Cotton University :: NEP UG Syllabus

Chemistry :: Sem–I

Chemistry Core/Minor – I **Credits (L+T+P)*: 3 + 0 + 1 = 4**

Learning Objectives:

1. Familiarization with the various states of matter.
2. Physical properties of each state of matter and laws related to describe the states.
3. Understanding kinetic model of gas, Maxwell distribution, collisions and kinetic energies.
4. Behaviour of real gases, its deviation from ideal behaviour, equation of state and critical state.
5. Liquid state and its various physical properties along with their temperature variation.
6. Solids, symmetry in solid structures, lattice parameters and structure of simple salts.
7. Learn the basic properties of organic molecules, and understand their structure and bonding.
8. Have the knowledge of various electronic effects, acid-base properties and reaction intermediates in organic compounds.
9. To understand about atomic theory and its evolution.
10. Learning scientific theory of atoms, concept of wave function.
11. To know about the arrangement of elements in periodic table; physical and chemical characteristics of elements and their periodicity.

Unit 1: States of Matter **(15 lectures)**

Gases: Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor and its variation with pressure for different gases. Causes of deviation from ideal behaviour. The van der Waals equation of state, its application in explaining real gas behaviour. Boyle temperature. Critical state, critical constants and van der Waals constants, Andrews' isotherms of CO_2.

Kinetic molecular theory of a gas, its postulates, derivation of the kinetic gas equation. Maxwell speed distribution, its use in evaluating the mean molecular speeds (average, root mean square and most probable speeds) and average kinetic energy, law of equipartition of energy, degrees of freedom (with lack in expression of vibrational ones at room temperature), molecular basis of heat capacities. Collision cross section, collision frequency and mean free path of gases.

Liquids: Structure and physical properties of liquids; vapour pressure, surface tension, viscosity, their dependence on temperature and their determinations. Effect of addition of various solutes on surface tension, cleansing action of detergents. Elementary ideas of liquid crystals.

Solids: Forms of solids. Elementary ideas of symmetry, symmetry elements and symmetry operations, unit cells, crystal systems, Bravais lattices. Laws of Crystallography – Law of constancy of interfacial angles, Law of rational indices. Weiss and Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl. Defects in crystals.

** **Note**: In L+T+P, L, T and P stand respectively for credits against Lecture, Tutorial and Practical*

Unit 2: Basics of Organic Chemistry **(15 lectures)**

(a) Hybridization, Shapes of molecules, Influence of hybridization on bond properties.
(b) Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications;
(c) Organic acids and bases; their relative strength.
(d) Homolytic and Heterolytic fission with suitable examples.
(e) Electrophiles and Nucleophiles; Nucleophlicity and basicity;
(f) Reaction intermediates: Types, shape and relative stabilities of Carbocations, Carbanions, Free radicals and Carbenes.
(g) Types of Organic reactions: Addition, Elimination and Substitution reactions.
(h) Aromaticity: Hückel's rule, Aromatic, non-aromatic and antiaromatic compounds.

Unit 3: Atomic Structure (**10 lectures**)

Concept of atom in ancient India, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Time-independent Schrödinger's wave equation, significance of ψ and $|\psi|^2$. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals (Contour boundary and probability diagrams). Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau principle and its limitations.

Unit 4: Periodicity of Elements **(5 lectures)**

The s, p, d, f block elements, the long form of periodic table. Discussion of the following properties with reference to s and p-block elements:
(a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.
(b) Concept of Atomic radii (van der Waals, covalent, ionic and metallic).
(c) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy.
(d) Electron gain enthalpy, trends of electron gain enthalpy.
(e) Electronegativity, Pauling, Mullikan, Allred Rachow scales, electronegativity and bond order, Partial charge.

Recommended Textbooks/ References:

1. P.W. Atkins and J. de Paula. Atkins' Physical Chemistry 8th Ed., Oxford University Press (2006)
2. D. W. Ball. Physical Chemistry Thomson Press, India (2007)
3. G. W. Castellan. Physical Chemistry 4th Ed. Narosa (2004)
4. R. G. Mortimer. Physical Chemistry 3rd Ed. Elsevier, Noida (UP). (2009).
5. I. N. Levine. Physical Chemistry 6th Ed., Tata McGraw-Hill, 2011.
6. Lee, J. D. Concise Inorganic Chemistry, Wiley, 5th Edition.
7. Douglas, B.E., McDaniel, D.H., Alexander J.J., Concepts & Models of Inorganic Chemistry, (Third Edition) John Wiley & Sons, 1999.

8. Atkins, P. W., Overton, T., Rourke, J., Weller, M., and Armstrong, F. Shriver & Atkins' Inorganic Chemistry, Fifth Edition, Oxford University Press, 2010.
9. Huheey, J.E., Inorganic Chemistry, Prentice Hall, 1993.
10. Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edn., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Pine S. H. Organic Chemistry, Fifth Edition, McGraw Hill, (2007)
12. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.

Practical (Lab) Experiments for Sem – I:

Physical Chemistry Lab

1. Determination of surface tension for three aqueous solutions of ethanoic acid (with concentrations not beyond 25% w/w) by drop number method to judge its change with increasing concentration.
2. Determination of coefficient of viscosity of three aqueous solutions of ethanol (with concentrations not beyond 30% w/w) using Ostwald viscometer to judge its change with increasing concentration.

Organic Chemistry Lab

1. Purification of organic compounds by crystallization using the following solvents:
a. Water b. Alcohol c. Alcohol-Water
2. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
3. Chromatography: Separation of a mixture of organic compounds by thin layer chromatography (TLC).

Recommended Textbooks/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, Eighth Edition, McGraw-Hill (2003).
3. Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry, Third Edition, W, H. Freeman (2003).
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
5. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)

Course Outcomes:

After the completion of the course, the students will be able to:

1. Know about real gas behaviour as different from ideal behaviour.
2. Know about kinetic molecular theory, collisions, mean free path and their interrelations. Perform numerical calculations on these topics.
3. Understand the distribution of molecular speeds and energies in gases, along with their numerical aspects.

4. Know about the structure and various physical properties of liquids, along with how the surface tension depends on solutes, and experimentally determine surface tension and coefficient of viscosity of liquids.
5. Understand the crystal structure and symmetry in crystalline solids and perform numerical calculations on these. Also, obtain introductory knowledge about liquid crystals.
6. Understand the basic properties of organic molecules, and their structure and bonding.
7. Apply the knowledge of various electronic effects in determining reactivity organic compounds.
8. Know about structure of atom, classical and quantum mechanical models and theories of atomic structure, dual behavior of electrons and concept of atomic orbitals.
9. Understand about arrangement of elements in periodic table, periodic variation of element's properties.

Cotton University NEP UG Syllabus
Chemistry :: Sem–II

Chemistry Core/Minor – II **Credits (L+T+P): 3 + 0 + 1 = 4**

Learning Objectives:

1. Understanding the fundamentals of chemical kinetics: concepts of rate, differential and integrated rate equations, half-life, order and molecularity, temperature dependence of rate.
2. Determination of progress of reaction, rate, rate constant and order.
3. Introductory knowledge about the theories of reaction rates.
4. Understanding the fundamentals of catalysis – types of catalysis, cause of catalytic action, mechanism of heterogeneous catalysis, introduction to acid-base catalysis and enzyme catalysis.
5. Learn 3-D structure and concept of chirality in organic molecules.
6. Learn properties and reactions of saturated and unsaturated hydrocarbon
7. Understand the concept of ionic bonding, lattice energy using Born-Landé equation, Born Haber Cycle and Solvation Energy.
8. Learn about VSEPR theory, VBT and MOT (homo- & hetero-nuclear diatomic molecules).
9. Understand the theory and application of acid-base and redox chemistry.

Unit 1: Chemical Kinetics **(10 Lectures)**

The concept of reaction rates. Effect of concentration, temperature and catalyst on reaction rates. Differential rate equation and the order of a reaction. Methods of experimental determination of the progress of a reaction and of the rate constant. Concept of molecularity, comparison between order and molecularity. Derivation of integrated rate equations for zeroth, first and second order reactions. Half–life of a reaction and its dependence on initial concentration for different orders. Methods for determination of the order from the half-life for single-reactant systems. Temperature dependence of the reaction rate, Arrhenius equation. Concept of pre-exponential factor, activation energy and their calculation.

Qualitative ideas of the Collision theory and Activated Complex theory of bimolecular reactions.

Unit 2: Catalysis **(5 lectures)**

Types of catalysis – homogeneous and heterogeneous. Cause of catalytic effect on reaction rate. Introductory ideas of acid-base catalysis. Mechanism of catalysed reactions at solid surface, effect of particle size. Enzyme catalysis, its characteristics, Michaelis-Menten mechanism. Specificity and selectivity in enzyme catalysis.

Unit 3: Stereochemistry **(7 Lectures)**

(a) Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.
(b) Conformations with respect to ethane, butane and cyclohexane.
(c) 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; CIP Rules: R/ S and E / Z Nomenclature

Unit 4: Chemistry of Aliphatic Hydrocarbons (8 Lectures)

Alkanes:

(a) *Preparation:* Catalytic hydrogenation, Wurtz Reaction, Wurtz-Fittig Reaction, Kolbe reaction
(b) *Reactions*: Combustion reaction, Cracking, Free radical substitutions: Halogenation - relative reactivity and selectivity.

Alkenes:

(a) *Preparation*: Elimination reactions: Dehydration of alkenes anddehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction).
(b) *Reactions*: cis-addition (alk. $KMnO_4$)and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Unit 5: Chemical Bonding (10 lectures)

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Born-Landé equation with derivation. Madelung constant, Born-Haber cycle and its application, Solvation energy.

Covalent bond: Lewis structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Shapes of simple molecules and ions containing lone-and bond-pairs of electrons multiple bonding, sigma and pi-bond approach, Valence Bond theory, (Heitler-London approach). Hybridization containing s, p and s, p, d atomic orbitals, shapes of hybrid orbitals, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of simple homonuclear and heteronuclear diatomic molecules, e.g., N_2, O_2, C_2, B_2, F_2, CO, NO, (idea of s-p mixing and orbital interaction to be given).

Unit 6: Acid Base and Redox Chemistry (5 lectures)

Arrhenius, Brönsted and Lewis theories of acids and bases, Strength of Brönsted acids and bases in water, Strength of Lewis acids and bases. Hard and soft acid-base (HSAB) concept and its applications.

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Recommended Textbooks/ References:

1. P. W. Atkins and J. De Paula. Physical Chemistry (10th Ed.), Oxford University Press, 2014.
2. G.W. Castellan. Physical Chemistry, 4th Ed., Narosa, 2004.
3. T. Engel and P. Reid. P. Physical Chemistry, 3rd Edition, Prentice-Hall, 2012.
4. D.W. Ball. Physical Chemistry, Cengage India, 2012.
5. R. G. Mortimer. Physical Chemistry 3rd Ed., Elsevier: NOIDA (UP), 2009.
6. I. N. Levine. Physical Chemistry 6th Ed., Tata McGraw-Hill, 2011.
7. C. R. Metz. Physical Chemistry 2nd Ed., Tata McGraw-Hill, 2009.
8. F. A. Carey, Organic Chemistry, Seventh Edition, Tata McGraw Hill (2008).
9. J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2nd Ed., (2012), Oxford University Press.

10. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and mechanism, Kluwer Academic Publisher, (2000).
11. Kemp, W. Organic Spectroscopy, Palgrave
12. E. L. Eliel: Stereochemistry o*f* Carbon Compounds, Tata McGraw Hill.
13. Kalsi, P. S. Textbook o*f* Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
14. J. D. Lee: A new Concise Inorganic Chemistry, E. L. B. S.
15. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
16. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
17. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of
18. Structure and Reactivity, Pearson Publication.
19. Rodger, G. E. Inorganic and Solid-State Chemistry, Cengage Learning, 2002.

Practical (Lab) Experiments for Sem – II:

Physical Chemistry Lab:

1. Study of the iodine clock reaction to judge the slowing down of the reaction rate with the passage of time.
2. To gauge the effect of added manganous ion catalyst to the initial rate of the titration process between oxalic acid solution versus permanganate ion in strong acidic medium done at room temperature.

Inorganic Chemistry Lab

1. Titrimetric Analysis
(i) Calibration and use of apparatus.
(ii) Preparation of solutions of different Molarity/Normality of titrants.
(iii) Use of primary and secondary standard solutions.

2. Acid-Base Titrations
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.

3. Oxidation-Reduction Titrimetry
(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Recommended Textbooks/References:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand, New Delhi, 2011.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, Eighth Edition, McGraw-Hill (2003).
3. Halpern, A. M. and McBane, G. C. Experimental Physical Chemistry, Third Edition, W, H. Freeman (2003).
4. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis Sixth Edition, Pearson, 2009.
5. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Course Outcomes:

On completion of this course, the students will be able to:

1. Know about and perform calculations on the rate laws for simple reactions of various orders and on temperature dependence of the reaction rate.
2. To learn about determination of the progress of a reaction and to experimentally perform such a determination.
3. To have an introductory understanding of the collision theory and the activated complex theory of chemical reactions.
4. Understand the types of catalysed reactions and the cause behind the catalytic effect, and the mechanisms of such reactions at solid surfaces, enzyme environments and acid-base mediums.
5. Understand the effect of spatial arrangements of atoms in organic molecules on their properties and reactivities.
6. Interpret reactions and properties of aliphatic hydrocarbons.
7. Have introductory idea about chemical bonding
8. Calculate relevant bonding parameters, interpret trends, predict and draw molecular structures using various bonding theories
9. Apply acid-base and redox concepts to inorganic compounds and reactions
10. They will also have hands-on experience at learning titrimetric techniques used in inorganic chemistry.

Cotton University NEP UG Syllabus
Chemistry :: Sem–I
MDE (Multi-Disciplinary Elective) Chemistry – I Credits (L+T+P): 3 + 0 + 0 = 3

Learning Objectives:

1. Understanding the meaning and significance of chemistry.
2. Knowing about classification of matter and its atomic and molecular constitution, along with quantitative aspects about their masses and numbers.
3. Understanding the structure of atoms and of molecules, including of organic molecules.
4. Knowing introductory ideas about catalysis including enzyme catalysis.
5. Knowing about polymer structure and classification, with examples about common polymers.

Unit 1: Fundamentals of Chemistry (15 Lectures)

Definition and importance of chemistry. Chemistry in daily life (cleansing action of surfactants, use of ion-exchange resin, etc.). Definition and classification of matter (pure substances and mixtures), homogeneous mixtures and heterogeneous mixtures. Definition of atoms and molecules, Atomic structure, Simple electronic configuration of elements without quantum numbers. Thomson model, Rutherford model and Bohr's model of an atom. Structure of atoms (electrons, protons and neutrons) – example of H, C, N and O atom. Atomic and molecular masses, actual masses of atoms and molecules, Mole concept, calculation of amount (number of moles) and number of atoms and molecules in a sample.

Unit 2: Chemicals and Chemical Structures (18 Lectures)

Elements and compounds, symbols and molecular formula. Covalent bonds between atoms in a molecule – examples of H_2, CO_2, H_2O, HCl. Ionic bond in ionic compounds such as the salts – continuity of ionic bonds in crystalline salts such as NaCl (each Na^+ bound to six $Cl^–$, every $Cl^–$ bound to six Na^+). Types of intermolecular forces among molecules (dispersion or London force, dipole-dipole force, hydrogen bonding). Octet rule, Lewis dot structures of simple molecules – H_2O and CH_4.

Meanings of a chemical equation. Combustion reactions of H_2, CO and CH_4. Names and structure of organic molecules – C-1 to C-4 alkanes, ethylene and acetylene. Structures of some selected compounds (ethanol, acetic acid, benzene and phenol). Elementary idea of catalysis, enzyme-catalysed reactions (production of ethanol from molasses).

Unit 3: Macromolecules and Polymers (12 Lectures)

Definition and classification of polymers (fibres, elastomers and plastics), structures and application of polymers – polyethene, polyethylene terephthalate (PET), polyvinyl chloride, polystyrene (polystyrene foam), teflon, linear polypeptide proteins, natural rubber, introduction to biodegradable polymers: examples.

Recommended Textbooks/ References:

1. Prasanta Rath and Subhendu Chakraborty, Chemistry, 2nd Ed., Cengage India, 2019
2. D. D. Ebbing and S. D. Gabbon, General Chemistry, 9th Ed., Cengage India, 2020
3. NCERT, Chemistry Textbooks, Class XI and Class XII, NCERT (India), 2022

Course Outcomes:

On completion of this course, the students will be able to:

1. Know the significance of chemistry, the classification of matter and its atomic and molecular organization, and will be able to calculate the masses and numbers of atoms/molecules.
2. Visualise the structure of atoms and of molecules, including that of organic molecules.
3. Have basic ideas about catalysis in general including that about enzyme catalysis, along with examples.
4. Visualise polymer structure and know their classification along with examples of several common polymers.

Cotton University NEP UG Syllabus
Chemistry :: Sem–II
MDE (Multi-Disciplinary Elective) Chemistry – II Credits (L+T+P): 3 + 0 + 0 = 3

Learning Objectives:

1. Understanding the types of hydrocarbons in petroleum fuels, about the issue of petrol quality, and about chemical processes for obtaining good quality petroleum fuels.
2. Knowing about chemical aspects of the varieties of coal and coal products and their uses.
3. Understand various issues of environmental pollution along with the efforts for mitigation, from sources such as fossil fuel combustion, industrial emission of heavy metals, use of fertilizers and pesticides, use of chlorofluorocarbons in air conditioning, etc.
4. Obtaining general ideas about the various classes of medicines with examples, and about the chemical nutrient constituents of our food as required for human health.

Unit 1: Chemistry of Fossil Fuels (14 Lectures)

Definition of hydrocarbons, simple molecular structure of hydrocarbons, classification of hydrocarbons in petroleum – paraffins, naphthenes and aromatics. Chemical compositions of natural gas, LPG, petrol and diesel. Quality of petrol: definition of flash point, knocking and octane number. Catalytic cracking and reforming processes. Elementary idea about power alcohol. Coal – chemical constitution of coal, various common types of coal. Elementary idea about production and use of coal gas, synthesis gas (water gas) and coke.

Unit 2: Chemistry of Environmental Pollution (16 Lectures)

Idea of environmental pollution, Production of pollutant gases in combustion and their chemical composition, harmful effects of such pollutant gases: exhaust hydrocarbons, CO, NO_x and SO_x. Control of pollution from automobile exhaust gases – role of catalytic converters. Toxic effects of some heavy metals and their sources – Pb, Hg and Cd. Effects of chemical fertilizers, detergents and pesticides on the environment. Greenhouse gases: effects of CO_2 and CH_4 in atmosphere, efforts for their mitigation. Chlorofluorocarbons and ozone layer depletion, efforts and recent success in preventing ozone layer depletion.

Unit 3: Elementary Medicinal Chemistry and Human Nutrition (15 Lectures)

Definition of drugs and medicines. Idea of classes of medicines: analgesics, antacids, antiparasitics, antibiotics, antiseptics and disinfectants. Examples of each of these classes (chemical structures of the examples not required). Concept of brand name and chemical name. Generic drugs. Concept of expiry date.

Carbohydrate, protein, fat, essential fatty acids and their examples, the vitamins and the essential minerals necessary for human nutrition and health.

Recommended Textbooks/ References:

1. Prasanta Rath and Subhendu Chakraborty, Chemistry, 2nd Ed., Cengage India, 2019
2. D. D. Ebbing and S. D. Gabbon, General Chemistry, 9th Ed., Cengage India, 2020
3. NCERT, Chemistry Textbooks, Class XI and Class XII, NCERT (India), 2022
4. A. K. De, Environmental Chemistry, New Age International, 2018.

Course Outcomes:

On completion of this course, the students will be able to:

1. Be conversant about the types of hydrocarbons in petroleum fuels, about petrol quality, and about the chemical processes performed for obtaining usable petroleum fuels.
2. Know about the types of coal and coal products from chemical viewpoint, along with their uses.
3. Visualise various issues of environmental pollution along with the efforts for mitigation, from fossil fuel combustion, industrial emission of heavy metals, use of fertilizers and pesticides, use of chlorofluorocarbons, etc.
4. Get a general introduction to various classes of medicines with examples, and about the nutrient constituents of food necessary for human health.