Chemistry

Grades: 11 and 12 **Subject code:** Che. 301 **(Grade 11),** Che. 302 **(Grade 12)**

Credit hrs: 5 **Working hrs: 160**

1. Introduction

This curriculum is of grade 11 and 12 chemistry. This is designed to provide students with general understanding of the fundamental scientific laws and principles that govern the scientific phenomena in the world. It focuses to develop scientific knowledge, skills, and attitudes required at secondary level (grade 11 and 12) irrespective of what they do beyond this level, as envisioned by national goals. Understanding of scientific concepts and their application, in day to day context as well as the process of obtaining new knowledge through holistic approach of learning in the spirit of national qualification framework is emphasized in the curriculum.

This curriculum aims: to provide sufficient knowledge and skills to recognize the usefulness and limitations of laws and principles of chemistry, to develop science related attitudes such as concern for safety and efficiency, concern for accuracy and precision, objectivity, spirit of enquiry, inventiveness, appreciation of ethno-science, and willingness to use technology for effective communication, to provide opportunity for the learners who have deeper interest in the subject to delve into the more advanced contents so that the study of chemistry becomes enjoyable and satisfying to all.

The curriculum prepared in accordance with National Curriculum Framework is structured for two academic years in such a way that it incorporates the level-wise competencies, grade-wise learning outcomes, scope and sequence of contents, suggested practical/project-work activities, learning facilitation process and assessment strategies so as to enhance the learning of the subject systematically.

2. Level-wise competencies

The expected competencies of this course are to:

1. think critically and creatively, communicate effectively in written and oral form and reason quantitatively
2. apply appropriate principles, concepts, theories, laws, models and patterns to interpret the findings, draw conclusion, make generalization, and to predict from chemical facts, observation and experimental data.
3. correlate old principles, concepts, theories, laws, tools, techniques; to the modern, sustainable and cost-effective skills, tools and techniques in the development of scientific attitude.
4. apply the principles and methods of science to develop the scientific skill in an industrial process to produce various chemicals in small as well as in industrial scale that are useful in our daily life and in the service of mankind.
5. explain the social, economic, environmental and other implications of chemistry and appreciate the advancement of chemistry and its applications as essential for the growth of national economy.

6. describe chemistry as a coherent and developing framework of knowledge based on fundamental theories of the structure and process of the physical world.
7. develop skills in safe handling of chemicals, taking into account of their physical and chemical properties, risk, environmental hazards, etc.
8. conduct either a research work or an innovative work in an academic year, under the guidance of teacher, using the knowledge and skills learnt.

3. Grade-wise learning Outcomes

Grade 11	Grade 12
Content Area: General and Physical Chemistry	
1. Foundation and Fundamentals 1.1 Recognize the importance and scope of chemistry. 1.2 Explain the terms atom, molecule, radicals, valency molecular formula and empirical formula. 1.3 Calculate percentage composition of constituent elements from molecular formula. 1.4 Define and use the terms relative atomic mass, relative molecular mass and relative formula mass.	**1. Volumetric Analysis** 1.1 Define and explain the terms volumetric and gravimetric analysis. 1.2 Express the concentration of solutions in terms of percentage, g/l, molarity, molality, normality, ppm, ppb 1.3 Define and calculate the equivalent weight of (elements, acids, bases, salts, oxidising and reducing agents). 1.4 Express the concentration of solution in terms of normality. 1.5 Explain and apply the concept of law of equivalence in chemical calculation. 1.6 Define and explain primary and secondary standard substance. 1.7 Explain different types of titration and their applications.
2. Stoichiometry 2.1 Explain Dalton's atomic theory and its postulates. 2.2 State and explain laws of stoichiometry (law of conservation of mass, law of constant proportion, law of multiple proportion, law of reciprocal proportion and law of gaseous volume). 2.3 Explain Avogadro's hypothesis and deduce some relationships among	**2. Ionic Equilibrium** 2.1 Explain the limitations of Arrhenius concepts of acids and bases. 2.2 Define Bronsted and Lowry concepts for acids and bases. 2.3 Define conjugate acids and conjugate base. 2.4 Identify conjugate acid-base pairs of Bronsted acid and base.

molecular mass with vapour density, volume of gas and number of particles. 2.4 Define mole and explain its relation with mass, volume and number of particles. 2.5 Interpret a balanced chemical equation in terms of interacting moles, representative particles, masses and volume of gases (at STP) and perform stoichiometric calculations. 2.6 Identify limiting and excess reagent in a reaction and calculate the maximum amount of products produced. 2.7 Calculate theoretical yield and percentage yield from the given actual yield. 2.8 Find empirical and molecular formula from percentage composition.	2.5 Define and explain Lewis acids and bases. 2.6 Use the extent of ionization and dissociation constant of acid (ka) and base (kb). 2.7 Explain ionization constant of water and calculate pH and pOH in aqueous medium using Kw values. 2.8 Show understanding of, and use, the concept of solubility product Ksp. 2.9 Calculate Ksp from concentrations and vice versa. 2.10 Show understanding of the common ion effect. 2.11 Describe the application of solubility product principle and common ion effect in precipitation reactions. 2.12 Define a Buffer and show with equations how a Buffer system works. 2.13 Explain the choice of suitable indicators for acid-base titrations and describe the changes in pH during acid-base titrations. 2.14 Define and differentiate different types of salts (simple salts, double salts, complex salt, acidic salts, basic salts and neutral salts). 2.15 Explain hydrolysis of salts (salts of strong acid and strong base, salts of weak acid and strong base and salts of weak base and strong acid).
3. Atomic Structure 3.1 Explain Rutherford atomic model and its limitations. 3.2 Summarize Bohr's atomic theory and its importance. 3.3 Explain the origin of hydrogen spectra with the help of Bohr's model. 3.4 Explain the general idea about Debroglie's	**3. Chemical Kinetics** 3.1 Define chemical kinetics. 3.2 Explain and use the terms rate of reaction, rate equation, rate constant. 3.3 Explain qualitatively factors affecting rate of reaction. 3.4 Use collision theory to explain how the rate of chemical reaction is

wave equation and probability. 3.5 Explain quantum numbers and Planck's quantum theory. 3.6 Explain the concept and general shapes of s,p,d and f orbitals. 3.7 Use Aufbau principle, Pauli Exclusion Principle and Hund's rule to write the electronic configuration of the atoms and ions.	influenced by temperature, concentration and particle size. 3.5 Explain the meaning of the term activation energy and activated complex. 3.6 Derive and explain integrated rate equation and half life for zero, and first order reaction. 3.7 Construct and use rate equations calculating an initial rate using concentration data. 3.8 Explain the significance of Arrhenius equation and solve the related problems. 3.9 Explain and use the terms catalyst and catalysis (homogenous, heterogeneous). 3.10 Describe enzyme as biological catalyst. 3.11 Explain the role of catalyst in the reaction mechanism. 3.12 Solve related numerical problems based on rate, rate constant and order of zero and first order reactions.
4. Classification of elements and Periodic Table 4.1 Explain modern periodic table and its features. 4.2 Classify the elements of periodic table in different blocks and groups. 4.3 Identify the elements as metals, non-metals and metalloids. 4.4 Define the term nuclear charge and effective nuclear charge. 4.5 Explain and interpret the Periodic trend of atomic radii, ionic radii, ionization energy, electronegativity, electron affinity and metallic characters of elements.	**4. Thermodynamics** 4.1 Define thermodynamics. 4.2 Explain the energy change in chemical reactions. 4.3 Define the terms internal energy and state function. 4.4 State and explain first law of thermodynamics. 4.5 State and explain enthalpy and enthalpy changes in various process (enthalpy of solution, enthalpy of formation enthalpy of combustion and enthalpy of reaction). 4.6 Explain endothermic and exothermic process with the help of energy profile

	diagram. 4.7 State laws of thermo-chemistry and solve numerical problems related to Hess law. 4.8 Define the term entropy and spontaneity. 4.9 State and explain second law of thermodynamics. 4.10 Define standard Gibbs free energy change of reaction by means of the equation $\Delta G = \Delta H - T\Delta S$. 4.11 Calculate ΔG for a reaction using the equation $\Delta G = \Delta H - T\Delta S$. 4.12 State whether a reaction or process will be spontaneous by using the sign of ΔG. 4.13 Explain the relationship between ΔG and equilibrium constant.
5. Chemical Bonding and Shapes of Molecules 5.1 Show structure atoms and ions by Lewis dot method. 5.2 Explain the ionic bond and the properties of ionic compounds. 5.3 Explain the covalent bond, co-ordinate bond and the properties of covalent compound. 5.4 Describe the feature of sigma and Pi-bond 5.5 Describe the co-ordinate covalent compounds with some examples. 5.6 Write the lewis dot diagrams of some ionic and covalent compounds (NaCl, MgCl2, NH4Cl, Oxides of Hydrogen, Nitrogen and Phosphorous, common mineral acids). 5.7 Write the resonance structure of some covalent species. 5.8 Explain the properties of molecular and	**5. Electrochemistry** 5.1 Define the terms: standard electrode (redox) potential. 5.2 Explain about standard hydrogen electrode and calomel electrodes. 5.3 Calculate a standard cell potential by combining two standard electrode potential. 5.4 Describe the applications of electrochemical series. 5.5 Define and explain standard cell potential with reference to voltaic cell: Zn-Cu cell, Ag-Cu cell 5.6 Use standard cell potentials to: explain/deduce the direction of electron flow in a simple cell and predict the feasibility of a reaction. 5.7 Explain the relationship between cell potential and free energy change.

metallic solids on the basis of vanderwaal's and metallic bonding. 5.9 Use VSEPR theory to describe the shapes of simple covalent molecules. 5.10 Describe the concept of hybridization in simple covalent molecules. 5.11 Explain the characterstics of bond in terms of dipole moment, Ionic character and bond length. 5.12 Describe the hydrogen bondng and outline the importance of hydrogen bonding to the physical properties of substances, including ice and water (for example, boiling and melting points, viscosity, surface tension and solubility).	5.8 State the possible advantages of developing other types of cell, e.g. the hydrogen/oxygen fuel cell and lithium-ion, rechargeable batteries.
6. Oxidation and Reduction 6.1 Define oxidation and reduction in terms of electronic concept. 6.2 Define oxidation number and explain the rules of assigning oxidation number. 6.3 Calculate oxidation numbers of elements in compounds and ions. 6.4 Explain redox processes in terms changes in oxidation number. 6.5 Use oxidation number change to identify oxidizing and reducing agent. 6.6 Balance the given redox reaction by oxidation number change or half equation method. 6.7 Explain the qualitative and quantitative aspects of faradays laws of electrolysis.	-
7. States of Matter 7.1 List the postulates of kinetic molecular theory. 7.2 State and explain Gas laws, related equations and related numerical problems. 7.3 Explain Boyle's law, Charle's law, Avogadro law, combined gas law, Daltons	-

law, Graham's law 7.4 State and use the general gas equation PV = nRT in calculations. 7.5 Explain the meaning of Universal gas constant and its significance. 7.6 Distinguish between real gas and ideal gas. 7.7 Explain qualitatively in terms of intermolecular forces and molecular size: the conditions necessary for a gas to approach ideal behavior. 7.8 Explain the cause of deviation of real gas from the gas laws. 7.9 Explain the physical properties of liquid like Evaporation and condensation, vapour pressure and boiling, surface tension and viscosity in terms of intermolecular force and intermolecular space. 7.10 Describe Liquid crystals and their applications. 7.11 Explain about Liquid crystal and its application. 7.12 Differentiate between amorphous and crystalline solids. 7.13 Describe the properties of crystalline solid (anisotropy, allotropy, isomorphism, polymorphism, transition temperature, habit of crystal, crystal growth). 7.14 Define unit cell, crystal lattice, efflorescence, deliquescence, hygroscopy, water of crystallization with examples.	
8. Chemical equilibrium 8.1 Explain physical and chemical equilibrium in terms of reversible reaction. 8.2 Describe the meaning of dynamic nature of equilibrium with example. 8.3 Explain and deduce law of mass action. 8.4 Write equilibrium expression and equilibrium constant with significance.	-

8.5 Derive the relation between Kp and Kc. 8.6 State Lechateliar's Principle and apply it to systems in equilibrium with changes in concentration pressure, temperature or the addition of catalyst.	
Content Area: Inorganic Chemistry	
9. Chemistry of Non-metals 9.1 Describe and compare the chemistry of atomic and nascent hydrogen. 9.2 Explain isotopes of hydrogen and their uses, application of hydrogen as fuel, heavy water and its applications. 9.3 Explain types of oxides (acidic, basic, neutral, amphoteric, peroxide and mixed oxides). 9.4 Recognize applications of hydrogen peroxide. 9.5 State medical and industrial application of oxygen. 9.6 Describe occurrence, preparation (from oxygen), structure and test of ozone. 9.7 Describe ozone layer depletion (causes, effects and control measures) and uses of ozone. 9.8 Give reason for inertness of nitrogen and active nitrogen. 9.9 Give chemical properties of ammonia [Action with CuSO4 solution, water, FeCl3 solution, Conc. HCl, Mercurous nitrate paper, O2]. 9.10 Explain applications of ammonia and explain harmful effects of ammonia. 9.11 Write the name and formula of oxy-acids of nitrogen. 9.12 Explain the chemical properties of nitric acid [HNO3] as an acid and oxidizing agent (action with zinc, magnesium, iron, copper, sulphur, carbon, SO2 and	**6. Transition Metals** 6.1 Explain characteristics of transition metals. 6.2 Explain oxidation states of transition metals. 6.3 Describe complex ions and metal complexes. 6.4 Show shapes of complex ions. 6.5 Describe d-orbitals in complex ions (simple explanation by crystal field theory) for octahedral complex. 6.6 Explain reasons for the colour of transition metal compounds. **6.7** Explain catalytic properties of transition metals.

	H2S).	
9.13	Detect nitrate ion in laboratory.	
9.14	Explain general characteristics of halogens.	
9.15	Compare the methods of preparation of halogens without diagram and description.	
9.16	Explain chemical properties of halogens [With water, alkali, ammonia, oxidizing character, bleaching action] and uses of halogens (Cl2, Br2 and I2).	
9.17	Explain laboratory preparation of Cl2, Br2 and I2.	
9.18	Show preparation of haloacids (without diagram and description) and properties (reducing strength, acidic nature and solubility).	
9.19	State the uses of haloacids (HCl, HBr and HI).	
9.20	Explain allotropes of carbon (crystalline and amorphous) including fullerenes (structure, general properties and uses).	
9.21	State properties (reducing action, reaction with metals and nonmetals) and uses of carbon monoxide.	
9.22	Name allotropes of phosphorus.	
9.23	Show preparation without diagram and description, properties (basic nature, reducing nature, action with halogens and oxygen) and uses of phosphine.	
9.24	Explain allotropes of sulphur (name only) and uses of sulphur.	
9.25	Prepare hydrogen sulphide using Kipp's apparatus.	
9.26	Explain properties (Acidic nature, reducing nature, analytical reagent) and uses of hydrogen sulphide.	
9.27	Explain properties of sulphur dioxide (acidic nature, reducing nature, oxidising	

nature and bleaching action) and its uses. 9.28 Explain sulphuric acid and its properties (acidic nature, oxidising nature, dehydrating nature) and its uses. 9.29 Write formula of sodium thiosulphate and uses.	
10. Chemistry of Metals 10.1 Define metallurgy and its types (hydrometallurgy, pyrometallurgy, and electrometallurgy). 10.2 Define ores, gangue or matrix, flux and slag, alloy and amalgam. 10.3 Explain general principles of extraction of metals (different processes involved in metallurgy) – concentration, calcination and roasting, smelting, carbon reduction, thermite and electrochemical reduction, refining of metals (poling and electro-refinement). 10.4 Give general characteristics of alkali metals. 10.5 State and explain extraction of sodium from Down's process. 10.6 Describe properties of sodium (action with Oxygen, water, acids nonmetals and ammonia) and uses. 10.7 Explain properties and uses of sodium hydroxide (precipitation reaction and action with carbon monoxide). 10.8 State and explain properties and uses of sodium carbonate (action with CO2, SO2, water, precipitation reactions). 10.9 Give general characteristics of alkaline earth metals. 10.10 Write molecular formula and uses of (quick lime, bleaching powder, magnesia plaster of paris and epsom salt). 10.11 Explain solubility of hydroxides, carbonates and sulphates of alkaline	**7. Studies of Heavy Metals** 7.1 Explain occurrence of heavy metals. 7.2 Describe extraction of heavy metals. 7.3 Describe properties (with air, acids, aqueous ammonia and metal ions) and uses of copper. 7.4 Explain chemistry (preparation, properties and uses) of blue vitriol. 7.5 Write formula and uses red and black oxide of copper. 7.6 Describe properties (with air, acid, alkali, displacement reaction) and uses of zinc. 7.7 Explain chemistry (preparation, properties and uses) of white vitriol. 7.8 State properties of mercury. 7.9 Explain chemistry (preparation, properties and uses) of calomel and corrosive sublimate. 7.10 Explain properties and uses of iron. 7.11 Explain manufacture of steel by basic oxygen method and open hearth process. 7.12 Explain corrosion of iron and its prevention. 7.13 Explain preparation and uses of silver chloride and silver nitrate.

earth metals. 10.12 Explain stability of carbonate and nitrate of alkaline earth metals.	
11. Bio-inorganic Chemistry 11.1 Explain bio-inorganic chemistry and compare it with other branches of chemistry. 11.2 Eefine micro and macro nutrients with examples. 11.3 State and explain importance of metal ions in biological systems (ions of Na, K, Mg, Ca, Fe, Cu, Zn, Ni, Co, Cr). 11.4 Elaborate ion pumps (sodium-potassium and sodium-glucose pump). 11.5 Explain metal toxicity (toxicity due to iron, arsenic, mercury, lead and cadmium).	-
Content Area: Organic Chemistry	
12. Basic concept of organic chemistry 12.1 Define organic chemistry and organic compounds. 12.2 State and explain origin of organic compounds. 12.3 Describe reasons for the separate study of organic compounds. 12.4 Explain tetra-covalency and catenation property of carbon. 12.5 Describe classification of organic	**8. Haloalkanes** 8.1 Describe briefly the nomenclature, isomerism and classification of monohaloalkanes. 8.2 Show the preparation of monohaloalkanes from alkanes, alkenes and alcohols. 8.3 State physical properties of monohaloalkanes. 8.4 Describe chemical properties of haloalkanes: substitution reactions

compounds. 12.6 Define functional groups and homologous series with examples. 12.7 State and explain the structural formula, contracted formula and bond line structural formula. 12.8 Introduce preliminary idea of cracking and reforming, quality of gasoline, octane number, cetane number and gasoline additive.	SN1 and SN2 reactions (basic concept only). 8.5 Show the formation of alcohol, nitrile, amine, ether, thioether, carbylamines, nitrite and nitro alkane using haloalkanes. 8.6 Describe elimination reaction (dehydrohalogenation- Saytzeff's rule), Reduction reactions, Wurtz reaction. 8.7 Show the preparation of trichloromethane from ethanol and propanone. 8.8 Explain the chemical properties of trichloromethane: oxidation, reduction, action on silver powder, conc. nitric acid, propanone, and aqueous alkali.
13: Fundamental principles 13.1 State IUPAC name of the organic compounds. 13.2 Detect N, S and halogens in organic compounds by Lassaigne's test. 13.3 Define and classify isomerism in organic compounds (structure isomerism, types of structure isomerism: chain isomerism, position, isomerism, functional isomerism, metamerism and tautomerism). 13.4 State and explain the concept of geometrical isomerism (cis&trans) & optical isomerism (d &l form). 13.5 Give preliminary idea of reaction mechanism (homolytic and herterolytic fission, electrophiles, nucleophiles and free- radicals, inductive effect: +I and –I effect, resonance effect: +R and –R effect, steric hindrance).	**9. Haloarenes** 9.1 Describe briefly the nomenclature and isomerism of haloarenes. 9.2 Show the preparation of chlorobenzene from benzene and benzene diazonium chloride. 9.3 State physical properties of haloarens. 9.4 Describe low reactivity of haloarenes as compared to haloalkanes in term of nucleophilic substitution reaction. 9.5 Explain the chemical propertiesof haloarens: reduction of chlorobenzene, electrophilic substitution reactions, action with Na (Fittig and Wurtz- Fittig reaction) and action with chloral. 9.6 Describe uses of haloarenes.
14. Hydrocarbons 14.1 Define and describe saturated	**10. Alcohols** 10.1 Describe briefly the nomenclature,

hydrocarbons (Alkanes). 14.2 Show preparation of alkanes from haloalkanes (Reduction and Wurtz reaction), Decarboxylation, Catalytic hydrogenation of alkene and alkyne. 14.3 Explain chemical properties of alkanes, i.e. substitution reactions (halogenation, nitration & sulphonation only), oxidation of ethane. 14.4 Define and describe unsaturated hydrocarbons (Alkenes & Alkynes). 14.5 Show preparation of alkenes by dehydration of alcohol, dehydrohalogenation and catalytic hydrogenation of alkyne. 14.6 Explain chemical properties of alkenes, i.e. addition reaction with HX (Markovnikov's addition and peroxide effect), H2O, O3 and H2SO4 only. 14.7 Show preparation of alkynes from carbon and hydrogen, 1,2dibromoethane, chloroform/iodoform only. 14.8 Describe chemical properties of alkynes, i.e. addition reaction with (H2, HX, H2O), acidic nature (action with Sodium, ammoniacal AgNO3 and ammoniacal Cu2Cl2). 14.9 Test unsaturation of hydrocarbons (ethene&ethyne): bromine water test and Baeyer's test. 14.10 Compare physical properties of alkane, alkene and alkyne. 14.11 Describe Kolbe's electrolysis methods for the preparation of alkane, alkene and alkynes.	isomerism and classification of monohydric alcohol. 10.2 Distinguish primary, secondary and tertiary alcohols by Victor Meyer's Method. 10.3 Show the preparation of monohydric alcohols from Haloalkane, primary amines and esters. 10.4 Explain the industrial preparation alcohol from: oxo process, hydroboration-oxidation of ethane & fermentation of sugar. 10.5 Define absolute alcohol, power alcohol, denatured alcohol (methylated spirit), rectified spirit; and alcoholic beverage. 10.6 State physical properties monohydric alcohols. 10.7 Explain chemical properties of monohydric alcoholswith HX, PX3, PCl5, and SOCl2. Action with reactive metals like Na, K and Li. Dehydration of alcohols. Oxidation of primary, secondary and tertiary alcohol with mild oxidizing agents like acidified KMnO4 or K2Cr2O7. Catalytic dehydrogenation of 1º and 2º alcohol and dehydration of 3º alcohol, Esterification reaction and test of ethanol.
15. Aromatic Hydrocarbons 15.1 Define aromatic compounds and their characteristics. 15.2 State and explain Huckel's rule, Kekule structure of benzene, resonance and	**11. Phenols** 11.1 Describe briefly the nomenclature of phenol. 11.2 Show the preparation of phenol from chlorobenzene, Diazonium salt and

isomerism. 15.3 Show the preparation of benzene from: decarboxylation of sodium benzoate, phenol, ethyne and chlorobenzene. 15.4 Explain physical properties and chemical properties of benzene (Addition reaction: hydrogen, halogen and ozone, Electrophilic substitution reactions: orientation of benzene derivatives (o, m & p), nitration, sulphonation, halogenation Friedal-Craft's alkylation and acylation, combustion of benzene) and uses.	benzene sulphonic acid 11.3 State physical properties of phenol. 11.4 Describe acidic nature of phenol (comparison with alcohol and water). 11.5 Explain the chemical properties of phenol with NH3, Zn, Na, benzene diazonium chloride and phthalic anhydride, Acylation reaction, Kolbe's reaction and Reimer-Tiemann's reaction Electrophilic substitution (nitration, sulphonation, brominaiton and Friedal-Craft's alkylation). 11.6 Describe test of phenol (FeCl3 test, aq. Bromine test &Libermann test). 11.7 State important uses of phenol.
-	**12. Ethers** 12.1 Describe briefly the nomenclature, classification and isomerism of ethers. 12.2 Show the preparation of aliphatic and aromatic ethers from Williamson's synthesis. 12.3 State physical properties of ether. 12.4 Explain chemical properties of ethoxyethane with HI , Conc. HCl, Conc. H2SO4, air and Cl2 12.5 State important uses of ethers.
-	**13. Aldehydes and Ketones** **(A) Aliphatic aldehydes and ketones** 13.1 Describe briefly the nomenclature and isomerism of aliphatic aldehydes and ketones. 13.2 Show the preparation of aldehydes and ketones from dehydrogenation, oxidation of alcohol, ozonolysis of alkenes, acid chloride, gem dihaloalkane and catalytic hydration of alkynes 13.3 State physical properties of aldehydes

	and ketones. 13.4 Describe structure and nature of carbonyl group. 13.5 Explain chemical properties of aliphatic aldehydes and ketones, i.e .addition of H2, HCN and NaHSO3. action of aldehyde and ketone with ammonia derivatives, i.e. NH2OH, NH2-NH2, phenyl hydrazine and semicarbazide. Aldol condensation, Cannizzaro's reaction, Clemmensen'sreduction. and Wolf-Kishner reduction. Action with PCl5 and action with LiAlH4 .Action of methanal with ammonia and phenol. 13.6 Distinguish between aliphatic aldehydes and ketones by using 2,4-DNP reagent, Tollen's reagent and Fehling's solution. 13.7 Define formalin and state its uses. **(B) Aromatic aldehydes and Ketones** 13.8 Show the preparation of benzaldehyde from toluene and acetophenone from benzene. 13.9 Explain chemical properties of benzaldehyde, i.e. Perkin condensation, Benzoin condensation, Cannizzaro's reaction and electrophilic substitution reaction.
-	**14. Carboxylic Acid and its Derivatives** **(A) Aliphatic and aromatic carboxylic acids** 14.1 Describe briefly the nomenclature and isomerism of aliphatic and aromatic carboxylic acids. 14.2 Show the preparation of monocarboxylic acids from: aldehydes, nitriles, dicarboxylic acid, sodium alkoxide and trihaloalkanes. 14.3 Show the preparation of benzoic acid

	from alkyl benzene. 14.4 State physical properties of monocarboxylic acids. 14.5 Explain chemical properties of aliphatic and aromatic carboxylic acids: Action with alkalies, metal oxides, metal carbonates, metal bicarbonates, PCl3, LiAlH4 and dehydration of carboxylic acid. Hell-Volhard-Zelinsky reaction. Electrophilic substitution reaction of benzoic acid (bromination, nitration and sulphonation). 14.6 Explain effect of constituents on the acidic strength of carboxylic acid. 14.7 Describe abnormal behaviour of methanoic acid. **(B) Derivatives of Carboxylic acids (acid halides, amides, esters and anhydrides)** 14.8 Show the preparation of acid derivatives from carboxylic acid. 14.9 Explain the comparative physical properties of acid derivatives. 14.10 Explain the comparative chemical properties of acid derivatives (hydrolysis, ammonolysis, amines-RNH2), alcoholysis, and reduction only. Claisen condensation and hofmannbromamide reaction. 14.11 Describe amphoteric nature of amide and relative reactivity of acid derivatives.
-	**15. Nitro Compounds** 15.1 Describe briefly the nomenclature and isomerism of nitro compounds. 15.2 Show the preparation from haloalkane and alkane. 15.3 State physical properties of nitro compounds.

	15.4 Explain chemical properties of nitro compounds, i.e. reduction. 15.5 Show preparation of nitrobenzene from benzene. 15.6 State physical properties of nitrobenzene. 15.7 Explain chemical properties of nitrobenzene, i.e. reduction in different media and electrophilic substitution reactions (nitration, sulphonation & bromination). 15.8 State important uses of nitro-compounds.
-	**16. Amines** **(A) Aliphatic amines** 16.1 Describe briefly the nomenclature, classification and isomerism of amines. 16.2 Show the separation of primary, secondary and tertiary amines by Hoffmann's method. 16.3 Show preparation of primary amines from haloalkane , nitriles, nitroalkanes and amides. 16.4 State physical properties of aliphatic amines. 16.5 Explain chemical properties of aliphatic amines, i.e. basicity of amines, comparative study of basic nature of 10, 20 and 30 amines. Reaction of primary amines with chloroform, conc. HCl, R-X, RCOX and nitrous acid ($NaNO_2$ / HCl) and test of 10, 20 and 30 amines (nitrous acid test). **(B) Aromatic amine (Aniline)** 16.6 Show preparation of aniline from nitrobenzene and phenol. 16.7 State physical properties of aromatic

	amine. 16.8 Explain chemical properties of aromatic amine, i.e. basicity of aniline, comparison of basic nature of aniline with aliphatic amines and ammonia, alkylation, acylation, diazotization, carbylamines, coupling reaction and electrophilic substitution (Nitration sulphonation and bromination). 16.9 State important uses of aniline.
-	**17. Organometallic Compounds** 17.1 Describe briefly the general formula and examples of organolithium, organocopper and organocadmium compounds. 17.2 Explain the nature of Metal-Carbon bond. 17.3 Define Grignard reagent. 17.4 Show the preparation Grignard reagent (using haloalkane and haloarene). 17.5 Explain reaction of Grignard reagent with water, aldehydes and ketones (preparation of primary, secondary and tertiary alcohols), carbon dioxide, HCN, RCN, ester and acid chloride.
Content Area: Applied Chemistry	
16. Fundamentals of Applied Chemistry 16.1 Explain chemical industry and its importance. 16.2 Explain stages in producing in the development of a new product. 16.3 Explain economics of production. 16.4 Explain cash flow in the production cycle. 16.5 Describe running a chemical plant.	**18. Chemistry in the Service of Mankind** 18.1 Explain addition and condensation polymers. 18.2 Explain elastomers and fibres. 18.3 Describe natural and synthetic polymers. 18.4 Explain some synthetic polymers (polythene, PVC, Teflon, polystyrene, nylon and bakelite). 18.5 Explain types of dyes on the basis of

16.6 Design a chemical plant 16.7 Describe continuous and batch processing. 16.8 Explain environmental impact of the chemical industry.	structure and method of application. 18.6 Describe characteristics of drugs. 18.7 Differentiate natural and synthetic drugs. 18.8 Classify some common drugs. 18.9 Be aware of adverse effect of drug addiction. 18.10 Explain insecticides, herbicides and fungicides.
17. Modern Chemical Manufactures 17.1 State and show manufacture of ammonia by Haber's process (principle and flow-sheet diagram). 17.2 State and show manufacture of nitric acid by Ostwald's process (principle and flow-sheet diagram). 17.3 State and show manufacture of sulphuric acid by contact process (principle and flow-sheet diagram). 17.4 State and show manufacture of sodium hydroxide by Diaphragm Cell (principle and flow-sheet diagram). 17.5 State and show manufacture of sodium carbonate by ammonia soda or Solvay process (principle and flow-sheet diagram). 17.6 Describe fertilizers (Chemical fertilizers, types of chemical fertilizers, production of urea with flow-sheet diagram).	**19. Cement** 19.1 Explain introduction and raw materials for cement production. 19.2 Give main steps in cement production (crushing and grinding, strong heating and final grinding). 19.3 Explain OPC and PPC cement. 19.4 Explain Portland cement process with flow-sheet diagram. 19.5 Explain cement Industry in Nepal.
-	**20. Paper and Pulp** 20.1 Explain raw materials, sources of raw materials and stages in production of paper. 20.2 Give flow-sheet diagram for paper production. 20.3 Describe quality of paper.

-	**21. Nuclear Chemistry and Applications of Radioactivity** 21.1 Describe natural and artificial radioactivity. 21.2 Give units of radioactivity. 21.3 Explain nuclear reactions. 21.4 Distinguish between nuclear fission and fusion reactions. 21.5 Describe nuclear power and nuclear weapons. 21.6 Explain industrial uses of radioactivity. 21.7 State the medical uses of radioactivity. 21.8 Explain radiocarbon dating. 21.9 Describe harmful effects of nuclear radiations.

4. Scope and Sequence of Contents (Theory)

Grade 11	T H	Grade 12	T H
Content Area: General and Physical Chemistry			
1. Foundation and Fundamentals 1.1 General introduction of chemistry 1.2 Importance and scope of chemistry 1.3 Basic concepts of chemistry (atoms, molecules, relative masses of atoms and molecules, atomic mass unit (amu), radicals, molecular formula, empirical formula) 1.4 Percentage composition from molecular formula	**2**	**1. Volumetric Analysis** 1.1 Introduction to gravimetric analysis, volumetric analysis and equivalent weight 1.2 Relationship between equivalent weight, atomic weight and valency 1.3 Equivalent weight of compounds (acid, base, salt, oxidizing and reducing agents) 1.4 Concentration of solution and its units in terms of : Percentage, g/L , molarity, molality, normality and formality, ppm and	**8**

		ppb 1.5 Primary and secondary standard substances 1.6 Law of equivalence and normality equation 1.7 Titration and its types: Acid-base titration, redox titration (related numerical problems)	
2. Stoichiometry 2.1 Dalton's atomic theory and its postulates 2.2 Laws of stoichiometry 2.3 Avogadro's law and some deductions 2.3.1 Molecular mass and vapour density 2.3.2 Molecular mass and volume of gas 2.3.3 Molecular mass and no. of particles 2.4 Mole and its relation with mass, volume and number of particles 2.5 Calculations based on mole concept 2.6 Limiting reactant and excess reactant 2.7 Theoretical yield, experimental yield and % yield 2.8 Calculation of empirical and molecular formula from % composition (Solving related numerical problems)	**8**	**2. Ionic Equilibrium** **Introduction to Acids and Bases** 2.1. Limitation of Arrhenius concepts of acids and bases 2.2 Bronsted –Lowry definition of acids and bases 2.3 Relative strength of acids and bases 2.4 Conjugate acid –base pairs 2.5 Lewis definition of acids and bases 2.6 Ionization of weak electrolyte (Ostwald's dilution law) 2.7 Ionic product of water(Kw) 2.8 Dissociation constant of acid and base, (Ka& Kb) 2.9 Concept of pKa and pKb 2.10 pH value: pH of strong and weak acids, pH of strong and weak bases 2.11 Solubility and solubility product principle 2.12 Common Ion effect 2.13 Application of solubility product principle and common ion effect in precipitation reactions 2.14 Buffer solution and its application 2.15 Indicators and selection of indicators in acid base titration 2.16 Types of salts: Acidic salts, basic salts, simple salts, complex salts (introduction and examples) 2.17 Hydrolysis of salts	**10**

		2.17.1 Salts of strong acid and strong base 2.17.2 Salts of weak acid and strong base 2.17.3 Salts of weak base and strong acid (solving related numerical problems)	
3. Atomic Structure 3.1 Rutherford's atomic model 3.2 Limitations of Rutherford's atomic model 3.3 Postulates of Bohr's atomic model and its application 3.4 Spectrum of hydrogen atom 3.5 Defects of Bohr's theory 3.6 Elementary idea of quantum mechanical model: de Broglie's wave equation 3.7 Heisenberg's Uncertainty Principle 3.8 Concept of probability 3.9 Quantum Numbers 3.10 Orbitals and shape of s and p orbitals only 3.11 Aufbau Principle 3.12 Pauli's exclusion principle 3.13 Hund's rule and electronic configurations of atoms and ions (up to atomic no. 30)	**8**	**3. Chemical Kinetics** 3.1 Introduction 3.2 Rate of reactions: Average and instantaneous rate of reactions 3.3 Rate law and its expressions 3.4 Rate constant and its unit and significance 3.5 Order and molecularity 3.6 Integrated rate equation for zero and first order reaction 3.7 Half-life of zero and first order reactions 3.8 Collision theory, concept of activation energy and activated complex 3.9 Factors affecting rate of reactions: Effect of concentration, temperature (Arrhenius Equation) and effect of catalyst (energy profile diagram) 3.10 Catalysis and types of catalysis: homogeneous, heterogeneous and enzyme catalysis (solving related numerical problems based on rate, rate constant and order of zero and first order reactions)	**7**
4. Classification of elements and Periodic Table 4.1 Modern periodic law and modern periodic table 4.1.1 Classification of elements into different groups, periods and blocks	**5**	**4. Thermodynamics** 4.1 Introduction 4.2 Energy in chemical reactions 4.3 Internal energy 4.4 First law of thermodynamics 4.5 Enthalpy and enthalpy changes:	**8**

4.2 IUPAC classification of elements 4.3 Nuclear charge and effective nuclear charge 4.4 Periodic trend and periodicity 4.4.1 Atomic radii 4.4.2 Ionic radii 4.4.3 Ionization energy 4.4.4 Electron affinity 4.4.5 Electronegativity 4.4.6 Metallic characters (General trend and explanation only)		Endothermic and exothermic processes) 4.6 Enthalpy of reaction, enthalpy of solution, enthalpy of formation, enthalpy of combustion 4.7 Laws of thermochemistry (Laplace Law and Hess's law) 4.8 Entropy and spontaneity 4.9 Second law of thermodynamics 4.10 Gibbs' free energy and prediction of spontaneity 4.11 Relationship between ΔG and equilibrium constant (Solving related numerical problems)	
5. Chemical Bonding and Shapes of Molecules 5.1 Valence shell, valence electron and octet theory 5.2 Ionic bond and its properties 5.3 Covalent bond and coordinate covalent bond 5.4 Properties of covalent compounds 5.5 Lewis dot structure of some common compounds of s and p block elements 5.6 Resonance 5.7 VSEPR theory and shapes of some simple molecules (BeF_2, BF_3, CH_4, CH_3Cl, PCl_5, SF_6, H_2O,NH_3,CO_2,H_2S, PH_3) 5.8 Elementary idea of Valence Bond Theory 5.9 Hybridization involving s and p orbitals only 5.10 Bond characteristics: 5.10.1 Bond length 5.10.2 Ionic character 5.10.3 Dipole moment 5.11 Vander Waal's force and molecular solids	**9**	**5. Electrochemistry** 5.1 Electrode potential and standard electrode potential 5.2 Types of electrodes: Standard hydrogen electrode and calomel electrodes 5.3 Electrochemical series and its applications 5.4 Voltaic cell: Zn-Cu cell, Ag- Cu cell 5.5 Cell potential and standard cell potential 5.6 Relationship between cell potential and free energy 5.7 Commercial batteries and fuel cells (hydrogen/oxygen)	**7**

5.12 Hydrogen bonding and its application 5.13 Metallic bonding and properties of metallic solids			
6. Oxidation and Reduction 6.1 General and electronic concept of oxidation and reduction 6.2 Oxidation number and rules for assigning oxidation number 6.3 Balancing redox reactions by oxidation number and ion-electron (half reaction) method 6.4 Electrolysis 6.4.1 Qualitative aspect 6.4.2 Quantitative aspect(Faradays laws of electrolysis)	**5**	-	
7 States of Matter **7.1 Gaseous state** 7.1.1 Kinetic theory of gas and its postulates 7.1.2 Gas laws 7.1.2.1 Boyle's law and Charles' law 7.1.2.2 Avogadro's law 7.1.2.3 Combined gas equation 7.1.2.4 Dalton's law of partial pressure 7.1.2.5 Graham's law of diffusion 7.1.3 Ideal gas and ideal gas equation 7.1.4 Universal gas constant and its significance 7.1.5 Deviation of real gas from ideality (Solving related numerical problems based on gas laws)	**8**	-	

7.2 Liquid state 7.2.1 Physical properties of liquids 7.2.1.1 Evaporation and condensation 7.2.1.2 Vapour pressure and boiling point 7.2.1.3 Surface tension and viscosity (qualitative idea only) 7.2.2 Liquid crystals and their applications **7.3 Solid state** 7.3.1 Types of solids 7.3.2 Amorphous and crystalline solids 7.3.3 Efflorescent, Deliquescent and Hygroscopic solids 7.3.4 Crystallization and crystal growth 7.3.5 Water of crystallization 7.3.6 Introduction to unit crystal lattice and unit cell			
8. Chemical equilibrium 8.1 Physical and chemical equilibrium 8.2 Dynamic nature of chemical equilibrium 8.3 Law of mass action 8.4 Expression for equilibrium constant and its importance 8.5 Relationship between Kp and Kc 8.6 Le Chatelier's Principle (Numericals not required)	**3**	-	
Content Area: Inorganic Chemistry			
9. Chemistry of Non-metals **9.1 Hydrogen** 9.1.1 Chemistry of atomic and nascent hydrogen	**4**	**6. Transition Metals** 6.1 Introduction 6.1.1 Characteristics of transition metals 6.1.2 Oxidation states of transition	**5**

9.1.2 Isotopes of hydrogen and their uses 9.1.3 Application of hydrogen as fuel 9.1.4 Heavy water and its applications **9.2 Allotropes of Oxygen** 9.2.1 Definition of allotropy and examples 9.2.2 Oxygen: Types of oxides (acidic, basic, neutral, amphoteric, peroxide and mixed oxides) 9.2.3 Applications of hydrogen peroxide 9.2.4 Medical and industrial application of oxygen **9.3 Ozone** 9.3.1 Occurrence 9.3.2 Preparation of ozone from oxygen 9.3.3 Structure of ozone 9.3.4 Test for ozone 9.3.5 Ozone layer depletion (causes, effects and control measures) 9.3.6 Uses of ozone		metals 6.1.3 Complex ions and metal complexes 6.1.4 Shapes of complex ions 6.1.5 d-orbitals in complex ions (simple explanation by crystal field theory) for octahedral complex 6.1.6 Reasons for the colour of transition metal compounds 6.1.7 Catalytic properties of transition metals	
9.4 Nitrogen 9.4.1 Reason for inertness of nitrogen and active nitrogen 9.4.2 Chemical properties of ammonia [Action with $CuSO_4$ solution, water, $FeCl_3$ solution, Conc. HCl, Mercurous nitrate paper, O_2] 9.4.3 Applications of ammonia 9.4.4 Harmful effects of ammonia 9.4.5 Oxy-acids of nitrogen (name and formula) 9.4.6 Chemical properties of nitric acid [HNO_3 as an acid and oxidizing agent (action with zinc, magnesium, iron, copper, sulphur, carbon, SO_2 and H_2S) 9.4.7 Ring test for nitrate ion	**5**	**7. Studies of Heavy Metals** **7.1 Copper** 7.1.1 Occurrence and extraction of copper from copper pyrite 7.1.2 Properties (with air, acids, aqueous ammonia and metal ions) and uses of copper 7.1.3 Chemistry (preparation, properties and uses) of blue vitriol 7.1.4 Other compounds of copper (red oxide and black oxide of copper) formula and uses only **7.2 Zinc** 7.2.1 Occurrence and extraction of zinc from zinc blende 7.2.2 Properties (with air, acid, alkali, displacement reaction) and uses	**15**
9.5 Halogens	**5**		

9.5.1 General characteristics of halogens 9.5.2 Comparative study on preparation (no diagram and description is required), 9.5.2.1 Chemical properties [with water, alkali, ammonia, oxidizing character, bleaching action] and uses of halogens (Cl_2, Br_2 and I_2) 9.5.3 Test for Cl_2, Br_2 and I_2 9.5.4 Comparative study on preparation (no diagram and description is required), properties (reducing strength, acidic nature and solubility) and uses of haloacids (HCl, HBr and HI)		of zinc 7.2.3 Chemistry (preparation, properties and uses) of white vitriol **7.3 Mercury** 7.3.1 Occurrence and extraction of mercury from cinnabar 7.3.2 Properties of mercury 7.3.3 Chemistry (preparation, properties and uses) of calomel and corrosive sublimate **7.4 Iron** 7.4.1 Occurrence and extraction of iron 7.4.2 Properties and uses of iron 7.4.3 Manufacture of steel by Basic Oxygen Method and Open Hearth Process 7.4.4 Corrosion of iron and its prevention **7.5 Silver** 7.5.1 Occurrence and extraction of silver by cyanide process 7.5.2 Preparation and uses of silver chloride and silver nitrate	
9.6 Carbon 9.6.1 Allotropes of carbon (crystalline and amorphous) including fullerenes (structure, general properties and uses only) 9.6.2 Properties (reducing action, reaction with metals and nonmetals) and uses of carbon monoxide **9.7 Phosphorus** 9.7.1 Allotropes of phosphorus (name only) 9.7.2 Preparation (no diagram and description is required), properties (basic nature ,reducing nature , action with halogens and oxygen) and uses of phosphine	**3**		
9.8 Sulphur 9.8.1 Allotropes of sulphur (name only) and uses of sulphur 9.8.2 Hydrogen sulphide (preparation from Kipp's apparatus with diagram,) properties (Acidic nature, reducing nature, analytical reagent) and uses 9.8.3 Sulphur dioxide its properties (acidic nature, reducing nature,	**5**	-	

oxidising nature and bleaching action) and uses 9.8.4 Sulphuric acid and its properties (acidic nature, oxidising nature, dehydrating nature) and uses 9.8.5 Sodium thiosulphate (formula and uses)			
10 Chemistry of Metals **10.1 Metals and Metallurgical Principles** 10.1.1 Definition of metallurgy and its types (hydrometallurgy, pyrometallurgy, electrometallurgy) 10.1.2 Introduction of ores 10.1.3 Gangue or matrix, flux and slag, alloy and amalgam 10.1.4 General principles of extraction of metals (different processes involved in metallurgy) – concentration, calcination and roasting, smelting, carbon reduction, thermite and electrochemical reduction 10.1.5 Refining of metals (poling and electro-refinement)	**5**	-	
10.2 Alkali Metals 10.2.1 General characteristics of alkali metals 10.2.2 Sodium [extraction from Down's process, properties (action with Oxygen, water, acids nonmetals and ammonia) and uses] 10.2.3 Properties (precipitation reaction and action with carbon monooxide) and uses of sodium hydroxide 10.2.4 Properties (action with CO_2, SO_2, water, precipitation reactions) and uses of sodium carbonate 10.3 Alkaline Earth Metals 10.3.1 General characteristics of alkaline	**5**	-	

earth metals 10.3.2 Molecular formula and uses of (quick lime, bleaching powder, magnesia, plaster of paris and epsom salt) 10.3.3 Solubility of hydroxides, carbonates and sulphates of alkaline earth metals (general trend with explanation) 10.3.4 Stability of carbonate and nitrate of alkaline earth metals (general trend with explanation)			
11. Bio-inorganic Chemistry **11. Introduction to Bio-inorganic Chemistry** 11.1 Introduction 11.2 Micro and macro nutrients 11.3 Importance of metal ions in biological systems (ions of Na, K, Mg, Ca, Fe, Cu, Zn, Ni, Co, Cr) 11.4 Ion pumps (sodium-potassium and sodium-glucose pump) 11.5 Metal toxicity (toxicity due to iron, arsenic, mercury, lead and cadmium)	**3**	-	
Content Area: Organic Chemistry			
12 Basic Concept of Organic Chemistry 12.1 Introduction to organic chemistry and organic compounds 12.2 Reasons for the separate study of organic compounds from inorganic compounds 12.3 Tetra-covalency and catenation properties of carbon 12.4 Classification of organic compounds 12.5 Alkyl groups, functional groups and homologous series 12.6 Idea of structural formula,	**6**	**8. Haloalkanes** 8.1 Introduction 8.2 Nomenclature, isomerism and classification of monohaloalkanes 8.3 Preparation of monohaloalkanes from alkanes, alkenes and alcohols 8.4 Physical properties of monohaloalkanes 8.5 Chemical properties, substitution reactions SN1 and SN2 reactions (basic concept only) 8.6 Formation of alcohol, nitrile, amine, ether, thioether,	**8**

contracted formula and bond line structural formula 12.7 Preliminary idea of cracking and reforming, quality of gasoline, octane number, cetane number and gasoline additive		carbylamines, nitrite and nitro alkane using haloalkanes 8.7 Elimination reaction (dehydrohalogenation- Saytzeff's rule), Reduction reactions, Wurtz reaction 8.8 Preparation of trichloromethane from ethanol and propanone 8.9 Chemical properties of trichloromethane: oxidation, reduction, action on silver powder, conc. nitric acid, propanone, and aqueous alkali	
13 Fundamental Principles of Organic Chemistry 13.1 IUPAC Nomenclature of Organic Compounds (upto chain having 6-carbon atoms) 13.2 Qualitative analysis of organic compounds (detection of N, S and halogens by Lassaigne's test) 13.3 Isomerism in Organic Compounds 13.4 Definition and classification of isomerism 13.5 Structural isomerism and its types: chain isomerism, position isomerism, functional isomerism, metamerism and tautomerism 13.6 Concept of geometrical isomerism (cis & trans) & optical isomerism (d & l form) **13.7 Preliminary Idea of Reaction Mechanism** 13.7.1 Homolytic and heterolytic fission 13.7.2 Electrophiles, nucleophiles and free- radicals 13.7.3 Inductive effect: +I and –I effect 13.7.4 Resonance effect: +R and –R effect	**10**	**9. Haloarenes** 9.1 Introduction 9.2 Nomenclature and isomerism of haloarenes 9.3 Preparation of chlorobenzene from benzene and benzene diazonium chloride 9.4 Physical properties 9.5 Chemical properties 9.5.1 Low reactivity of haloarenes as compared to haloalkanes in term of nucleophilic substitution reaction 9.5.2 Reduction of chlorobenzene 9.5.3 Electrophilic substitution reactions 9.5.4 Action with Na (Fittig and Wurtz- Fittig reaction) 9.5.5 Action with chloral 9.6 Uses of haloarenes	**3**
14. Hydrocarbons **14.1 Saturated Hydrocarbons**	**8**	**10. Alcohols** 10.1 Introduction	**7**

(Alkanes) 14.1.1 Alkanes: Preparation from haloalkanes (Reduction and Wurtz reaction), Decarboxylation, Catalytic hydrogenation of alkene and alkyne 14.1.2 Chemical properties: Substitution reactions (halogenation, nitration & sulphonation only), oxidation of ethane **14.2 Unsaturated hydrocarbons (Alkenes & Alkynes)** 14.2.1 Alkenes: Preparation by Dehydration of alcohol, Dehydrohalogenation, Catalytic hydrogenation of alkyne 14.2.1.1 Chemical properties: Addition reaction with HX (Markovnikov's addition and peroxide effect), H_2O, O_3, H_2SO_4 only **14.3 Alkynes: Preparation from carbon and hydrogen, 1,2 dibromoethane, chloroform/iodoform only** 14.3.1 Chemical properties: Addition reaction with (H_2, HX, H_2O), Acidic nature (action with Sodium, ammoniacal $AgNO_3$ and ammoniacal Cu_2Cl_2) **14.4 Test of unsaturation (ethene & ethyne): bromine water test and Baeyer's test** **14.5 Comparative studies of physical properties of alkane, alkene and alkyne** 14.6 Kolbe's electrolysis methods for the preparation of alkane, alkene and alkynes		10.2 Nomenclature, isomerism and classification of monohydric alcohol 10.3 Distinction of primary, secondary and tertiary alcohols by Victor Meyer's Method 10.4 Preparation of monohydric alcohols from Haloalkane, primary amines, and esters 10.5 Industrial preparation alcohol from: oxo process, hydroboration-oxidation of ethene & fermentation of sugar 10.6 Definition of common terms: Absolute alcohol, power alcohol, denatured alcohol (methylated spirit), rectified spirit; alcoholic beverage 10.7 Physical properties monohydric alcohols 10.8 Chemical properties of monohydric alcohols 10.8.1 Reaction with HX, PX_3, PCl_5, $SOCl_2$ 10.8.2 Action with reactive metals like Na, K, Li 10.8.3 Dehydration of alcohols 10.8.4 Oxidation of primary, secondary and tertiary alcohol with mild oxidizing agents like acidified $KMnO_4$ or $K_2Cr_2O_7$ 10.8.5 Catalyic dehydrogenation of 1^0 and 2^0 alcohol and dehydration of 3^0 alcohol 10.8.6 Esterification reaction 10.8.7 Test of ethanol	
15. Aromatic Hydrocarbons 15.1 Introduction and characteristics of aromatic compounds 15.2 Huckel's rule of aromaticity	**6**	**11. Phenols** 11.1 Introduction and nomenclature 11.2 Preparation of phenol from i. chlorobenzene ii. Diazonium salt and iii. benzene sulphonic acid	**4**

15.3 Kekule structure of benzene 15.4 Resonance and isomerism 15.5 Preparation of benzene from decarboxylation of sodium benzoate, phenol, and ethyne only 15.6 Physical properties of benzene 15.7 Chemical properties of benzene: Addition reaction: hydrogen, halogen, Electrophilic substitution reactions: orientation of benzene derivatives (o, m & p), nitration, sulphonation, halogenations, Friedal-Craft's reaction (alkylation and acylation), combustion of benzene (free combustion only) and uses		11.3 Physical properties of phenol 11.4 Chemical properties 11.4.1 Acidic nature of phenol (comparison with alcohol and water) 11.4.2 Action with NH_3, Zn, Na, benzene diazonium chloride and phthalic anhydride 11.4.3 Acylation reaction, Kolbe's reaction, Reimer-Tiemann's reaction 11.4.4 Electrophilic substitution: nitration, sulphonation, brominaiton and Friedal-Craft's alkylation 11.5 Test of phenol: ($FeCl_3$ test, aq. Bromine test & Libermann test) 11.6 Uses of phenol	
-		**12. Ethers** 12.1 Introduction 12.2 Nomenclature, classification and isomerism of ethers 12.3 Preparation of aliphatic and aromatic ethers from Williamson's synthesis 12.4 Physical properties of ether 12.5 Chemical properties of ethoxyethane: action with HI , Conc. HCl, Conc. H_2SO_4, air and Cl_2 12.6 Uses of ethers	**2**
-		**13. Aldehydes and Ketones** **13.1 Aliphatic aldehydes and ketones** 13.1.1 Introduction, nomenclature and isomerism 13.1.2 Preparation of aldehydes and ketones from: Dehydrogenation and oxidation of alcohol, Ozonolysis of alkenes, Acid chloride, Gem dihaloalkane,	**10**

		Catalytic hydration of alkynes 13.1.3 Physical properties of aldehydes and ketones 13.1.4 Chemical properties 13.1.4.1 Structure and nature of carbonyl group 13.1.4.2 Distinction between aldehyde and ketones by using 2,4- DNP reagent, Tollen's reagent, Fehling's solution 13.1.4.3 Addition reaction: addition of H2, HCN and $NaHSO_3$ 13.1.4.4 Action of aldehyde and ketone with ammonia derivatives; NH_2OH, NH_2-NH_2, phenyl hydrazine, semicarbazide, 13.1.4.5 Aldol condensation 13.1.4.6 Cannizzaro's reaction 13.1.4.7 Clemmensen's reduction 13.1.4.8 Wolf-Kishner reduction 13.1.4.9 Action with PCl_5 and action with $LiAlH_4$ 13.1.4.10 Action of methanal with ammonia and phenol 13.1.5 Formalin and its uses **13.2 Aromatic aldehydes and Ketones** 13.2.1 Preparation of benzaldehyde from toluene and acetophenone from benzene 13.2.2 Properties of benzaldehyde 13.2.2.1 Perkin condensation 13.2.2.2 Benzoin condensation 13.2.2.3 Cannizzaro's reaction 13.2.2.4 Electrophilic substitution reaction	
-		**14. Carboxylic Acid and its Derivaties** **14.1 Aliphatic and aromatic carboxylic acids**	**9**

		14.1.1 Introduction, nomenclature and isomerism 14.1.2 Preparation of monocarboxylic acids from: aldehydes, nitriles, dicarboxylic acid, sodium alkoxide and trihaloalkanes 14.1.3 Preparation of benzoic acid from alkyl benzene 14.1.4 Physical properties of monocarboxylic acids 14.1.5 Chemical properties: Action with alkalies, metal oxides, metal carbonates, metal bicarbonates, PCl_3, $LiAlH_4$ and dehydration of carboxylic acid 14.1.6 Hell-Volhard-Zelinsky reaction 14.1.7 Electrophilic substitution reaction of benzoic acid - bromination, nitration and sulphonation) 14.1.8 Effect of constituents on the acidic strength of carboxylic acid 14.1.9 Abnormal behaviour of methanoic acid **14.2 Derivatives of Carboxylic acids (acid halides, amides, esters and anhydrides)** 14.2.1 Preparation of acid derivatives from carboxylic acid 14.2.2 Comparative physical properties of acid derivatives 14.2.3 Comparative chemical properties of acid derivatives (hydrolysis, ammonolysis, amines (RNH_2), alcoholysis, and reduction only) 14.2.4 Claisen condensation 14.2.5 Hofmann bromamide reaction 14.2.6 Amphoteric nature of amide 14.2.7 Relative reactivity of acid derivatives	

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-		**16. Amines** **16.1 Aliphatic amines** 16.1.1 Introduction, nomenclature, classification and isomerism 16.1.2 Separation of primary, secondary and tertiary amines by Hoffmann's method 16.1.3 Preparation of primary amines from haloalkane, nitriles, nitroalkanes and amides 16.1.4 Physical properties 16.1.5 Chemical properties: basicity of amines, comparative study of basic nature of 10, 20 and 30 amines 16.1.6 Reaction of primary amines with chloroform, conc. HCl, R-X, RCOX and nitrous acid ($NaNO_2$ / HCl) 16.1.7 Test of 10, 20 and 30 amines (nitrous acid test) **16.2 Aromatic amine (Aniline)**	**7**

		16.2.1 Preparation of aniline from nitrobenzene, phenol 16.2.2 Physical properties 16.2.3 Chemical properties: basicity of aniline, comparison of basic nature of aniline with aliphatic amines and ammonia, alkylation, acylation, diazotization, carbylamine and coupling reaction, electrophilic substitution: Nitration sulphonation and bromination 16.2.4 Uses of aniline	
-		**17. Organometallic Compounds** 17.1 Introduction, general formula and examples of organolithium, organocopper and organocadmium compounds 17.2 Nature of Metal-Carbon bond 17.3 Grignard reagent 17.3.1 Preparation (using haloalkane and haloarene) 17.3.2 Reaction of Grignard reagent with water, aldehydes and ketones (preparation of primary, secondary and tertiary alcohols), carbon dioxide, HCN, RCN, ester and acid chloride	**2**
Content Area: Applied Chemistry			
Unit: 16 Fundamentals of Applied Chemistry **16.1 Fundamentals of Applied Chemistry** 16.1.2 Chemical industry and its importance 16.1.3 Stages in producing a new product 16.1.4 Economics of production 16.1.5 Cash flow in the production cycle 16.1.6 Running a chemical plant	**4**	**18. Chemistry in the service of mankind** **18.1 Polymers** 18.1.1 Addition and condensation polymers 18.1.2 Elastomers and fibres 18.1.3 Natural and synthetic polymers 18.1.4 Some synthetic polymers (polythene, PVC, Teflon, polystyrene, nylon and bakelite **18.2 Dyes**	**4**

16.1.7 Designing a chemical plant 16.1.7 Continuous and batch processing 16.1.8 Environmental impact of the chemical industry		18.2.1 Introduction 18.2.2 Types of dyes on the basis of structure and method of application **18.3 Drugs** 18.3.1 Characteristics of drugs 18.3.2 Natural and synthetic drugs 18.3.3 Classification of some common drugs 18.3.4 Habit forming drugs and drug addiction **18.4 Pesticides** 18.4.1 Introduction to insecticides, herbicides and fungicides	
Unit: 17 Modern Chemical Manufactures **17.1 Modern Chemical Manufactures (principle and flow sheet diagram only)** 17.1.1 Manufacture of ammonia by Haber's process, 17.1.2 Manufacture of nitric acid by Ostwald's process, 17.1.3 Manufacture of sulphuric acid by contact process, 17.1.4 Manufacture of sodium hydroxide by Diaphragm Cell 17.1.5 Manufacture of sodium carbonate by ammonia soda or Solvay process **17.2 Fertilizers (Chemical fertilizers, types of chemical fertilizers, production of urea with flow-sheet diagram)**	**11**	**19. Cement** 19.1 Introduction 19.2 Raw materials for cement production 19.3 Main steps in cement production (crushing and grinding, strong heating and final grinding) 19.4 Types of cement- OPC and PPC 19.5 Portland cement process with flow-sheet diagram 19.6 Cement Industry in Nepal	**4**
-		**20. Paper and Pulp** 20.1 Introduction 20.2 Raw materials 20.3 Sources of raw materials 20.4 Stages in production of paper	**3**

		20.5 Flow-sheet diagram for paper production 20.6 Quality of paper	
-		**21 Nuclear Chemistry and Applications of Radioactivity** 21.1 Natural and artificial radioactivity 21.2 Units of radioactivity 21.3 Nuclear reactions 21.4 Nuclear fission and fusion reactions 21.5 Nuclear power and nuclear weapons 21.6 Industrial uses of radioactivity 21.7 Medical uses of radioactivity 21.8 Radiocarbon dating 21.9 Harmful effects of nuclear radiations	**2**
	128		**128**

5. Practical Portion **(32 Teaching hours)**

The practical work that students do during their course is aimed at providing them learning opportunities to accomplish competency of the curriculum as well as reinforcing their learning of the theoretical subject content. This part of the curriculum focuses more on skill development than knowledge building. Students must spend lots of time for working with chemical materials. Observations and investigations can enhance student learning. Project work may consist of activities designed to demonstrate the concepts and ideas through collecting, processing, analyzing and communicating data.

Students should learn to,

- collect and identify
- preserve
- dissect
- draw figure, chart, preparing models, slides etc
- handle the equipment, instruments and laboratory handling with experimentation
- draw conclusion

Students should perform at least 10 experiments, either listed below or designed by teacher, so that no more than three experiments come from the same categories mentioned below.

a) List of Experiments for grade 11

A. Experiments based on laboratory techniques:

1. To separate the insoluble component in pure and dry state from the given mixture of soluble and insoluble solids (NaCl, sand and camphor).
2. To separate a mixture of two soluble solids by fractional crystallization (KNO_3 + NaCl).
3. To prepare a saturated solution of impure salt and obtain the pure crystal of the same salt by crystallization.
4. To separate the component of a mixture of two insoluble solids (one being soluble in dil. acids).
5. To determine the number of water of crystallization of hydrated crystals.
6. To determine the volume occupied by 1 mole of hydrogen gas at NTP. (Wt of Mg = ...…g).
7. To obtain pure water from given sample of impure water (Distillation).

B. Experiments to study the different types of reactions (Neutralization, Precipitation, Redox reaction and Electrolysis):

8. To carry out the following chemical reactions, represent them in molecular as well as ionic forms and write the colour of the products formed:
    a. Ferrous sulphate solution + ammonia solution
    b. Ferric chloride solution + ammonia solution
    c. Copper sulphate solution + sodium hydroxide solution (heat the mixture)
    d. Copper sulphate solution + ammonia solution (add ammonia drop by drop at first and then excess)
    e. Ferric chloride solution + potassium ferrocyanide solution
    f. Ferrous sulphate solution + potassium ferricyanide solution
    g. Copper sulphate solution + potassium iodide solution
    h. Potassium chromate + silver nitrate solution
    i. Barium chloride solution + silver nitrate solution
    j. Dilute sulphuric acid + barium chloride solution
9. To perform precipitation reaction of $BaCl_2$and H_2SO_4 and obtain solid $BaSO_4$.
10. To neutralize sodium hydroxide with hydrochloric acid solution and recover the crystal of sodium chloride.
11. To test the ferrous ions in the given aqueous solution and oxidise it to ferric ion,

    (Ferrous and Ferric ion) (Redox Reaction)
12. To study the process of electrolysis and electroplating.

C. Experiments on quantitative analysis:

13. To determine the weight of given piece of Mg by hydrogen displacement method.
14. To determine the solubility of the given soluble solid at laboratory temperature.
15. To determine the relative surface tension of unknown liquid by drop count method.

16. To study the rate of flow of liquid through Ostwald's viscometer and determine the relative viscosity of unknown liquid.

17. To determine the molecular weight of given metal carbonate (M_2CO_3).

D. Experiments on preparation of gas and study of properties:

18. To prepare and collect hydrogen gas and study the following properties;

    a. Solubility with water, colour, odour;

    b. Litmus test;

    c. Burning match stick test; and

    d. Reducing properties of nascent hydrogen.

19. To prepare and collect ammonia gas and investigate the following properties:

    a. Solubility with water, colour and odour;

    b. Litmus test;

    c. Action with copper sulphate solution phenolphathalein solution

    d. Action with mercurous nitrate paper.

20. To prepare carbon dioxide gas and investigate the following properties:

    a. Solubility, colour and odour;

    b. Litmus paper test;

    c. Lime water test; and

    d. Action with burning magnesium ribbon.

21. To study the properties of hydrogen sulphide (physical, analytical and reducing).

22. To study the following properties of sulphuric acid:

    a. Solubility with water;

    b. Litmus paper test;

    c. Precipitating reaction; and

    d. Dehydrating reaction.

E. Experiments on qualitative analysis:

23. To detect the basic radical of the given salt by dry way and the acid radical by dry and wet ways in its aqueous solution.

    Basic radicals: Zn^{++}, Al^{+++}, Mg^{++}, Ca^{++} ,

    Acid radicals: CO_3^{--}, SO_4^{--}, NO_3^{-}, Br^{-}, I^{-}, Cl^{-}

24. To detect the presence of Cl^{-}, SO_4^{--} and CO_3^{--} in the given sample of tap water and distilled water.

b) List of Sample project works for grade 11

1. Observe in your surroundings (kitchen, school, shop, etc.) and make a possible list of organic and inorganic compounds. How are they different? Why is it necessary to study them separately, put your argument?

2. Study of the methods of purification of water.
3. Testing the hardness of drinking water from different sources and the study of cause of hardness.
4. Study of the acidity of different samples of the tea leaves.
5. Preparation of molecular models using stick and clay.
6. Study of adulteration of food materials.
7. Study of application and adverse effects of pesticides on human health.
8. Study of use and adverse effects of plastics on environment.
9. Analysis of soil samples. (elaboration need pH, humus content)
10. Investigation on corrosion and rusting on iron.
11. Comparison of ground and surface water quality of a given place-colour, odour, pH, conductivity, turbidity etc.
12. Design and development of water filter (Charcoal filter with sand can be designed and water quality can be monitored).

Note: Students are free to choose any topic listed in this curriculum or a topic suggested by teacher provided that it is within the theoretical contents of the syllabus. However, repetition of topic should be discouraged.

c) List of experiments for grade 12

A. Experiments based on recovery and preparation of salt

1. To recover blue vitriol crystals from the given mixture of copper sulphate and sodium chloride.
2. To recover $CaCO_3$ from the mixture of $CaCO_3$ and $MgCO_3$ (dolomite).
3. To obtain hydrated calcium sulphate from the given marble chips.

B. Experiments based on volumetric analysis (Titration)

4. To prepare primary standard solution of Na_2CO_3 and standardize the given acid solution (HCl) by the standard solution.
5. To determine the strength of approximate $\frac{N}{10}$ NaOH solution with the help of standard decinormal solution of HCl supplied.
6. To determine the strength of bench sulphuric acid (H_2SO_4) with the help of standard NaOH or Na_2CO_3 solution and express the concentration in (i) normality (ii) molarity (iii) gm/litre (iv) percentage (Double titration).
7. To standardize the given approximate $\frac{N}{10}$ $KMnO_4$ solution with the help of primary standard oxalic solution (Redox titration).

C. Experiments based on organic chemistry:

8. To detect foreign elements present in a given organic compounds (N, S and X).
9. To identify the functional group present in the organic compounds (-OH, -COOH, –CHO, –CO–,–NH_2), and –COO–)

10. To test the presence of:

    a) Saturated or unsaturated fats b) Carbohydrates

    c) Proteins d) Phenol

D. Experiments based on thermochemistry:

11. To determine the enthalpy of neutralization of a strong acid and strong base.
12. To determine the molar enthalpy change of ammonium chloride solution

E. Experiments based on chemical kinetics:

13. To study the kinetics of the reaction between sodium thiosulphate and hydrochloric acid.
14. To study the kinetics of the reaction between propanone and iodine

F. Experiments based on salt analysis:

15. To perform complete salt analysis to detect the acid and basic radicals present in the given inorganic salt (at least three salt samples).

G. Experiments based on applied and analytical Chemistry:

16. To separate the components of ink by paper chromatography and determine the Rf values.
17. To determine the contents of acetic acid in the given volume of vinegar by titrimetric analysis.
18. To prepare some common compounds:

    a. Potash alum b. Iodoform c. Fehling's solution d. Tollen's reagent

19. To isolate hippuric acid from given sample of cow urine.
20. To demonstrate the pH value of unknown sample solutions.

d) List of sample project works for grade 12

1. Observe brick industry/chemical industry/old smooky cooking kitchen/use of chemical fertilizers/use of insecticides/ vehicular smokes, etc. and draw the conclusion of environmental impact of the chemical pollution.
2. Visit nearby paper industry if possible or consult e-media and observe the raw materials required, steps of manufacturing and quality endorsement of paper. Also, prepare a complete report.
3. Visit nearby cement industry if possible or consult e-media and observe the raw materials required, steps of manufacturing and quality endorsement of cement. Also, prepare a complete report.
4. Collect different brands of OPC and PPC cement and observe their setting duration.
5. Collect different types of plastics (or synthetic polymers) and study the effect of heat on them.
6. Extraction of essential oils from selected plants using Clevenger's apparatus.
7. Preparation of soap using coconut oil or any vegetable oil.
8. Study of quantity of casein present in different samples of milk.

9. Study of formation of rust in the iron nail in various conditions.
10. Study of the different types of food preservatives used in different food available in the market.
11. Study of common food adulterants in fat, oil, butter, sugar, turmeric powder, chilli powder and pepper.
12. Investigation on the foaming capacity of different washing soaps and the effect of addition of sodium carbonate on them.
13. Study the acidic nature of alcohol and phenol.
14. Study the distinction between aliphatic aldehyde, aromatic aldehyde and aliphatic ketone.
15. Detect the presence of acetic acid in vinegar.
16. Study the nitrous acid test of primary, secondary and tertiary amines.
17. Study the different types of dyes.
18. Study the positive and negative effect of drugs.
19. Study the setting of cement.
20. Study the presence of pesticides residues in fruits and vegetables.
21. Test of protein in various foods.

Note: Students are free to choose any topic listed in this curriculum or a topic suggested by teacher provided that it is within the theoretical contents of the syllabus. However, repetition of topic should be discouraged.

6. Learning Facilitation Process

Students should be facilitated to learn rather than just accumulation of information. Teacher plays vital role for delivering subject matters although others' role is also important. Student centered teaching-learning process is highly emphasized. Students are supposed to adopt multiple pathway of learning, such as online search, field visit, library work, laboratory work, individual and group work, research work etc. with the support of teacher. Self-study by students is highly encouraged and learning should not be confined to the scope of curriculum. Teacher should keep in mind intra and inter-disciplinary approach to teaching and learning, as opposed to compartmentalization of knowledge. Supportive role of parents/guardians in creating conducive environment for promoting the spirit of inquiry and creativity in students' learning is anticipated.

During the delivery process of science teaching in grade 11 and 12, basically following three approaches will be adopted;

a) Conceptual/Theoretical Approach

Possible theoretical methods of delivery may include the following;

a. lecture
b. interaction
c. question answer
d. demonstrations
e. ICT based instructions
f. cooperative learning
g. group discussions (satellite learning group, peer group, small and large group)
h. debate
i. seminar presentation
j. Journal publishing
k. daily assignment

b) Practical/Application/Experimental approach

Practical work is the integral part of the learning science. The process of lab based practical work comprises as;

a. familiarity with objective of practical work
b. familiarity with materials, chemicals, apparatus
c. familiarity with lab process (safety, working modality etc.)
d. conduction of practical work (systematically following the given instruction)
e. analysis, interpretation and drawing conclusion

c) Project work Approach

Project work is an integral part of the science learning. Students should be involved in project work to foster self-learning of students in the both theoretical and practical contents. Students will complete project work to have practical idea through learning by doing approach and able to connect the theory into the real world context. It is regarded as method/ process of learning rather than content itself. So use of project work method to facilitate any appropriate contents of this curriculum is highly encouraged.

In this approach student will conduct at least one **research work, or an innovative work** under the guidance of teacher, using the knowledge and skills learnt. It could include any of the followings;

(a) Mini research
(b) Survey
(c) Model construction
(d) Paper based work
(e) Study of ethno-science

General process of research work embraces the following steps;

a. Understanding the objective of the research
b. Planning and designing
c. Collecting information
d. Analysis and interpretation
e. Reporting /communicating (presentation, via visual aids, written report, graphical etc.)

General process of innovative work embraces the following steps;

a. Identification of innovative task (either assigned by teacher or proposed by student)
b. Planning
c. Performing the task
d. Presentation of the work
e. Record keeping of the work

Students are free to choose any topic listed in this curriculum or a topic suggested by teacher provided that it is within the theoretical contents of the Curriculum. However, repetition of topic should be discouraged.

Learning process matrix

Knowledge and understanding	Scientific skills and process	Values, attitudes and application to daily life
• Scientific phenomenon, facts, definition, principles, theory, concepts and new discoveries • Scientific vocabulary, glossary and terminology • Scientific tools, devises, instruments apparatus • Techniques of uses of scientific instruments with safety • Scientific and technological applications	• Basic and integrated scientific process skills <u>Process</u> • Investigation • Creative thinking • problem solving	• Responsible • Spending time for investigation

Basic Science Process Skills includes,

1. Observing: using senses to gather information about an object or event. It is description of what was actually perceived.
2. Measuring: comparing unknown physical quantity with known quantity (standard unit) of same type.
3. Inferring: formulating assumptions or possible explanations based upon observations.
4. Classifying: grouping or ordering objects or events into categories based upon characteristics or defined criteria.

5. Predicting: guessing the most likely outcome of a future event based upon a pattern of evidence.
6. Communicating: using words, symbols, or graphics to describe an object, action or event.

Integrated Science Process Skills includes,

1. Formulating hypotheses: determination of the proposed solutions or expected outcomes for experiments. These proposed solutions to a problem must be testable.
2. Identifying of variables: Identification of the changeable factors (independent and dependent variables) that can affect an experiment.
3. Defining variables operationally: explaining how to measure a variable in an experiment.
4. Describing relationships between variables**:** explaining relationships between variables in an experiment such as between the independent and dependent variables.
5. Designing investigations: designing an experiment by identifying materials and describing appropriate steps in a procedure to test a hypothesis.
6. Experimenting: carrying out an experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times.
7. Acquiring data: collecting qualitative and quantitative data as observations and measurements.
8. Organizing data in tables and graphs: presenting collected data in tables and graphs.
9. Analyzing investigations and their data: interpreting data, identifying errors, evaluating the hypothesis, formulating conclusions, and recommending further testing where necessary.
10. Understanding cause and effect relationships: understanding what caused what to happen and why.
11. Formulating models: recognizing patterns in data and making comparisons to familiar objects or ideas.

7. Student Assessment

Evaluation is an integral part of learning process. Both formative and summative modes of evaluation are emphasized. Formative evaluation will be conducted so as to provide regular feedback for students, teachers and parents/guardians about how student learning is. Class tests, unit tests, oral question-answer, home assignment etc, are some ways of formative evaluation.

There will be separate evaluation of theoretical and practical learning. Summative evaluation embraces theoretical examination, practical examination and evaluation of research work or innovative work.

(a) Internal Evaluation

Out of 100 full marks Internal evaluation covers 25 marks. Internal evaluation consists of Practical work (16 marks), (b) Marks from trimester examinations (6 marks), and (c) Classroom participation (3 marks)

- **Practical Activities**

Practical works and project works should be based on list of activities mentioned in this curriculum or designed by teacher. Mark distribution for practical work and project work will be as follows:

S. N.	Criteria	Elaboration of criteria	Marks
1.	Laboratory experiment	Correctness of apparatus setup/preparation	2
		Observation/Experimentation	2
		Tabulation	1
		Data processing and Analysis	1
		Conclusion (Value of constants or prediction with justification)	1
		Handling of errors/precaution	1
2.	Viva-voce	Understanding of objective of the experiment	1
		Skills of the handling of apparatus in use	1
		Overall impression	1
3.	Practical work records and attendance	Records (number and quality)	2
4	Project work	Reports (background, objective, methodology, finding, conclusion	2
		Presentation	1
		Total	**16**

Note:

(i) Practical examination will be conducted in the presence of internal and external supervisors. Evaluation of laboratory experiment will focus both the product of work and skills competencies of student in using apparatus.

(ii) Project work assessment is the internal assessment of reports and presentation of their project works either individually or group basis. In case of group presentation, every member of the group should submit a short reflection on the presented report in their own language. Records of project works must be attested by external supervisor.

- **Marks from trimester examinations**

Total of 6 marks, 3 marks from each trimester.

- **Classroom participation (3 marks)**

Classroom participation includes attendance (1) and participation in learning (2).

(b) External Evaluation

Out of 100 marks theoretical evaluation covers 75 marks. The tool for external evaluation of theoretical learning will be a written examination. Questions for the external examination will be based on the specification grid developed by Curriculum Development Centre. Examination question paper will be developed using various levels of revised Bloom's taxonomy including remembering level, understanding level, application level and higher ability (such as analyzing, evaluating, creating).