R.C. Denney, J.D. Barnes, M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, 6th Ed., Pearson Education Asia, England, 2000 3. Anil J. Elias, *Collection of Interesting chemistry experiments*, University Press (India) private limited, Hyderabad 2002 4. R.A. Day & A.L. Underwood, Quantitative analysis,6th Edition, Prentice Hall, New Delhi 2001	

	5. John Kenkel, *Analytical chemistry for Technicians* 4th edition, CRC press, Tylor & Francis Group, Boca Raton, Londn NewYork, 2013
Course Outcomes:	At the end of the course student will be able to 1. explain the principle and instrumentation of Polarimetry. 2. illustrate the principle of Electroanalytical techniques such as voltametry, conductometry and Karl Fischer titration. 3. describe the principle, instrumentation and working of ESR radioanalytical techniques. 4. Separate and estimate organic and inorganic compounds using different types of chromatographic methods. 5. Interpret basic information in spectra of NMR, MS, HPLC, GC 6. Apply knowledge to interpret spectra.

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-414 Minor (4)**
Title of the course : **Advanced Pharmaceutical Chemistry and Analysis II**
Number of Credits : **3T+1P**
Effective from AY : **2024-25**

Prerequisites for the course	Students should have knowledge of drugs and spectroscopy	
Course Objectives:	1. To define and classify the drugs 2. To understand the concept of drug designing. 3. To analyze and identify the drugs using spectroscopic methods 4. To introduce process of writing and filing a patent.	
Content		**No of hours**
	Definition and Classification with structure of the following drugs: **1. Hypotensive agents, General and Local Anaesthetics**: **Cholinergic and Adrenergic Agents,** **Hypotensive agents** acting on vascular smooth muscles: Glyceryl nitrite **General Anaesthetics**: Ether, Ultra short acting Barbiturates-Thiopental sodium. **Local anaesthetics**: Benzocaine, Procaine, Lidocaine, Purgatives and cathartics: Phenolphthalein. **Synthesis, use and side effects of Thiopental sodium, and Benzocaine, Classification of cholinergic agents**: Drugs acting on cholinergic nervous system: Methacholine, Tropicamide, Classification of adrenergic agents, Drug acting on adrenergic nervous system: Propranolol, **Synthesis and side effects of methacholine, propranolol.** **Mechanism of Action of Procaine.**	**06**
	2. Cardiovascular drugs, antihypertensive agents, and antibiotics: Digitoxin, Antihypertensive agents Methyl dopa, vasodilators drugs: Nitroglycerin, Antibiotics: Penicillin, Chloramphenicol. **Synthesis, use and side effect of nitroglycerin** and **Methyl dopa.** **Analgesics, Antipyretics and Inflammatory agents:** Analgesics, antipyretics and anti-inflammatory agents: Naproxen, Diclofenac. Narcotic analgesic agents: Morphine, Non-narcotic analgesic agents: Dextropropoxyphene. **Synthesis, use and side effect of Diclofenac.** **Neglected Tropical diseases**. Background, overview of Neglected tropical diseases, (Poverty diseases) Human Schistosomiasis, African trypanosomiasis (Chagas), leishmaniasis, sleeping sickness. Nitroheterocycles, Benznidazole, Nifurtimox **Synthesis, use, side effects of Benznidazole** **SAR of Naproxen**	**06**

	3. Drug Design, Structure Activity Relationship and Enzyme Inhibitors as drugs Development of new drugs: Introduction, procedure followed in drug design, the search for lead compounds, molecular modification of lead compounds, prodrugs and soft drugs, prodrug; introduction, prodrug formation of compounds containing various chemical groups, multiple prodrug formation, soft drugs; Comparison between prodrugs and soft drugs **Structure-Activity Relationship (SAR):** Factors effecting bioactivity, resonance, inductive effect, isosterism, biological properties of simple functional groups. 4-5 illustrative examples depicting structural activity relationship studies. Basic concepts in drug theories, occupancy theory, rate theory, induced fit theory. **Design of Enzyme Inhibitors as drugs** Enzyme inhibitors-Broad Classification with one example. Design of Enzyme Inhibitors, 9-mercaptopurines and allopurines.	**09**
	4. QSAR Studies in drug discovery and IPR in Pharmaceuticals Advantages and drawbacks of Hansch analysis and Free-Wilson analysis, Their application, relationship between Hansch and Free-Wilson analysis (the mixed approach), non-linear relationship, Introduction to other QSAR approaches- Free Topliss Method-Postulates and Illustration. Introduction to molecular modelling using computers and docking, uses of molecular modelling manual. Computers Aided Drug design: Basic concept of Computational chemistry. Virtual Screening. Current trends in the field of drug discovery and design. **Pharmaceuticals and IPR**: Patents and intellectual property rights: IPR, introduction to types of IPR, Patent and its importance, Pharmaceutical patent and chemical patent, Criteria for patenting. Patentable inventions, Steps for filing a patent. Patent writing a case study.	**10**
	5. Spectral analysis of drugs-I **UV-Visible Spectroscopy:** **Ultra Violet (UV)-visible spectroscopy and its pharmaceutical applications**: Electronic excitations, Beer Lamberts Law, predicting UV absorption using Woodward-Fieser, Fieser-Kuhn and Nelson rules; Calculation of λ_{max} for Vitamin K1, Vitamin A. Comparison of λ_{max} values of β-carotene and γ-carotene. (Numerical problems are to be solved). **Infrared (IR) spectroscopy**: Principle of Infra Red spectroscopy, Hooke's Law, Applications: Identification of functional groups in the following drugs: Mefloquine, Clotrimazole, Niclosamide, p-aminosalicylic acid, Spectral interpretation with examples of above. Infra-red spectroscopy in monitoring the progress of reaction of preparation of benzocaine from p-aminobenzoic acid.	**06**

	6. Spectral Analysis of drugs-II **Nuclear Magnetic Resonance (NMR) spectroscopy**: Principle of proton NMR spectroscopy, chemical shift-shielding and deshielding effect, NMR solvents. Interpretation of NMR spectra of some drugs (Ibuprofen, Albendazole). ^{13}C-NMR, correlation of structure with spectra: Chemical environment, shielding and carbon-13 chemical shift, proton-coupled Carbon Spectra, Proton decoupled C spectra. Explanation of spectra of some drugs.(Clotrimazole, Thiotepa)	**08**
Pedagogy	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations /industry visits/ self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning.	
References / Readings	1. Patrick, G.L., *Introduction to Medicinal Chemistry*, 7th ed., Oxford University Press, UK, 2023. 2. Singh, H. and Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry*, 3rd ed., Vallabh Prakashan, Pitampura, New Delhi, 2012. 3. Foye, W.O. Lemke, T.L. William, D.A., *Principles of Medicinal Chemistry*, 7th ed., B. I. Waverly Pvt. Ltd. New Delhi, 2012. 4. Beale, J.H. and Blocks, J.H., *Wilson and Gisvold's Textbook of Organic, Medicinal and Pharmaceutical Chemistry*, 12th ed., Lippinkott Williams and Wilkins, Philadelphia, USA, 2011. 5. Lednicer, D. and Meischer, L.A., *Organic Chemistry of Drug Synthesis*. Vol. I to III. John Wiley & Sons, New Jersey, USA, 2005. 6. Sriram, D. and Yogeshwari, P., *Medicinal Chemistry*, 1st ed., Pearson Education, London, 2007. 7. Sriram, D. and Yogeshwari, P., *Medicinal Chemistry*, 2nd ed., Pearson Education, London, 2010. 8. Wolff, M. E., *Burger's Medicinal Chemistry and Drug Discovery*, 5th ed., John Wiley & Sons, New Jersey, USA,1997. 9. Chatwal, G.R., *Medicinal Chemistry*, 2nd ed., Himalaya Publishing house, Mumbai, 2002. 10. Sharma, B.K., *Instrumental Methods of Chemical Analysis*, Goel Publishing House, Meerut, 2014. *11.* Raghuraman, K. Prabhu, D. V. Prabhu, C. S. and Sathe, P. A., *Basic principles in Analytical Chemistry*, 5th ed., Shet Publications pvt. ltd, Mumbai, 2014. 12. Chatwal, G. R. and Anand, S., *Instrumental Methods of Chemical Analysis*, 5th ed., Himalaya publications, Mumbai, 2003. 13. Willard, H. H. Meritt, L. L. Dean, J.A. and Settle, F.A., *Instrumental Methods of Analysis*, 7th ed., Balmond Wadsworth, California, 1988. 14. Skoog, D.A. and Leary, J.J., *Principles of Instrumental analysis*, 4th ed., Saunders College Publication, USA, 1992. 15. Connors, K. A., *Text book of pharmaceutical analysis*, 3rd ed., Wiley Interscience Publication, London, 1990. *16.* Skoog, D. A. Holler, F. J. and Crouch, S., *Principles of Instrumental Analysis*, 7th ed., Cengage Learning, Australia, 2018.	

17. Ahuja, S. and Scypinski, S., *Handbook of Modern Pharmaceutical Analysis*, 2nd ed., Elseviers Publishers, Amsterdam, Netherlands, 2010.
18. Venn, R. F., *Principles and Practice of Bioanalysis*, 2nd ed., CRC Press, Florida, USA, 2008.
19. Pavia, D. L. Lampman, G. M. Kriz, G.S. and Vyvyan, J. A., *Introduction to Spectroscopy*, 3rd ed., Thomson learning, Ontario, Canada, 2001.
20. Kemp, W., *Organic Spectroscopy*, 3rd ed., New York Palgrave, New York, 2019.
21. Williams, D. H. and Fleming, I., *Spectroscopic Methods in Organic Chemistry*, 5th ed., McGraw Hill, New York, USA, 1995.
22. Silverstein, R. M. Webster, F. X. and Kiemie, D. J., *Spectrometric Identification of Organic Compounds*, 7th ed., Wiley and Sons, New Jersey, USA, 2005.
23. Dyer, J. R., *Applications of Absorption Spectroscopy of Organic Compounds*, Prentice Hall of India Pvt. Ltd., New Jersey, USA, 1978.
24. Atole, D.M. and Rajput, H. H., *Ultraviolet spectroscopy and its pharmaceutical applications-A brief review*, Asian J Pharm Clin Res, Vol 11, Issue 2, 2018, 59-66.
25. Agarwal, P., *NMR Spectroscopy in Drug Discovery and Development*, Materials and Methods, 2014, 4, 599.
26. Pellecchia, M. Sem, D. and Wuthrich, K., *NMR in drug discovery*. Nat. Rev. Drug Discov., 2002;1:211-9.
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28. Pandeya, S. S. and Dimmock, J.R., *An Introduction to Drug Design*, New Age International (P) Ltd. Publishers, New Delhi, 2007.
29. Gringauz, A., *Introduction to Medicinal Chemistry*, 1st ed., Wiley-VCH, New Jersey, USA, 1996.
30. Silverman, R.B., *Organic Chemistry of Drug design and Drug action*, 3rd ed., Academic Press, Massachusetts, USA, 2014.
31. Smith, J., *Introduction to the Principles of Drug design and action*, 4th ed., Taylor and Francis, UK, 2010.
32. Leach, A., *Molecular Modelling: Principles and applications*, 2nd ed., Pearson India, 2001.
33. Acharya, N.K., *Textbook on intellectual property rights*, 3rd ed., Asia Law House, Hyderabad, Telangana, 2001.
34. Guru, M. and Rao, M.B., *Understanding Trips: Managing Knowledge in Developing Countries*, 1st ed., Sage Publications, New Delhi, 2003.
35. Ganguli, P., *Intellectual Property Rights: Unleashing the Knowledge Economy*, 1st ed., Tata McGraw-Hill, New Delhi, 2001.
36. Miller, A. R. and Davis, M. H., *Intellectual Property: Patents, Trademarks and Copyright in a Nutshell*, 3rd ed., West Group Publishers, Minnesota, USA, 2000.
37. Christian, G. D., *Analytical Chemistry*, 6th ed., John Wiley & Sons, New Jersey, USA, 2001.

Number of Credits: 01 (Practicals)

Course Objectives:	1. To apply theoretical concepts to experiments. 2. To acquire hands on training in spectrophotometric and chromatographic technique. 3. To acquire hands on training in preparation of bioactive compounds.	
Content		**No of hours**
	a) Qualitative and Quantitative tests of (Any 1) (1) Ibuprofen as per IP Monograph (2) Paracetamol as per IP Monograph	**06**
	b) Spectrophotometric assay of bulk drug or tablets (Any 2) Chlorpromazine HCl, Metformin hydrochloride, Albendazole, Isoniazid and Caffeine	**04**
	c) Titrimetric assay of bulk drug/ tablet (Any 2) Isoniazid, chlorpromazine hydrochloride, atropine, Dapsone, ethosuximide, Vitamin C	**04**
	d) Simultaneous estimation of the following by UV spectroscopy (Any 1) i) Diclofenac and paracetamol ii) Aspirin and Caffeine iii) Paracetamol and Ibuprofen	**04**
	e) Synthesis of bioactive compounds (Any 3) Warfarin, 2-p-methylphenylbenzoxazole, Monastrol, Altretamine, benzotriazole, 3-methyl-1-phenyl pyrazole-5-one, Procarbazine, Tolbutamide	**06**
	f) Interpretation of Infra-Red and ^{1}HNMR Spectra of the following drugs Warfarin, Benzotriazole, Monastrol, Altretamine	**02**
	g) Drawing structures in silico using Chemdraw or Chemsketch	**02**
	h) Case study of a patent for a given invention.	**02**
	Total:	**30 hrs**
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. Furniss, B. S., Hannaford, A. J., Smith P. W. G. and Tatchell, A. R., *Vogel's Textbook of Practical Organic Chemistry*, 5thed., Pearson Education Ltd., London, 2011. 2. Pasto, D. Johnson, C. and Miller, M., *Experiments and Techniques in Organic Chemistry*, 1st ed., Prentice Hall, New Jersey, USA, 1991. 3. Fieser, L.F. and Williamson, K.L., *Organic Experiments*, 7th ed., D. C. Heath, Massachusetts, USA, 1992. 4. Bansal, R. K., *Laboratory Manual in Organic Chemistry,* 5th ed., New Age International private limited, New Delhi, 2016. 5. Indian Pharmacopoeia, new edition. 6. Siddique, A. A., *Laboratory Manual-Selected experiments in pharmaceutical analysis*, 2nd ed., CBS Publishers, New Delhi, 2020.	

	7. Mondal, P. and Mondal, S., *Handbook of Practical, Pharmaceutical Organic, Inorganic and Medicinal Chemistry*, Educreation Publishing, New Delhi, 2019. 8. Singh, R., *Handbook of practical pharmaceutical chemistry (A systematic approach to titrimetric analysis*), Shivalik College of Pharmacy, Punjab, 2016. 9. Indian Pharmacopoeia, The Indian Pharmacopoeia Commission, Ghaziabad, 2007, Volume 2, page 303-304.
Course Outcomes	At the end of the course, students will be able to: 1. classify drugs based on their uses. 2. apply SAR and QSAR approach to design drugs. 3. analyze and identify the drugs using spectroscopic methods. 4. write and file a patent. 5. refer Pharmacopoiea and apply in laboratory experiments 6. synthesize drugs and drug like compounds. 7. demonstrate spectroscopic methods in drug analysis. 8. explain the patent process

Name of the Programme : **B.Sc. Semester VIII (Chemistry)**
Course Code : **CHC-461**
Title of the course : **Dissertation**
Number of Credits : **12**
Effective from AY : **2024-25**

Prerequisites for the course	The student should have knowledge of Chemistry
Course Objectives:	1. To introduce skills set such as independent thinking, literature survey, data collection and interpretation 2. To gain knowledge about critical analytical reasoning, statistical understanding, hypothesis testing, project management and copy editing.
Content:	**1. Dissertation in the parent institute or any other higher education or research institute** The student must complete literature review followed by research work/ dissertation in minimum of three months, or the equivalent. The student should submit a certificate of attendance that has been signed by the respective guide.
	2. Dissertation writing Student are required to submit hardbound copies of the duly certified dissertation report in the department
	3. Viva -Voce Examination Students are required to present their dissertation report and defend the same.
Pedagogy:	literature review/Hands-on-training
References/ Readings	Research articles and reviews from journals and books.
Course Outcomes	Upon successful completion of dissertation course, students will be able to: 1. write an original research project in order to address research problem. 2. design a discipline specific research methodology. 3. analyze the raw data and draw conclusions. 4. develop analytical skills and gain expertise in scientific writing.

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