LEARNING OUTCOMES
SUBJECT: CHEMISTRY
STREAM: GENERAL

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Contents

LEARNING OUTCOMES

SUBJECT: CHEMISTRY

STREAM: GENERAL

SEMESTER: 1

Course Code: CC-1A/GE-1

Course Title: ***Atomic Structure, Chemical Periodicity, Acids And Bases, Redox Reactions, General Organic Chemistry & Aliphatic Hydrocarbons***

Topic: ***Atomic Structurc***

Upon completion of this topic, learners should be able to:

- Outline the historical developments of atomic theory.
- Describe the structure of the atom.
- Write the postulates of different atomic theory.
- Derive the Rydberg equation using Bohr's atomic model.
- Determine the wavelength and frequency of radiation of emission spectrum.
- Draw s, p, d and f orbitals.
- Write Pauli's exclusion principle, Hund's rules of maximum multiplicity, Aufbau principle.
- Write the electronic configuration of atoms.

Topic: ***Chemical Periodicity***

Upon completion of this topic, learners should be able to:

- Outline the historical developments of Periodic table.

- Describe the position of s-, p-, d- and f-block elements in the periodic table.
- Write the general characteristics of s-, p-, d- and f-block elements.
- Define different periodic properties viz. atomic and ionic size, ionization energy, electron affinity, electronegativity.
- Write the variation of periodic properties along the group and along the period in the periodic table.
- Describe the position of hydrogen and noble gases in the periodic table.

Topic: ***Acids and bases***

Upon completion of this topic, learners should be able to:

- Differentiate the following concepts Brönsted–Lowry concept, Lewis acid- base concept.
- Classify Lewis acids and bases.
- Describe conjugate acids and bases and relative strengths of acids and bases.
- Understand Lux-Flood concept and solvent system concept.
- Elucidate HSAB concept and its applications.

Topic: ***Redox Reaction***

Upon completion of this topic, learners should be able to:

- Get of balancing of equations by oxidation number and ion-electron method.
- Predict oxidimetry and reductimetry processes.

Topic: ***Organic Chemistry***

Upon completion of this topic, learners should be able to:

- Learn inductive effect, resonance and hyperconjugation.
- Differentiate between homolytic and heterolytic cleavage of bonds.
- Predict the structure of organic molecules on the basis of VBT.

- Draw orbital diagram of different types of bonding in organic compounds.
- Identify nucleophiles, electrophiles, nucleofuges and electrofuges.
- Get idea about reactive intermediates e.g. carbocations, carbanions and free radicals.
- Represent the molecule in different projection formulae (e.g. Fischer and Newman).
- Illustrate the asymmetric and dissymmetric molecules; enantiomers and diastereomer.
- Describe absolute and relative configuration: D/L, R/S and E/Z nomenclature.
- Learn elementary mechanistic aspects of nucleophilic substitution reactions (SN1 & SN2) and elimination reactions (E1 & E2).CO 11 Predict Saytzeff and Hofmann elimination products
- Recognize substitution-elimination dichotomy in case of base catalyzed reactions.
- Get idea about different types of aliphatic hydrocarbons.
- Prepare alkanes using catalytic hydrogenation, Wurtz reaction, Kolbe's electrolysis, Grignard reagent and organocopper reagents.
- Functionalize alkanes and carry out substitution reactions of alkanes via free radical mechanism such as halogenations reactions.
- Synthesize alkenes via elimination reactions e.g. dehydration of alcohols, dehydrohalogenation of alkyl halides, partial catalytic hydrogenation of alkynes and Birch reduction of alkynes.
- Prepare diol on reaction with Baeyer's reagent, OsO4 with alkenes.
- Prepare vicinal dibromides, halohydrins, epoxides with reasonable mechanisms.
- Add unsymmetrical addendum of HX type according to Markownikoff's and anti-Markownikoff's addition with unsymmetrical alkenes.

- Carry out hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reactions on alkenes.
- Synthesize alkynes from metal carbides, by dehalogenation of tetra halides and dehydrohalogenation of vicinal & geminal dihalides.
- Convert terminal alkynes into non-terminal alkynes and vice-versa.
- Carry out addition, ozonolysis and oxidation reactions of alkynes.
- Exploit the acidity of acetylenic protons to form various metal acetylides.

SEMESTER: 2

Course Code: CC-1B /GE-2

Course Title: ***States of Matter & Chemical Kinetics, Chemical , Bonding and Molecular Structure, p-BlockElements Kinetic Theory of Gases and Real gases***

Upon completion of this topic, learners should be able to:

- Explain the concept of pressure and temperature from Kinetic Theory of gases.
- State the postulates of kinetic theory of gas.
- Derive the equations of states for an ideal gas and a real gas.
- Describe physical basis for the kinetic theory of gases.
- Represent the laws from kinetic theory of gases.
- State the assumptions for Maxwell's law of distribution of molecular speed.
- Explain the relationship between partial pressures and the total pressure as described in Dalton's law of Partial Pressure.

Liquids

Upon completion of this topic, learners should be able to:

- Explain surface tension and its determination through stalagmometer.
- Describe viscosity and principle of determination of coefficient of viscosity using Ostwald viscometer.
- Illutrate the effect of temperature on surface tension and coefficient of viscosity of a liquid.

Solids

Upon completion of this topic, learners should be able to:

- Be familiar with different forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements.

- Know two laws of crystallography - Law of constancy of interfacial angles, Law of rational indices.
- Assign Weiss and Miller indices of different planes and interplanar distance.
- Formulate Bragg's law.
- Describe the structures of NaCl, KCl and CsCl qualitative.
- Describe various types of defects in crystals.
- Define Glasses and liquid crystals.

Chemical Kinetics

Upon completion of this topic, learners should be able to:

- List reasons for studying chemical kinetics.
- Discuss the factors that affect the rate of chemical reactions.
- Differentiate between order and molecularity of a chemical reaction.
- Describe the general form of a (differential) rate law and how the rate of a chemical reaction depends on the concentrations of species that appear in the rate law.
- Determine the "overall reaction order" for a chemical reaction using the (differential) rate law.
- Derive a general expression for the unit of rate constant and to find the unit of rate constant for zero, 1^{st}, 2^{nd} and 3^{rd} order reaction.
- Explain why reactant molecules must have a certain minimum amount of kinetic energy when they collide in order for a chemical reaction to occur.
- Write the temperature dependence of reaction rate(Arrhenius equation).
- Signify "activation energy".

Inorganic Chemistry

Chemical Bonding and Molecular Structure

Upon completion of this topic, learners should be able to:

- Know the general characteristics of different kinds of bonding.

- Interpret energy considerations in ionic bonding, lattice energy and solvation energy.
- Establish the Born-Landé equation for calculation of latticeenergy, Born-Haber cycle and its applications.
- Describe polarizing power and polarizability.
- Illustrate Fajan's rules, ionic character in covalent compounds, dipole moment and percentage ionic character.
- Elucidate VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR.
- Define hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.
- Know the general concept of resonance and resonating structures in various inorganic and organic compounds.
- Illustrate MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals
- Describe MO treatment of homonuclear diatomic molecules of 1st and 2nd periods.
- Describe MO treatment of heteronuclear diatomic molecules such as CO, NO and NO^{+}.
- Differentiate VB and MO approaches.

Comparative study of p-block elements

Upon completion of this topic, learners should be able to:

- Explain Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect.
- Elucidate Group 13 to 17 and their important compounds.

SEMESTER: 3

Course Code: CC-1C/GE-3

Course Title: ***Chemical energetic, equilibria, organic chemistry***

Topic: ***Chemical Energetics***

Upon completion of this topic, learners should be able to:

- Have idea about intensive and extensive properties.
- Exemplify state function and path function.
- Classify systems and boundary walls between system and surrounding.
- Conceptualize work, heat and internal energy.
- State the first law of thermodynamics and its form in different thermodynamic processes.
- Derive /Write expressions of work done by/on the system in reversible/irreversible isothermal/adiabatic processes.
- Mention salient features of different thermodynamic processes.
- State the outcomes of Joule's experiment.
- Define and explain the concept of enthalpy.
- Correlate heat capacities of different kind with internal energy and enthalpy.
- Define with examples various types of enthalpy change associated with chemical reactions and physical changes. Also comment on their temperature dependence.
- Justify the necessity of the 2nd law of thermodynamics.
- Explain the concept of engine.
- Work out the efficiency of a Carnot engine.
- Discuss about the concept of entropy and its importance in explaining the feasibility of a thermodynamic process.
- Apply Gibbs-Helmohltz equation in explaining the spontaneity of a physical process or chemical reaction.

Topic: ***Chemical Equilibrium***

Upon completion of this topic, learners should be able to:

- Write the thermodynamic conditions for equilibrium.
- Write the relationship between equilibrium constant and standard Gibbs free energy change.
- Define K_p, K_c and K_x.
- Derive the relationship between the equilibrium constants (K_p, K_c and K_x).
- Describe van't Hoff's reaction isotherm, isobar and isochore.
- Derive the van't Hoff's equation.
- Find the value of equilibrium constant at a particular temperature using van't Hoff's equation.
- Describe the effect on variation of temperature, pressure and concentration on equilibrium constant by Le Chatelier's principle.
- Describe the effect on addition of inert gas(es) in a reaction system already in equilibrium.

Topic: ***Ionic Equilibria***

Upon completion of this topic, learners should be able to:

- Define and exemplify strong, moderate and weak electrolytes.
- Elucidate degree of ionization, factors affecting degree of ionization and ionization constant.
- Discuss ionic product of water.
- Explain ionization of weak acids and bases
- Define pH scale
- Discuss and derive salt hydrolysis constant, degree of hydrolysis and pH for different salts.
- Define buffer solutions.

- Discuss and explain solubility and solubility product of sparingly soluble salts and its applications.

Topic: ***Organic Chemistry***

Upon completion of this topic, learners should be able to:

- Prepare benzene from phenol, benzenesulfonic acid, acetylene, iodoform, benzoic acid, aniline and nitrobenzene.
- Learn general mechanistic aspects of electrophilic aromatic substitution reactions e.g. nitration, halogenations, sulfonation, Friedel-Craft's alkylation & acylation.
- Predict the products of side chain oxidation of various types of alkyl benzenes.
- Synthesize halobenzenes from phenol and via Sandmeyer reactions.
- Understand the effect of NO_2 groups on nucleophilic aromatic substitution reactions of halobenzenes (activated nucleophilic substitution).
- Understand the use of Zn instead of Mg in Reformatsky reaction.
- Prepare alcohols using Grignard reagent, reduction of aldehydes, ketones, carboxylic acid, carboxylic esters and hydration of alkenes.
- Differentiate 1°, 2° and 3°- alcohols employing Lucas test.
- Carry out alkaline $KMnO_4$/acidic dichromate/concentrated HNO_3 mediated oxidation reactions of alcohols.
- Correlate Oppenauer oxidation with MPV reduction.
- Prepare 1, 2-diols on reaction with OsO_4 and Baeyer's reagent
- Explain mechanistically the involvement of 1, 2-diols in pinacol-pinacolone rearrangement.
- Prepare phenols using cumene-hydroperoxide method and from diazonium salts.
- Compare the acidity of phenols and carboxylic acids.

- Carry out the electrophilic aromatic substitution reactions on phenols e.g. nitration, halogenations, Reimer-Tiemann, Houben–Hoesch reaction.
- Perform esterification reaction employing Schotten-Baumann reaction condition.
- Prepare adrenaline and noradrenaline with the help of Fries rearrangement.
- Know the mechanistic pathway of Claisen rearrangement.
- Prepare ethers using Williamson's ether synthesis technique.
- Cleavage ethers with HI.
- Synthesize carbonyl compounds from acid chlorides, nitriles and Grignard reagents.
- Mechanistically know the reactions of carbonyl functionality with HCN, H2O, ROH, NaHSO3, Hydrazine, Hydroxylamine, semicarbazide and 2, 4-DNP.
- Differentiate between aldehydes and ketones using iodoform, Tollens' and Fehling's tests.
- Predict the types of compounds responsive to haloform test.
- Elaborate condensation reactions of aldehydes and ketones e.g. aldol condensation and benzoin condensation.
- Convert carbonyls into alkenes via Wittig reaction.
- Reduce carbonyls via Clemmensen reduction, Wolff- Kishner reduction and Meerwein-Pondorff-Verley (MPV) reduction.

SEMESTER: 4

Course: CC-1D /GE-4

Course Title: Solutions, Phase equilibria, Conductance, Electrochemistry & Analytical and Environmental Chemistry

Solutions

Upon completion of this topic, learners should be able to:

- Define ideal and non-ideal solution.
- Know about vapour pressure.
- State Raoult's law for ideal and non-ideal solution.
- Draw and explain the curve for ideal and non-ideal solution accordingly Raoult's law.
- Draw and explain the vapour pressure composition and temperature composition curve for ideal and non-ideal solution.
- Discuss different types of distillation process.
- State Lever rule.
- Define and discuss azeotropes.
- Define and explain critical solution temperature.
- Discuss the effect of impurity on partial miscibility of liquids.
- Know about immiscibility of liquids and State the principle of steam distillation.
- Discuss Nernst distribution law and its application.

Phase Equilibria

Upon completion of this topic, learners should be able to:

- Understand the meaning phase, component and degree of freedom of a system.
- Exemplify different systems and explain the phase, component and degree of freedom of each system.
- Understand the criteria of phase equilibrium.

- Use accurate values of C, P and F in practical cases.
- State and derive Gibb's phase rule.

Conductance & Electromotive force

Upon completion of this topic, learners should be able to:

- Write Faraday's laws of electrolysis.
- Construct cell from half-cell potential.
- Determine the cell potential.
- Derive Nernst equation.
- Calculate the thermodynamic parameters G, H and S.
- Explain reversible and irreversible cells with examples.
- Define liquid junction potential and figure out its removal.
- Exemplify standard electrodes like hydrogen electrodes and calomel electrodes.
- Understand electrochemical series and its applications.
- Enumerate the advantages using calomel electrode over hydrogen electrode as standard electrodes.
- Describe the determination of pH of a solution using hydrogen electrode and quinhydrone electrode.

Chemical Analysis

Upon completion of this topic, learners should be able to:

- State the steps involved in gravimetric analysis.
- Demonstrate the general rules followed during precipitation step of gravimetric analysis.
- Define co-precipitation, post-precipitation, digestion/aging, peptization and coagulation.
- Indicate the importance of proper washing and aging procedures of precipitates in gravimetric analysis.

- Identify the requirements of a solution to be chosen as an ideal wash liquid.
- Calculate gravimetric factor and to use them in the gravimetric estimation of different elements and groups prescribed in the syllabus.
- Illustrate the criteria of primary and secondary standard solutes.
- Disclose the principles of acid-base, redox and complexometric titrations.
- Exemplify acid-base, redox and chelometric indicators.
- Rationalize the principle of estimation of Na_2CO_3 and $NaHCO_3$ in a mixture.
- Justify the reason of using EDTA as the chelometric titrant.
- Classify complexometric titrations.
- Elucidate chromatography and retention factor.
- Arrange different chromatographic techniques based on the principles involved and use of stationary & mobile phases.
- Discern column chromatography and thin layer chromatography.
- Point out the applications of chromatographic techniques.

Environmental Chemistry

Upon completion of this topic, learners should be able to:

- Understand composition and structure of atmosphere.
- Determine variousair pollutants and how they creates problem in our environment.
- Understand ozone layer depletion and green house effect.
- Characterize the role of water in our environment; causes and effects of water pollution.
- Understand the way we can minimize the water pollution.
- How to determine the DO, COD, BOD, TDS and hardness parameters of water.

Course Code: SEC-2

Course Title: *Pharmaceuticals Chemistry*

After completion of the course, the learners will be able to:-

- Understand how a drug is discovered and what are the different stages a molecule must successfully overcome to become a drug candidate.
- Easily classify drugs based on their mechanism of action.
- Follow retrosynthetic approach to synthesize analgesics agents, antipyretic agents, anti-inflammatory agents, antibiotics, antibacterial agents, antifungal agents, antiviral agents, Central Nervous System agents, cardiovascular drugs, anti-leprosy drugs, and HIV-AIDS related drugs.

SEMESTER: 5

Course Code: DSE-1A

Course Title: ***Transition Metal & Coordination Chemistry, Analytical and Industrial Chemistry***

Topic: Inorganic Chemistry

Upon completion of this topic, learners should be able to:

- Exemplify different oxidation states of 3d series elements.
- Calculate the magnetic moment of complexcompounds.
- Note down important oxidation states with examples of Mn, Fe and Cu along with their colour, stability and magnetic behavior.
- Present a brief history of the emergence of coordination chemistry.
- Differentiate between double and complex salts.
- State Werner's theory of coordination complexes.
- Classify ligands into different categories.
- Justify the binding of ambidentate ligands with the aid of SHAB principle, symbiotic effect and competitive pi-bonding.
- Explain chelate effect.
- Write a note on inner-metallic complexes.
- Name coordination complexes obeying the rules set by IUPAC.
- Expound different types of isomerism in square planar and octahedral complexes.
- Put down the postulates of the Valence Bond Theory and apply the same to different coordination complexes.
- Point out the limitations of the Valence Bond Theory.
- Elaborate the ideas of Crystal Field Theory.
- Apply Crystal Field Theory to different stereochemistries.
- Able to determine the Crystal Field Stabilisation Energy (CFSE) for different dn configurations in different stereochemistries.

- Describe the reason for placing f-block elements below the main periodic table.
- Describe the separation of lanthanoid elements by ion-exchange methodology.
- Compare the spectral, magnetic and complexing properties of the lanthanoid and actinoid elements with the d-block elements.
- Point out the reason why some f-block elements show oxidation states other than +3.
- Define lanthanide contraction and its effects in chemical and physical properties.
- Write the electronic configurations of lanthanoid and actinoid elements.

Topic: ***Analytical and Industrial Chemistry***

Upon completion of this topic, learners should be able to:

- Classify of fuels and know heating value of fuels.
- Describe origin of coal, carbonization of coal, coal gas, producer gas, water gas, coal based chemicals.
- Describe origin and composition of petroleum.
- Elucidate petroleum refining process.
- Define and explain cracking, knocking, octane number, antiknock compounds and its applications.
- Discuss the use of kerosene, liquefied petroleum gas (LPG) and liquefied natural gas (LNG).
- Define fertilizer and its classify.
- Describe manufacture of ammonia and ammonium salts, urea and superphosphate in industry.
- Discuss biofertilizers.
- Define glass and ceramics.
- Describe manufacture of glasses, optical glass and coloured glass, clay and feldspar.

- Understand Ggazing, vitrification, glazed porcelain and enamel.
- Define Cement: portland cement.
- Describe composition and setting of cement and white cement.

SEMESTER: 6

Course Code: DSE-1B

Course Title: ***Functional Group Organic Chemistry and Industrial Chemistry***

Functional Group Organic Chemistry

Upon completion of this topic, learners should be able to:

- Identify the various types of carboxylic acids and their synthesis procedure.
- Distinguish between BAc2 and AAc2 mechanisms.
- Understand the conversation, derivative preparation and interconversion of various acids.
- State the significance of different forms of amines.
- Understand the synthesis and derivative preparation of amines, nitro compounds and amino acids.
- Classify the carbohydrates and distinguish them by structure and properties.
- Apply different methods for synthesis of carbohydrates.
- Define mutarotation.
- Be familiar with different types of nitrogen containing organic compounds *e.g.* amine, nitro, nitrile, isonitrile, diazonium salts and azo compounds.
- Synthesize (incorporate) those above mentioned nitrogen containing functionalities and encounter with various types of reactions they undergo.
- Interconvert between different functional groups.
- Differentiate between different types of amines and nitro compounds through visual colour change reactions.

Industrial Chemistry

Upon completion of this topic, learners should be able to:

- Understand the meaning of polymer.
- Discuss different type of polymers.
- Discuss synthesis, physical properties and importance of polyethylene, polystyrene, phenol formaldehyde, polyvinyl chloride, polyester and nylon-66.
- Define synthetic rubber and fiber.
- Understand the meaning of paint, binder.
- Discuss primary constituents of paints, formulation of paints, and solvent for paints.
- Discuss oil based paints, latex paints and alkyd resin paints.
- Define varnish.
- Discuss constituents of varnishes and formulation of varnishes.
- Understand synthetic dye.
- Discuss synthesis and structure of methyl orange, congo red, malachite green and crystal violet.
- Discuss necessity of drugs and pharmaceuticals.
- Discuss preparation and important use of aspirin, paracetamol, sulphadiazine and metronidazole.
- Differentiate between fats and oils.
- Write the industrial production of vanaspati and margarine.
- Describe the production of toilet and washing soaps, enzyme-based detergents, detergent powder, liquid soaps.
- Write the production, applications and residual toxicity of gammaxane, parathion, DDT.

- Discuss in detail about food flavour, food colour, food preservatives, artificial sweeteners, acidulants, alkalies, edible emulsifiers and edible foaming agents.

Course Code: SEC-4

Course Title: *Polymer Chemistry*

After completion of the course, learners will be able to:-

- Classify polymers from different angles.
- Understand nomenclature of polymers.
- Identify molecular forces and chemical bonding present in polymers.
- Explain the basis of formation of synthetic polymers.
- Classify polymerization processes.
- Relate between functionality, extent of reaction and degree of polymerization.
- Understand the mechanism and kinetics of step growth and radical chain growth polymerization.
- Determination of molecular weights of polymers M_n and M_W by viscometry and osmometry.
- Introduce preparation, structure, properties and application of certain polymers *e.g.* polystyrene, poly(vinyl chloride), phenol-formaldehyde resins (Bakelite, Novolac).
- Have clear ideas about conducting polymers *e.g.* polyacetylene.