General Certificate of Education (Advanced Level)

GRADES 12-13

CHEMISTRY SYLLABI

(Implemented from 2017)

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INTRODUCTION

This syllabus had been designed to provide a basic background of chemistry that would be required by those intending to proceed to higher studies as well as by those who would utilize their knowledge of chemistry gained at the GCE(A/L) in various other spheres.

The syllabus comprises 14 units presented in a sequence appropriate (but not mandatory) to be followed during teaching. The presentation of the subject matter in each unit is organized on the basis of competencies.

The experiments indicated in italics at the end of subunits are an essential component of the syllabus, illustrating the link between theory and experiment. This syllabus is effective from 2017onwards.

Changes of the New Syllabus

The following changes have been made in the new syllabus which will be implemented from 2017 onwards.

- The flow of the content of **unit 01** has been rearranged and the details of the properties of α, β and γ radiations were removed.
- The content of **unit 02** was rearranged by indicating relevant limitations. (Resonance structures of simple molecules and ions only were considered. Examples: O_3, N_2O, CO_2, CO_3^{2-}, NO_3, $NO_2$and similar molecules and ions)

- Lattice structures of diamond, graphite and silica have been shifted to unit 06.
- The content of **unit 03** has been expanded and the number of periods has been increased.

The following content has been introduced to **unit 03.**

- More periods have been allocated to solve problems related to stoichiometry.
- Preparation of solutions.

1.1 National goals

1. Based on the concept of respecting human values and understanding the differences between the Sri Lankan multi-cultural society, building up the nation and confirming the identity of Sri Lanka by promoting national integrity, national unity, national coherence and peace.

2. While responding to the challenges of the dynamic world, identifying and conserving the national heritage.

3. Creating an environment which comprises the conventions of social justice and democratic life to promote the characteristics of respecting human rights, being aware of the responsibilities, concerning each other with affectionate relationships.

4. Promoting a sustainable life style based on the people's mental and physical wellbeing and the concept of human values.

5. Promoting positive feelings needed for a balanced personality with the qualities of creative skills, initiative, critical thinking and being responsible.

6. Developing the human resources, needed for the progress of the wellbeing of an individual, the nation as well as the economic growth of Sri Lanka, through education.

7. Preparing the people for the changes that occur in a rapidly changing world by adapting to it and controlling them; developing abilities and potentialities of people to face the complex and unexpected occasions.

8. Sustaining the skills and attitudes based on justice, equality, mutual respect which is essential to achieve a respectable place in the international community.

National Education Commission Report (2003).

1.2 Basic Competencies

The competencies promoted through the education mentioned below help to achieve the above mentioned National Goals.

i. Competencies in Communication

This first set of competencies is made up of four subsets - Literacy,Numeracy, Graphics and Information Communication skills:

Literacy :	Listening, carefully speaking clearly, and reading for comprehension, writing clearly and accurately.
Numeracy:	Using numbers to count, calculate, code and to measure, matter, space and time.
Graphics :	Making sense of line and form, expressing and recording essential data, instructions and ideas with line, form, colour,two and three-dimensional configurations, graphic symbols and icons.
ICT Competencies:	Knowledge on computers, and the ability to use the information communication skills at learning or work as well as in private life.

ii. Competencies relating to personality development

- Generic skills such as creativity, divergent thinking, initiative, decision making, problem-solving, critical and analytical thinking, team work,inter-personal relationships, discovering and exploring
- Values such as integrity, tolerance and respect for human dignity.
- Cognition

iii. Competencies relating to the environment

This is the second set of competencies related to the Social, Biological and Physical Environments.

Social Environment:	Awareness, sensitivity and skills linked to being a member of society, social relationship, personal conduct, general and legal conventions, rights, responsibilities, duties and obligations.
Biological Environment:	Awareness, sensitivity and skills linked to the living world, man and the ecosystem, the trees,forests, seas, water, air and life - plant, animal and human life.
Physical Environment:	Awareness, sensitivity and skills relating to space,energy, fuel, matter, materials and their links with human living, food, clothing, shelter, health,comfort, respiration, sleep, relaxation, rest, waste and excretion, media of communication and transport.

Included here are the skills in using tools to shape and for materials for living and learning.

iv. Competencies relating to preparation for the world of work

Employment related skills to maximize their potential and to enhance their capacity to contribute to economic development; to discover their vocational interests and aptitudes; to choose a job that suits their abilities and to engage in a rewarding and sustainable livelihood.

v. Competencies relating to religion and ethics

- Develop competencies pertaining to managing environmental resources intelligently by understanding the potential of such resources.
- Develop competencies related to the usage of scientific knowledge to lead a physically and mentally healthy life.
- Develop competencies pertaining to becoming a successful individual who will contribute to the development of the nation in collaboration, engage in further studies and undertake challenging job prospects in the future.
- Develop competencies related to understanding the scientific basis of the natural phenomena and the universe.
- Use appropriate technology to maintain efficiency and effectiveness at an optimum level in utilizing energy and force.

2.0 Aims

At the end of the course student will be able to:

1. Understand the basic concepts of chemistry and to appreciate the unifying themes and patterns within the subject.
2. Develop critical and imaginative thinking in applying concepts and knowledge of chemistry to chemical phenomena.
3. Recognize the value of chemistry to society, and to acquire an understanding of the applications of science to technological, economic and social development.
4. Develop an understanding of natural resources and the issues involved in the conservation and utilization of natural resources.

List of topics and allocated number of periods

	Topic	Number of Periods
Unit 01	Atomic structure	35
Unit 02	Structure and bonding	35
Unit 03	Chemical calculations	37
Unit 04	Gaseous state of matter	32
Unit 05	Energetics	41
Unit 06	Chemistry of *s,p* and *d* block elements	64
Unit 07	Basic concepts of organic chemistry	17
Unit 08	Hydrocarbons and halohydrocarbons	46
Unit 09	Oxygen containing organic compounds	46
Unit 10	Nitrogen containing organic compounds	14
Unit 11	Chemical kinetics	41
Unit 12	Equilibrium	94
Unit 13	Electro chemistry	33
Unit 14	Industrial chemistry and Environmental pollution	65
	Total =	**600**

Proposed term- wise breakdown of the syllabus

Grade	Term	Competency Levels
Grade 12	First Term	From 1.1 to 3.3 (11 Competency Levels)
	Second Term	From 4.1 to 6.6 (15 Competency Levels)
	Third Term	From 7.1 to 10.3 (20 Competency Levels)
Grade 13	First Term	From 11.1 to 12.2 (7 Competency Levels)
	Second Term	From 12.3 to 13.4 (8 Competency Levels)
	Third Term	From 14.1 to 14.8 (8 Competency Levels)

3.0 Syllabus - 3.1 - Grade 12

Unit 01: Atomic Structure **Periods 35**

Competency	Competency level	Contents	Outcome	No. of Periods
1.0 Uses electronic arrangements and energy transactions in determining the nature of matter	1.1 Reviews the models of atomic structure	• Properties of cathode rays • Introduction to atom and sub atomic particles • Rutherford model • Atomic number and mass number • Isotopes • Nuclides • Relative atomic mass • *Demonstrating properties of cathode rays*	**Student should be able to-** • writes the observations after observing the demonstration of cathode rays. • discuses the properties of cathode rays. • describes the atom and subatomic particles. • describes the Rutherford's model with the help of the conclusion of gold leaf experiment. • states the atomic number and mass number. (nucleon number) • explains the contribution of protons and neutrons to atomic nuclei to define isotope • states nuclides. • works out simle calculations using the ralative atomic mass of an atom. • appreciates the attempts made by scientists in understanding nature.	06

Competency	Competency level	Contents	Outcomes	No.of Periods
	1.2 Investigates the different types of electromagnetic radiation	• Wave- particle dual nature of matter • Electromagnetic radiation · [speed (c), wavelength (λ), frequency (ν), energy (E)] • $c = \nu\lambda$ • $E = h\nu$, $\lambda = \frac{h}{mV}$ • Electromagnetic spectrum	• states de Broglie equation • describes wave-particle duality of the matter with de Broglie equation. $\lambda = \frac{h}{mV}$ • names physical quantities that describe the properties of waves with the relationships among them. • states the electromagnetic radiation. • works out simple problems using $c = \nu\lambda$ and $E = h\nu$ ' $\lambda = \frac{h}{mV}$, $E= mc^2$ • names the different ranges in the electromagnetic spectrum.	04

Competency	Competency level	Contents	Outcomes	No.of Periods

	1.3 States the evidence for electronic energy levels of atoms	• Variation of successive ionization energies of variation of successive ionization energies of elements
		• Introduction to Bohr theory and Bohr model
		• Atomic spectrum of hydrogen
		  • Explanation of hydrogen spectrum using Bohr theory
		• Quantization of energy
		• Existence of electrons in energy levels
		  • Introduction to atomic orbitals s, p, d and f
		• Brief introduction to four quantum numbers
		  • The principal quantum number (*n*)
		  • The Azimuthal quantum number (*l*)
		  • The magnetic quantum number (m_l)
		  • The spin quantum number (m_s)
		• Shapes of orbitals (s and p *only*)
			• recalls ionization energy of an element.
			• describes succesive ionization energies.
			• presents evidences for the presence of electrons of atoms in main energy levels and sub energy levels using graphs of successive ionization energies.
			• describes the Bohr model.
			• explains qualitatively the series of lines in the atomic spectrum of hydrogen using the Bohr model.
			• states that energy releases or absorbs by an atom as photons/quanta.
			• describes four quantum numbers.
			• explains the existence of electrons in energy levels using quantum numbers up to fourth energy level.
			• states that the identity of an electron in a certain atom is described by the relevant set of quantum numbers.
			• states the information given by four quantum numbers.
			• illustrates the shapes of s and p orbitals.
				09

Competency	Competency level	Contents	Outcomes	No.of Periods

	1.4 States the ground state electronic configuration of isolated (gaseous) atoms and ions	• The maximum numbers of electrons in sub energy levels
		• Principles and rules relevant to the filling up of electrons
		  • Hund rule
		  • Pauli exclusion principle
		  • Aufbau principle and its deviations in higher atomic numbers
		• Ground state electronic configurations of isolated gaseous atoms of elements of atomic numbers from 1 to 54 and their ions
		• Relatively stable electron configurations of sub energy levels(s^2, p^3, p^6 , d^5 and d^{10} only)
			• states the number of electrons in sub energy levels.
			• states the principles and rules relevant to the filling up of electrons.
			• writes the electronic configuration of isolated gaseous atoms and ions of elements with atomic number from 1 to 54 according to the standard form.
			• states the deviation of Aufbau principle using the accepted electron configuration of Pd in 4d series.
			• gives examples for the existence of stable electronic configurations.
				06

Competency	Competency level	Contents	Outcomes	No.of Periods

	1.5 Analyses the electronic configuration of elements to verify their placement in the periodic table and relates atomic properties to electronic configuration	• Building up of the periodic table
		• Introduction to the long form of the periodic table
		  • s, p, d and f blocks
		• Elements in groups 1- 18
		• Trends shown by s and p block elements across the period and down the group
		  • shielding effect and effective nuclear charge (qualitative discussion only)
		  • Atomic radius;
		    • Covalent radius
		    • van der Waals radius
		    • Metallic radius
		  • Ionization energy/ successive ionization energy
		  • Electron gain energy (quantitatively only)
		  • Electronegativity (Pauling scale only)
		  • Formation of cations and anions
			• builds up the periodic table on the basis of electronic configuration.
			• classifies the elements under s, p and d block in relation to the electronic configuration.
			• identifies elements belonging to groups 1 to 18 and periods 1to 7 relevant to the electronic configuration.
			• describes the shielding effect and effective nuclear charge.
			• describes the atomic radius of an element using covalent radius, van der Waals radius and metallic radius.
			• compares the cationic and anionic radius with their atomic radii.
			• explains the variation of covalent radius of s and p block elements accross the periods and down the groups using a graph.
			• explains the zig zag variation of first ionization energies of elements considering their electronic configuration.
			• states electron gain energy.
			• describes the variation of elecron gain energy accross the period and down the group.
			• describes electro negativity of an element according to the Pauling scale.
				08

Unit 02: Bonding and Structure **Periods 35**

Competency	Competency level	Contents	Outcome	No. of Periods

2.0 Relates bonding and structure to properties of matter.	2.1 Analyses the primary interactions of polyatomic systems by means of determining the structure and properties of matter	• Formation of chemical bonds primary interactions
		• Covalent bonding
		  • Single bonds and multiple bonds
		• Structure of molecules and ions
		  • Lewis structures (dot-cross,dot -dot and dot-dash structures)
		  • Rules for drawing Lewis structures.
		• Electronegativity differences to compare bond nature (Pauling electronegativity only)
		• Polarity and dipole moment of a bond
		• Non- polar covalent bonding (e.g. - H_2, Cl_2 , O_2 , N_2)
		• Polar covalent bonding (e.g. HCl, H_2O, NH_3)
		• Dipole moment of molecules
		• Co-ordinate (Dative covalent) bonding (e.g. H_3O^+,NH_4^+, NH_3BF_3)
		• Ionic bonding
		  • Ionic Lattice
		• Covalent character of ionic bonds
		  • Polarizing power of cations
		  • Polarizability of anions
		• Metallic bonding
			Student should be able to:
			• overviews chemical bonds to understand the participation of valence electrons by sharing electrons.
			• explains the formation of covalent bonds by sharing electrons.
			• identifies the single bonds and multiple bonds.
			• describes the rules regarding with the drawing of Lewis structures.
			• draws Lewis structures of covalent molecules and groups of ions.
			• compare the nature of non- polar covalent bonds, polar covalent bonds and ionic bonds depending on the difference of electronegativity of the atoms involved in the bond.
			• describes the polar covalent nature of bond and molecules using the concepts of polarization and dipole moment giving suitable examples.
			• explains the formation of the dative-covalent bond.
			• explains the formation of ionic bonds.
			• explains the structure and physical properties of ionic lattice using NaCl.
				12

Competency	Competency level	Contents	Outcome	No. of Periods
			• explains the covalent character of ionic bonds based on the polarizing power of cation and polarizability of anions. • compares the ionic characters and covalent characters of compounds • explains the structure of the metallic bond. • states the covalent, ionic and metallic bonding as primary interactions.	

	2.2 Analyses the shapes of covalent and polar covalent molecules and simple ionic groups	• Concept of resonance
		  • Resonance structures of simple molecules and ions using Lewis dot dash structures
		• Hybridization of the central atom (sp, sp^2 and sp^3 only, excluding compounds containing unpaired electrons- 2nd period only) (Hybridization of terminal atoms not required)
		  • Nature of σ and π bonds in molecules/ ions
		• Valence shell electron pair repulsion (VSEPR) theory
			• draws the resonance structures commonly encountered and containing up to a maximum of ten atoms, by using standard rules.
			• explains using resonance the reason for the equality of bond lengths in the ozone molecule and the carbonate ion.
			• explains the hybridization of atomic orbitals.
			• describes how sp, sp^2 and sp^3 hybridizations take place in the central atom by using suitable examples.
			• states that the σ bond can be formed by the linear overlapping of s-s, s-p and p-p orbitals.
			• states that the π bond can be formed by the latteral overlapping of two p orbitals.
			• compares stregnth of σ bond and π bond.
			• describes the formation of sigma bonds by overlapping of hybridized orbitals.
				16

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Predicting the shape of molecules/ ions using VSEPR theory (central atom surrounded by a maximum of six pairs of electrons only) • Geometrical shapes • Linear • Trigonal planar • Tetrahedral • Pyramidal • Angular • Trigonal bipyramid • See- saw shape (distorted tetrahedral) • T-shaped • Octahedral • Square pyramid • Square planar • Variations of electronegativities with environment (charge/hybridization/ oxidation number only) • ***Displaying the shapes by using models***	• predicts using the valence shell electron pair repulsion theory, how the pairs of electrons are oriented around the central atom (electron pair geometry) of covalent molecules and ions and thereby the shapes of the molecule/ion (molecular geometry). • compares the bond angles of different types of molecules (exact values of bond angles will not be tested). • constructs the models of molecules to illustrate the shapes. • describes the variation of electronegativities according to the charge , hybridization and oxidation number.(qualitative only)	

Competency	Competency level	Contents	Outcomes	No.of Periods
	2.3 Analyses the secondary interactions existing in various systems as a means of determining the structure and propertiesof matter	• Secondary interactions (van der Waals forces) • Dipole - dipole interactions • Ion - dipole interactions • Hydrogen bonding • Ion - induced dipole interactions • Dipole - induced dipole interactions • Dispersion interactions (London forces) (qualitative treatment only) • Formation of simple molecular lattices due to secondary interactions. (I_2 and H_2O)	• describes the types of secondary interactions using suitable examples. • highlights the relationship between the nature of secondary interactions present in a substance and its physical properties. • explains the effect of hydrogen bonds on the melting poins of the hydrides of elements in groups 15, 16 and 17. • States the importance of secondary interactions and their effect on the state. • explains the formation of molecular lattices using given examples. • predicts the physical properties of lattice structures.	07

Unit 03: Chemical calculations **Periods 37**

Competency	Competency level	Contents	Outcome	No. of Periods

3.0 Works out chemical calculations accurately	3.1 Determines chemical formulae using physical quantities related to atoms and molecules and works out relevant calculations using relevant data	• The concept of oxidation number
		• Chemical formulae and IUPAC nomenclature of simple compounds
		• Common names of simple compounds
		• Simple calculation based on moles molar mass and Avogadro constant
		• Empirical formula and molecular formula
		• The parameters of composition
		  • Mass fraction
		  Weight percentage (w/w%)
		  Parts per million, mg kg^{-1}
		  Parts per billion, μg kg^{-1}
		  • Volume fraction
		  Volume percentage (v/v%)
		  Parts per million (for gases), μL L^{1}
		  • Mole fraction
		  • Weight/volume
		  ppm as mg $dm^{-3}$for dilute aqueous solutions
		  ppb as μg dm^{-3} for dilute aqueous solutions
			Student shold be able to:
			• finds the oxidation number of the constituent atoms of a given species
			• writes chemical formulae and names them using IUPAC rules.
			• states the common names of the chemical compounds used frequently.
			• states the value of Avogadro constant (L).
			• carries out calculations related to moles and Avogadro constant.
			• determines the empirical formula when the percentage composition is known
			• determines the molecular formula when the empirical formula and the molar mass are known.
			• determines the composition of elements when the molecular formula is given.
			• reviews the parameters of composition (mass fraction, volume fraction, mole fraction, concentration)
			• solves problems related to mass fraction, volume fraction and mole fraction.
				13

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Concentration (molarity), mol/volume mol dm^{-3}, mmol m^{-3} , mol m^{-3} • Preparation of solutions • ***Handling glassware and four beam balance***	• defines concentration as the composition expressed in terms of moles of the solute per volume. • uses ppm and ppb to express the composotion containing trace amounts of substances. • calculates and expresses the compositions in terms of mass/volume, amount/volume (concentration) • solves problesms related with mass/volume and amount/volume. • handles glassware such as pipette, burette, beakers, measuring cylinders and four beam balance in the laboratory.	
	3.2Uses different kind of methods to balance the equations	• Balancing chemical equations • Inspection method • Redox method • Using oxidation number • Using half ionic equations • Balancing simple nuclear reactions	• examines the balance in a chemical equation considering the mass and charge conservation. • balances equations by using inspection method and the redox method. • balances simple nuclear reactions.	10

Competency	Competency level	Contents	Outcomes	No.of Periods

	3.3Carries out calculations associated with stoichiometry and reaction equations.	• Calculations involving in various types of chemical reactions
		  • Calculation involving acid-base and redox reactions
		  • Calculation involving precipitation (gravimetry)
		• Preparation of solution
			• calculates quantities in chemical reactions using stoichiometry.
			• explains methods of preparation of solutions and dilution.
			• Prepares a standard solution of Na_2CO_3
				14

Unit 4: State of matter; Gaseous State **Periods 32**

Competency	Competency level	Contents	Outcome	No. of Periods

4.0 Investigates the behavior of the gaseous state of matter	4.1 Uses organization of particles in three principal states of matter to explain their typical characteristics	• Principal states of matter
		  • Solid
		  • Liquid
		  • Gas
		• Arrangement of particles and their movements
		• Qualitative comparison of properties
		  • Volume
		  • Density
		  • Shape/ gravity
		  • Compressibility
			Student shold be able to:
			• investigates the organization of particles in the principal states solid, liquid and gas.
			• compares the macroscopic properties such as volume, density, shape (under the influence of gravity) and compressibility of solids, liquids and gases in relation to the arrangement of particles and their movement.
				02

	4.2 Uses the model of ideal gas as a means of describing the behavioral patterns of real gases.	• Introduction to an ideal gas • Ideal gas equation and its derivatives (P,V, T and n as variables) P=CRT Pv=m/M RT PM=dRT • Boyle law, Charles law and Avogadro law • Consistency of Boyle law, Charles law and Avagadro law with the ideal gas equation • Molar volume	• defines an ideal gas. • writes the ideal gas equation and its derivatives with their terms. • states Boyle, Charles and Avogadro laws and show the consistency of the ideal gas equation. • defines the molar volume of a gas.	10

Competency	Competency level	Contents	Outcomes	No.of Periods
		• ***Experimental determination of molar volume of a gas*** • ***Experimental determination of relative atomic mass of magnesium using molar volume of hydrogen gas***	• solves problems related to the ideal gas equation and its derivatives. • determines experimentally the molar volume of oxygen. • determines the relative atomic mass of magnesium experimentally.	
	4.3 Uses molecular kinetic theory of gases as a means of explaining the behavior of real gases	• Molecular kinetic theory of gases • Pressure of a gas • Expressions for mean speed, mean square speed and root mean square speed • Kinetic molecular equation $PV = \frac{1}{3}mN\overline{C^2}$ (Derivation is not necessary.) • $\overline{C^2} = \frac{3RT}{M}$ • Simplified form of Maxwell - Boltzmann distribution (graphically) • Variation of the distribution with temperature and molar mass	• states the assumptions of the molecular kinetic theory of gases. • describe the factors affecting the pressure of a gas. • writes expressions for mean speed, mean square speed and root mean square speed. • states the kinetic molecular equation and describes its terms. • derives $\overline{C^2} = \frac{3RT}{M}$ • solves simple problem reated to $\overline{C^2} = \frac{3RT}{M}$ • describes the information given by Maxwell - Boltzmann curves for gases. • explains the changes of Maxwell - Boltzmann curves with teamparature and molar masses.	08

Competency	Competency level	Contents	Outcomes	No.of Periods
	4.4 Uses Dalton law of partial pressures to explain the behavior of a gaseous mixture	• Total pressure and partial pressure • Dalton law of partial pressures	• explains the term partial pressure. • states Dalton law of partial pressures. • derives Dalton law of partial pressure from the ideal gas equation. • solves problems related to Dalton law of partial pressures.	06

	4.5 Analyses amendments to the ideal gas equation for applying it to real gases	• Compressibility factor (only to check the ideality)
		• Deviation of real gases from ideal gas law
		  • Molecular interactions
		  • Volume of molecules
		• Corrections to the ideal gas equation
		  • van der Waals equation (Qualitative description only)
		• Critical temperature
			• defines the compressibility factor.
			• presents graphically how this value varies with temperature in real and ideal gases.
			• describes the reasons for the deviation of real gases from the behavior of ideal gases by using assumptions of molecular kinetic theroy.
			• presents van der Waals equation as an equation constructed to explain the deviation of real gases from the ideal behavior.
			• describes the critical temperature.
			• values the idea that scientific concepts are not static but subject to continuous improvements based on facts.
				06

Unit 05: Energetics **Periods 41**

Competency	Competency level	Contents	Outcome	No. of Periods
5.0 Predicts the stability of chemical systems and feasibility of conversions by investigating associated changes in enthalpy and entropy	5.1 Explores concepts related to enthalpy	• Extensive and intensive properties • System, surroundings and boundary • Standard states of pure substances and solutions • State of a system and state functions • Heat and enthalpy • Integral enthalpy changes associated with a process, $\Delta H = H(final) - H(initial)$ express in kJ enthalpy change per extent of reaction expressed in kJ mol^{-1} • Enthalpy changers associated with standard states $\Delta H^{o} = H^{o}(final) - H^{o}(initial)$	**Student should be able to** • describes the extensive and intensive properties. • defines the terms system, surrounding, boundary, closed system, open system and isolated system. • states the standard states of pure substances and solutions. • defines the terms state of a system and a state function. • explains the enthalpy change of a reaction. • describes enthalpy as a function of state or thermodynamic property but not heat. • states that integral value for ΔH reported in kJ or per unit extent of reaction kJ mol^{-1}. • calculates the enthalpy changes in associated with process using $\Delta H = H(final) - H(initial)$ • calculates the enthalpy changes at standard states using $\Delta H^{o} = H^{o}(final) - H^{o}(initial)$	05

Competency	Competency level	Contents	Outcomes	No.of Periods

	5.2 Defines the enthalpy changes and calculates enthalpy changes associated with a given conversion	• Calculation of heat changes and heat of a reaction, using $Q = mc\Delta T$
		• Endothermic (energy absorbing) and exothermic (energy releasing) processes
		• Enthalpy changes and standard enthalpy changes
		  • Enthalpy of formation (ΔH_f)
		  • Enthalpy of combustion (ΔH_c)
		  • Enthalpy of bond dissociation (ΔH_d)
		  • Mean bond dissociation enthalpies
		  • Enthalpy of neutralization(ΔH_{neu})
		  • Enthalpy of hydration (ΔH_{hyd})
		  • Enthalpy of solution (ΔH_{sol})
		• Enthalpy level diagrams and enthalpy cycles of different processes
		  • Difference between an Enthalpy level diagram and an Enthalpy cycle
		• Hess law (as an application of state function)
		  • Calculations of enthalpy changes associated with different processes using different methods and applying Hess law
			• calculates heat changes at constant pressure using $Q = mc\Delta T$.
			• explains the endothermic and exothermic reactions using energy diagram.
			• defines enthalpy changes and standard enthalpy changes given in the syllabus.
			• states Hess Law.
			• calculates enthalpy changes using
			  • enthalpy diagrams
			  • thermodynamic cycles
			  • only using formation enthalpies as well as only using bond dissociation enthalpies separately.
			• determines experimentally the enthalpy of neutralization of acids and bases.
			• states that the nutralisation enthalpy of strong acids and strong bases is constant.
			• states that the nutralisation enthalpy of week acide/weak base is some what deffrent than strong acide/strong base.
			.• tests the validity of Hess law by preparing 1mol dm^{-3} NaCl , 250 cm^3 using two methods.
				23

Competency	Competency level	Contents	Outcomes	No.of Periods
		• ***Experimental determination of the enthalpy of acid/base neutralization*** *(NaOH and HCl, KOH and HNO_3, NaOH and CH_3COOH, NH_4OH and HCl)* • ***Validation of Hess law through experiments***		

	5.3 Calculates the lattice enthalpy or enthalpy of formation of an ionic compound using Born-Haber cycles	• Calculation of lattice energy of ionic compounds by using Born - Haber cycle
		  • Enthalpy of sublimation (ΔH_S)
		  • Enthalpy of vapourisation (ΔH_{vap})
		  • Enthalpy of fusion (ΔH_{fus})
		  • Enthalpy of atomization (ΔH_{atm})
		  • Enthalpy of ionization (ΔH_I)
		  • Enthalpy of electron gain (ΔH_{EA})
		  • Lattice enthalpy (ΔH_{LE})
			• defines the enthalpy changes used to develop the Born Haber cycle.
			• develops the Born – Haber cycle related to lattice enthalpy.
			• calculates the standard lattice enthalpy using the Born – Haber cycles.
			• calculates the standard lattice enthalpy using enthalpy diagrams.
			• explains the variation of electron gain enthalpies of elements of second and third periods.
				08

	5.4 Predicts the spontaneity of chemical reactions	• Entropy (*S*) and entropy change (ΔS) • Gibbs energy (*G*) and Gibbs energy change (ΔG) • Relationship between ΔG, ΔH and ΔS	• explains the terms entropy (*S*) and entropy changes(ΔS) as a mesaurement of randomness. • explains that the stability of the system increases with the randomness.	05

Competency	Competency level	Contents	Outcomes	No.of Periods
		• $\Delta G = \Delta H - T\Delta S$ • Standard Gibbs energy change G^0 and standard entropy change ΔS^0 • Relationship between G^0, H^0 and S^0 • $\Delta G^0 = \Delta H^0 - T\Delta S^0$ • Determination of spontaneity of a reaction using ΔG • $\Delta G = 0$, equilibrium • $\Delta G < 0$, spontaneous • $\Delta G > 0$, non spontaneous	• states that the entropy change depends on the temperature, physical state and the arrangement of particles. • explains Gibbs energy (G) and Gibbs energy change (ΔG) • states that S and G are state functions. • calculates ΔS and ΔG using • $\Delta S = S_{(products)} - S_{(reactants)}$ • $\Delta G = G_{(products)} - G_{(reactants)}$ • Energy cycle • explains the terms ΔG^0 and ΔS^0 • states the relationship among ΔG, ΔH and ΔS. • states the relationship among ΔG^0, ΔH^0 and ΔS^0. • predicts the spontaneity of a reaction or an event occurring under constant pressure and temperature using ΔG. • states that ΔG and ΔS are reported as a integral quantity ΔG (kJ), ΔS (JK^{-1}) or per extent of a reaction. (kJ mol^{-1}) ΔG (kJ mol^{-1}) ,ΔS (kJK^{-1} mol^{-1}) • calculates the problems based on standard values ΔG^0, ΔH^0 and ΔS^0. • forecasts the feasibility of a reaction using the value of ΔG and $\Delta G = \Delta H - T\Delta S$	

Unit 06: Chemistry of *s, p* and *d* block elements **Periods 64**

Competency	Competency level	Contents	Outcome	No. of Periods

6.0 Investigates the properties of elements and compounds of s, p and d blocks	6.1 Investigates the properties of elements in the s block	• Occurrence of s block elements (only Na, k, Mg and Ca)
		• Reactions of selected *s* block elements
		  • with water
		  • with air/ O_2
		  • with N_2
		  • with H_2
		  • with acids
		• ***Comparison of the reactions of s- block metals with air, water and acids***
		• ***Identification of elements of compounds by the flame test (Li, Na, K, Ca, Ba, Sr)***
			Student should be able to:
			• describes the occurrence of s block elements and compounds.
			• describes the nature of the reactions by means of balanced chemical equations of elements of the first and second groups with air/O_2, water, acids, N_2 and H_2.
			• observes reactions of Na and Mg with air, oxygen, water, acids taking them as representative elements.
			• comperes the reacctivity of the elements of group I and II by using experimental observations.
			• explains that s block elements can function as reducing agents by forming stable cations with noble gas configuration by giving up outermost shell electrons (oxidation) which are loosely bonded to the nucleus.
			• states the colours of the s elements using flame test.
				10

Competency	Competency level	Contents	Outcomes	No.of Periods

	6.2 Investigates the properties of elements and compounds of p block	• occurrence of p block elements (only C, N, O)
		• p block elements (groups 13- 18)
		• Properties of selected elements and their compounds
		  • Aluminium
		    • Aluminium oxide
		    • Amphoteric properties of aluminium and aluminium oxide
		  • Electron deficiency of aluminium chloride
		• Carbon
		  • Allotropes of carbon (diamond, graphite and fullarin.
		  • Oxides of carbon
		  • Oxoacids of carbon
		• Nitrogen
		  • Oxidation numbers of nitrogen in nitrogen containing compounds
		  • Acyclic oxoacids and oxides
		  • Reactions of HNO_3 with metals and nonmetals (Mg, Cu, C, S)
		• Ammonia
			• describes the occurrence of p -block elements and compounds compound to s - block.
			• describes the reactions of aluminium and aluminium oxide to show their amphoteric nature.
			• describes electron deficiency of $AlCl_3$ and the formation of Al_2Cl_6.
			• names three main allotrophic forms of carbon as diamond, graphite and fullererin.
			• explains the structure graphite and diamond.
			• explains the melting point lubricafing ability, hardness and electrical conductivity of diamond and graphite.
			• present structures of CO and CO_2 and their properties.
			• presents structure of H_2CO_3 and explains its acidic property.
			• explains the inert nature of nitrogon using bond energy.
			• writes examples for different oxidation numbers of nitrogen.
			• present structures of oxides and oxoacids of nitrogen.
				23

Competency	Competency level	Contents	Outcomes	No.of Periods

		• Oxidizing and reducing properties (with Na, Mg,Cl_2, CuO)
		• Ammonium salts
		• Thermal decomposition of ammonium salts. (halides, NO_3^-,NO_2^-,CO_3^{2-} ,SO_4^{2-} ,$Cr_2O_7^{2-}$)
		• Oxygen and sulphur
		  • Allotropes
		  • Acyclic oxoacids (H_2SO_4, H_2SO_3, $H_2S_2O_3$)
		  • Reactions of H_2SO_4 (with metals, C and S)
		  • Compounds containing oxygen and sulphur
		    • Amphiprotic property of water
		    • Oxidizing and reducing properties of H_2O_2 , H_2S, SO_2
		• Halogens
		  • Reactions of chlorine with copper , iron and ammonia
		  • Displacement reactions of halogens with other halide ions
		  • Disproportionation of chlorine with water and NaOH
			• writes balanced equations for reaction of HNO_3 with Mg, Cu, C and S
			• writes reactions of ammonia as an oxidizing agent with Na and Mg.
			• writes reactions of ammonia as an reducting agent with Cl_2 and CuO.
			• writes balanced equations for thermal decomposition of ammonium salts.
			• identifies ammonia gas and ammonium ion experimentally using HCl, litmus and nestler reagent.
			• presents information about allotropic forms of oxygen and sulphur.
			• presents structure of oxoacids of sulphur.
			• writes reactions to explain the oxidizing ability of conc. H_2SO_4 with metals, C and S.
			• describes the amphiprotic property of water using the reactions with NH_3 and HCl.
			• writes reactions of H_2O_2 with $H^+/KMnO_4$, $H^+/K_2Cr_2O_7$.
			• writes reducing reactions of H_2O_2 with KI and Fe^{2+}
			• writes oxidising reactions of H_2S with $H^+/KMnO_4$, $H^+/K_2Cr_2O_7$, and SO_2.
			• writes reducing reactions of H_2S with Na and Mg.	

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Disproportionation of chlorate(I) ion • Oxoacids of chlorine • Halides • Acidity of hydrogen halides in aqueous media • Noble gases • Fluorides of xenon • ***Identification of anions*** • ***halides,*** SO_4^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, S^{2-}, CO_3^{2-}, NO_3^-, NO_2^- (except F^-) • ***Showing the presence of nitrogen in air by experiment*** • ***Identification of halides*** • ***Standardization of solution of thiosulphate ions using*** KIO_3 ***and KI*** • ***Identification of ammonia gas and ammonium salts (with litmus, HCl, Nessler's reagent)***	• writes oxidising reactions of SO_2 with H^+/ $KMnO_4$, OH^-/$KMnO_4$ • writes reducing reactions of SO_2 with H_2S and Mg. • describes physical states and colours of halogens. • writes balanced equations for the reactions of chlorine with Cu ,Fe and NH_3. • writes balanced equations for displacement reactions of halogens. • compares the relative oxidation powers of the halogens. • describes the disproportionation of chlorine and chlorate(I) ions with balanced eqations. • presents structures of the oxoacids of chlorine of different oxidation states. • compares the acidity and oxidizing ability of oxoacids of chlorine using oxidation states. • describes giving suitable examples, the acidity of hydrogen halides in aqueous medium. • states the properties of the noble gases giving examples - XeF_4, XeF_2, XeF_6. • identifies the anions SO_4^{2-} , SO_3^{2-}, $S_2O_3^{2-}$, S^{2-}, CO_3^{2-} using precipitation method. • explains the solubility of the precipitates of in acids based on the nature of the anions.	

Competency	Competency level	Contents	Outcomes	No.of Periods
			• identifies NO_3^- and NO_2^- using dil HCl, brownirng test and NaOH/Al. • examines the presence of nitrogen in air using Mg. • identifies the halide ions using $AgNO_3$ / NH_3, $Pb(NO_3)_2$ and Cl_2/CCl_4. • determines the concentration of a given thiosulphate solution using KI/KIO_3.	

	6.3Investigates the properties of compounds and their trends associated with s and p block elements.	• Trends shown by compounds of s block elements down the groups.
		  • Comparing solubility of hydroxides, carbonates, bicarbonates, nitrites, nitrates, halides, sulphides, sulphities , chromates, phosphates, oxalates and sulphates of s block elements
		  • Comparing thermal stability of nitrates, bicarbonates and carbonates of s block elements
		• Trends shown by compounds of s and p block elements across the period and down the group
		  • Acid/base/ amphoteric nature of oxides and hydroxides accross the 3^{rd} period.
			• compares experimentaly the solubility of the salts of s block elements in water.
			• compares experimentaly the thermal stability of the nitrates, carbonates and bicarbonates of s block elements.
			• explains how the acidic/ basic/ amphoteric nature of the oxides and hydroxides of s and p blocks vary along the 3^{rd} period.
			• writes balanced chemical equations for reactions of hydrides and halides with water to understand the trends of hydrolysis.
			• compares the hydrolysing ability of halides of group 15 elements.
				08

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Reactions of hydrides and halides with water across the third period • Reactions of halides with water down the group 15 • ***Testing the solubility of salts of* s *block elements*** • ***Testing the thermal stability of nitrates, and carbonates of* s *block elements***	• Compares the water solubility of salts of S block elements experimentally. • Compares the themal stability of nitrates and carbonates of s block elements experimentally.	
	6.4 Investigates properties of elements of d block and their variation across the period	• Occurence and uses of some d block elements and their cmpounds (Cu, Fe and Ti) • Comparison of the following properties of d block elements with s and p block elements • Electron configurations and variable oxidation states • Electronegativity • Metallic properties • Catalytic action • Ability to form coloured compounds • ***Identification of the colours of complex ions in aqueous medium***	• describes the occurence and ues of d block elements (Cu, Fe and Ti) and their compounds. • states the variable oxidation states shown by the d block elements of the fourth period using electron configuration. • compares the ability to form variable oxidation states of d block elements with that of s and p block elements. • compares electronegativity of d block elements with that of s block elements. • compares the metallic properties of d block elements with those of s block elements. • describes the catalytic property of d block elements.	06

Competency	Competency level	Contents	Outcomes	No.of Periods
			• describes the ability of d block elements to form coloured complexes. • identifies the colours of d block complex ions experimentally.	
	6.5 Investigates properties of compounds of the d block.	• Acidic/basic/amphoteric nature of oxides of chromium and manganese • Oxoanions of chromium and manganese • CrO_4^{2-}, $Cr_2O_7^{2-}$ and MnO_4^- ions as oxidizing agents • ***Determination of the concentration of a ferrous ion solution using acidified potassium permanganate*** • ***Determination of the concentration of $KMnO_4$ solution using standard acidified $K_2C_2O_4$ solution.***	• expresses acidic/basic/amphoteric nature of oxides of chromium and manganese. • writes balanced equations for oxidation and reduction reactions of oxoanions of Cr and Mn in acidic/basic medium. • determines the concentration of Fe^{2+} in a given sample using acidified $KMnO_4$ experimentally. • determines the concentration of $KMnO_4$ solution using acidified $K_2C_2O_4$ experimentally.	08

Competency	Competency level	Contents	Outcomes	No.of Periods
	6.6 Investigates properties of complex compounds of the d block	• Complex compounds of ions of Cr, Mn, Fe, Co, Ni and Cu formed with the following mono-dentate ligands and their colours • H_2O, • Cl^- • Names of above complex using IUPAC rules • Reactions of cations (Cr^{3+}, Mn^{2+}, Fe^{2+}, Fe^{3+} Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}) with NaOH and NH_3 (aq) (ammine complexes of Mn^{2+}, Fe^{3+} and Cr^{3+} are not required) • ***Observing the colours of the complexes of Cu(II), Ni(II) and Co(II) with hydrochloric acid and ammonia*** • ***Observing the different colours of oxidation states (+2,+4,+6,+7) of manganese containing compounds using redox reactions*** • ***Identification of Ni^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+} and Cr^{3+} ions using NaOH and NH_3***	• writes complexes formed by Cr, Mn, Fe, Co, Ni, Cu with H_2O and Cl^-. • names complexes containing only one type of ligand using IUPAC rules. • writes reaction of d block cations Cr^{3+}, Mn^{2+}, Fe^{2+}, Fe^{3+}, Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}. with NaOH and NH_3 (aq) • Names the colours by observing the colour of copper (II), cobalt (II) and nickel (II) salts with hydrochloric acid and ammonia. • Observes experimentally the colours relevant to the oxidation states +2, +4, +6 and +7 of manganese using redox reactions. • Identifies Ni^{2+}, Fe^{2+}, Fe^{3+}, Cu^{2+} and Cr^{3+} ions in aqueous solution experimentally.	09

Unit 07: Basic concepts of organic chemistry **Periods 18**

Competency	Competency level	Contents	Outcome	No. of Periods
7.0 Investigates the variety of organic compounds	7.1 Investigates the importance of organic chemistry as a special field of chemistry	• Introduction to organic chemistry • Reasons for the presence of a large number of organic compounds • Importance of organic compounds in day to day life	**student should be able to .** • states that there is a large number of natural and synthetic compounds containing carbon as the main constituent element. • explains giving the relevant facts the ability of carbon to form a large number of compounds. • shows the importance of organic chemistry in daily life by giving examples from various fields. • accepts that organic chemistry is applied in various fields in day to day life.	02

	7.2 Investigates the variety of organic compounds in terms of the functional groups	• Variety of organic compounds
		  • Aliphatic (acyclic) hydrocarbons and aromatic hydrocarbons (benzene and substituted benzenes only)
		  • Alkyl halides and aryl halides
		  • Alcohols and phenols
		  • Ethers
		  • Aldehydes and ketones
		  • Carboxylic acids
		  • Acid chlorides
		  • Esters
		  • Amides
		  • Aliphatic amines and aryl amines
		• Amino acids
			• recognizes hydrocarbons as being aliphatic or aromatic form with their structural formulae.
			• identifies the names and symbols of functional groups that are included in the syllabus.
			• names the variety of organic compounds in terms of the functional groups present.
			• names the homologous series of compounds containing each of the functional groups and presents examples.
				02

Competency	Competency level	Contents	Outcomes	No.of Periods

	7.3 Names simple aliphatic organic compounds.	• Trivial names of common organic compounds
		• Rules of IUPAC nomenclature applicable to compounds within the following structural limits
		  • The number of carbon atoms in the main carbon chain should not exceed six.
		  • Only saturated, unbranched and unsubstituted side chains of C should be connected to the main chain.
		  • The total number of C-C double bonds and triple bonds of an unsaturated compound should not exceed one.
		  • The C-C double bond or triple bond is not considered a substituent but is a part of the main chain.
		  • The number of substituent groups on the main carbon chain should not exceed two.
			• states the trivial names of the common organic compounds when the structural formula is given.
			• recognizes the need for a standard nomenclature.
			• names the given organic compounds which are structurally within the limit stated in the syllabus, using the IUPAC rules.
			• draws the structural formula of a compound when the IUPAC name is stated.
				06

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Only the following groups should be present as substituent groups.-F, -Cl, -Br, -I, $-CH_3$, $-CH_2CH_3$, -OH, $-NH_2$, $-NO_2$, -CN,-CHO, >C=O • Only the following groups should be present as the principal functional group. -OH, -CHO, >C=O, -COOH, -COX, -COOR, $-NH_2$, $-CONH_2$ • The principal functional group should not occur more than once(nomenclature of aromatic compounds will not be tested)		
	7.4 Investigates the different possible arrangements of atoms in molecules having the same molecular formula.	• Isomerism • Constitutional (structural) isomers • Chain isomers • Position isomers • Functional group isomers • Stereoisomers • Diastereomers (illustrated by geometrical isomers only)	• draws all the possible structural formulae for a given molecular formula. • explains the term, isomerism. • classifies the given structures for given molecular formulae as chain, position, and functional group isomers. • states the requirements to be satisfied to exhibit geometrical and optical isomerism. • recognizes structural formulae of compunds that can exist as enantiomers and dioastereomers. • summarizes all type of isomerism.	07

Unit 08: Hydrocarbons and halohydrocarbons **Periods 46**

Competency	Competency level	Contents	Outcome	No. of Periods

8.0 Investigates the relationship between structure and properties of hydrocarbons and halohydrocarbons.	8.1 Investigates the structure,physical properties and nature of bonds of aliphatic hydrocarbons. (only acyclic aliphatic compounds are considered)	• Types of hydrocarbons
		  • Alkanes
		  • Alkenes
		  • Alkynes
		• Homologous series
		• Physical properties
		  • Intermolecular forces
		  • Melting points and boiling points
		• Hybridization of carbon atoms in organic compounds (sp^3, sp^2 and sp)
		• Geometrical shapes of alkanes, alkenes and alkynes
			student should be able to:-
			• describes the nature of the bonds in alkanes, alkenes, and alkynes using suitable examples.
			• explains the variation of physical properties along the homologous series of alkanes, alkenes and alkynes.
			• relates the geometrical shapes of the simple alkanes, alkenes and alkynes to the hybridization of carbon atoms.
				05

	8.2 Investigates and compares the chemical reactions of alkanes, alkenes and alkynes in terms of their structures\	• Reactions of alkanes
		• Lack of reactivity of alkanes towards common reagents
		• Reactions with free radicals
		  • Substitution reactions with chlorine
		  • Mechanism of chlorination of methane
		    • Homolytic cleavage of bonds
		    • Free radicals as reaction intermediates
		• Reactions of alkenes
		  • Electrophilic additions as characteristic reactions of alkenes
			• explains the nonreactivity of alkanes with polar reagents in terms of the non poloar nature of the C - C and C-H bonds.
			• explains the machanism of the free radical chlorination of methane.
			• explains the tendency for alkenes to undergo electrophilic addition reactions in terms of their unsaturation and electon rich nature.
			• write the mechnanism for the reaction of hydrogen halide with alkenes.
				14

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Addition of hydrogen halides to simple alkenes and its mechanism • Carbocations as reactive intermediates • Relative stability of primary, secondary and tertiary carbocations • Anomalous behaviour of HBr in the presence of peroxides (mechanism is not necessary) • Addition of bromine to simple alkenes • Mechanism of addition of bromine to propene • Addition of sulphuric acid and the hydrolysis of the addition product • Catalytic addition of hydrogen • Reactions of alkenes with cold alkaline $KMnO_4$ (Bayer's test) • Reactions of alkynes • Electrophilic additions as characteristic reactions of alkynes • Addition of bromine • Addition of hydrogen halide • Addition of water in the presence of mercuric ions and sulphuric acid • Catalytic addition of hydrogen including partial hydrogenation	• identifies carbo cations as reactive intermediates in the addition of hydrogen halides to alkenes • compares the relative stabilities of primary, secondary and tertrary carbocations. • recognizes that the direction of addition of hydrogen halides to alkenes is determined by the relative stability of the carbocation that can be formed as an intermidiate. • recognizes that the reatction of bromine with alkene is also and electrophilic addition due to the polarization of the bromine molecule during the reaction leading to the initial addition of Br^+. • writes the mechanism between alkenes and Bromine. • write a final product obtain by the reaction between alkenes and dil H_2SO_4 followed by hydrolysis.	

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Acidic nature of alkynes with terminal hydrogen explained by the nature of bonding • Reactions of alkynes with terminal hydrogen • Na and $NaNH_2$ • Ammonical CuCl • Ammonical $AgNO_3$ • ***Observing reactions of alkenes and alkynes with alkaline $KMnO_4$ and bromine water.*** • ***Observing reactions of terminal alkynes with ammonical silver nitrate and ammonical cuprous chloride.***	• writes the product of catalytic hydrogenation of alkenes. • writes the product formed by the reactions of alkenes with alkaline $KMnO_4$. indicating their colour changes. • explaines the tendency for alkynes to undergo electrophilic addition reactions in terms of their unsaturation and electron rich nature. • writes the elecphilic addition reactions of alkynes with reagents Br_2, H, dil H_2SO_4 / Hg^{2+} • writes the reactions of alkynes within the presence of Ni/Pt/Pd. • writes the product obtained by partial hydrogenation of alkynes in the presence of Pd/$BaSO_4$/Quinoline. • recognizes that the acidity of terminal H of an alkyne due to the state of hybridization of the carbon atom and that this H can be replaced by metals.	

Competency	Competency level	Contents	Outcomes	No.of Periods
	8.3 Investigates the nature of bonding in benzene	• Structure of benzene • Hybridization of carbon atoms • Delocalization of electrons • Concept of resonance • Stability of benzene	• gives reasons why the structure for benzene first presented by Kekule does not explain all the properties of benzene. • explains the structure and the stability of benzene using hybridization of carbon atoms and delocalization of electrons. • presents evidences in support of the true structure of benzene.	03
	8.4 Analyses the stability of benzene in terms of its characteristic reactions	• Preference for substitution reactions over addition reactions • Electrophilic substitution reactions as characteristic reactions of benzene • Nitration and its mechanism • Alkylation and its mechanism • Acylation and its mechanism • Halogenation in the presence of FeX_3 and its mechanism (X = Cl, Br) • Resistance to oxidation • Oxidation of alkyl benzene (except tertiary) and acylbenzene using $H^+/KMnO_4$ and $H^+/K_2Cr_2O_7$ • Difficulty of hydrogenation compared to alkenes • Catalytic hydrogenation of benzene	• shows using suitable examples the tendency of benzene to undergo substitution reactions rather than addition reactions. • describes the electrophilic substitution reactions as characteristic reactions of benzene using the mechanisms of nitration, alkylation, acylation and halogenation. • compares the reactions of benzene with those of alkanes, alkenes and alkynes. • describes the increase in the tendency to undergo oxidation of alkyl groups and acyl groups when they are attached to benzene.	07

Competency	Competency level	Contents	Outcomes	No.of Periods
	8.5 Recognizes the directing abilityof substituent groups of monosubstituted benzene	• Ortho, para directing groups -OH, $-NH_2$, -NHR, -R, -Cl, -Br, $-OCH_3$ • Meta directing groups -COOH, -CHO, -COR, $-NO_2$ (explanation is not necessary)	• identifies the substituent groups of mono substituted benzene as ortho, para or meta directing groups. • states the position to which a second substituent group attaches in a mono-substituted benzene on the basis of the directing property of the first substitued group.	05

	8.6 Investigates the structure and polar nature of C-X bond and reactions of alkyl halides	• Classification
		  • Primary, secondary, tertiary
		• Polar nature of the C-X bond (X=F, Cl, Br,I)
		• Physical properties (melting point, boiling point, solubility)
		• Nucleophilic substitution reactions of alkyl halides
		  • Elimination as a competing reaction
		  • Hydroxide ions, cyanide ion, acetylide, alkynide ion, alkoxide ion as nucleophiles
		  • Comparison of non-reactivity of aryl halides and vinyl halides with alkyl halides.
			• classifies alkyl halides as primary, secondary and tertiary.
			• relates the tendency of alkyl halides to undergo nucleophilic substitution reactions with the polar nature of the C – X bond.
			• recognizes that nuclephilies can act as bases.
			• explains the non reactivity of aryl halides and vinyl halides (halogens attached to sp^2 carbon atoms).
			• describes the prepration and the properties of Grignard reagent.
			• compares the polarity of C- Mg with that of C-X bond and recognizes that their polarities are reversed.
			• recognizes that due to polarization of C-Mg bond, the C attached to Mg in a Grignard reagent can act as the base as well as nucleophile.
				09

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Reaction of alkyl halides with magnesium (preparation of Grignard reagent) • The need for anhydrous conditions • Nature of the metal-carbon bond • Reactions of Grignard reagent with proton donors, • Water • Acids • Alcohols and phenols • Amines • Alkynes with acidic 'H' atoms	• writes the product obtained by the Grignard reagent with proton doners given in the syllabus.	
	8.7 Analyses the nucleophilic substitution reactions of alkylhalides in terms of the timing of bond making and bond breaking steps	• One step reaction (Bond making and bond breaking steps take place simultaneously. No reaction intermediates are formed.) • Two step reaction (Bond breaking step takes place first. A carbocation is formed as a reaction intermediate. In the second step nucleophile forms a bond with the carbocation)	• recognizes that there are two possible pathways for the nucleopilic substitution reactions of alkyl halides. • describes the nucleophlic substitution reaction of alkyl halides as a one step reaction when bond breaking and bond making take place simultaneously. • describes the nucleophilic substitution reaction of alkyl halides as a two step reaction when the formation of the new bond takes place after the breaking of the bond.	03

Unit 09: Oxygen containing organic compounds **Periods 45**

Competency	Competency level	Contents	Outcome	No. of Periods
9.0 Investigates the relationship between the structure and properties of oxygen containing organic compounds	9.1 Investigates the structure, polar nature of carbon-oxygen bond and oxygen-hydrogen bond and reactions of alcohols	• Classification of alcohols • Primary, secondary and tertiary • Physical properties • Boiling point • Solubility in water and common organic solvents • Reactions involving cleavage of O-H bond • Reaction with sodium (Acidic nature of hydrogen bonded to oxygen) • Reaction with carboxylic acid (Acylation of alcohols to give esters) • Nucleophilic substitution reactions involving cleavage of C-O bond • Reaction with • HBr and HI • PCl_3/ PBr_3 • PCl_5 • Reactions with $ZnCl_2$ and conc. HCl acid (Lucas test)(Explained by the relative stability of the carbocation formed by the cleavage of C-O bond) - Reaction of benzyl alcohol is not necessary	**student should be able to:-** • classifies alcohols as primary, secondary and tertiary. • describes the polar nature of the O- H bond and C- O bond. • relates the physical properties of alcohols with their ability to form hydrogen bonds. • recognizes that alcohols under go reactions in two different ways by clevage of C-H bond and cleveage of C-O bond. • explains nucleophilic substitution reactions of alcohols with HBr, HI, PCl_3/PBr_3, PCl_5 due to the cleavage of C - O bonds. • writes the product obtained by the reactions of alcohols with conc H_2SO_4,Al_2O_3 as dehydration. • relates the ease of formation of carbocation from alcohols in the prsecnce of acids to their primary, secondary and tertiary nature. • recognizes that primary, secondary and tertiary alchols behave differently when reacted with different oxidizing reagents.	08

Competency	Competency level	Contents	Outcomes	No.of Periods

		• Elimination reaction with concentrated sulphuric acid or Al_2O_3 (dehydration to give alkenes)
		• Oxidation with
		  • $H^+/KMnO_4$
		  • $H^+/K_2Cr_2O_7$
		  • Pyridiniumchlorochromate (primary alcohols to aldehydes and secondary alcohols to ketones)
		• ***Testing properties of alcohols***
			• Records the properties of alchols by examing them.	

	9.2 Analyses the reactions of phenol in terms of its carbon-oxygen bond and oxygen-hydrogen bond	• Structure of hydroxy benzene, the simplest phenol
		• Higher acidity of phenols compared to alcohols
		• Reactions of phenols with
		  • sodium metal
		  • sodium hydroxide
		• Non reactivity of phenols under conditions where alcohols undergo nucleophilic substitution reactions
		• ***Testing properties of phenol***
			• explains why phenols are more acidic than alcohols.
			• explains why phenols do not undergo nucleophilic substitution reactions undergone by alcohols.
			• States the reactions of alcohols with Na and Sodium hydroxides
			• Records the properties of phenol by using, simple tests.
				04

Competency	Competency level	Contents	Outcomes	No.of Periods
	9.3 Investigates the effect of the -OH group on the reactivity of the benzene ring in phenol	• Electrophilic substitution reactions • Bromination • Nitration	• recognizes that in the substitution reactions of phenol, the substituent gets attached to the ortho (2, 6) and para (4) positions relative to the –OH group. • explains why the aromatic ring of phenol is more reactive towards electrophiles than benzene itself.	02
	9.4 Investigates the polar nature and unsaturated nature of > C=O bond in aldehydes and ketones as exemplified by their reactions	• Nucleophilic addition reactions as characteristic reactions of aldehydes and ketones • Reaction with HCN and its mechanism • Reaction with Grignard reagent and its mechanism • Reaction with 2,4-dinitrophenyl hydrazine (2,4-DNP or Brady's reagent) (Explained as a nucleophilic addition followed by dehydration / Detailed mechanism is not necessary.) • Self-condensation reactions of aldehydes and ketones in the presence of sodium hydroxide	• explains the unsaturated nature of the carbonyl group. • explains nucleopihlic addition reactions as the characteristic reactions of aldehydes and ketones. • explains the mechanisum of nucleophlic addtion reactions of adhyde and ketones with Grignard reagents and HCN. • recognizes that the reaction of aldehyde and ketones with 2,4-Dinitrophenylhydrazine is representative of the reaction of NH_2, group with >C=O group. • shows the reactivity of carbonyl compounds containing α - H using suitable examples.	16

Competency	Competency level	Contents	Outcomes	No.of Periods

		• Reduction of aldehydes and ketones by $NaBH_4$ or $LiAlH_4$ followed by hydrolysis (Detailed mechanism and intermediate products are not necessary)
		• Reaction with Zn(Hg)/concentrated HCl (Clemmenson reduction of carbonyl group to methylene group)
		• Oxidation of aldehydes
		  • By ammonical silver nitrate (Tollens' reagent)
		  • By Fehling's solution
		  • By $H^+/KMnO_4$
		  • By $H^+/K_2Cr_2O_7$ (Compare with the non reactivity of ketones)
		• ***Tests for aldehydes and ketones***
			• recognizes that aldehydes and ketones are reduced to alcohols by hydride reducing agents.
			• recognizes that aldehydes are more easily oxidized than ketones.
			• Distingushes between aldehydes and ketones using relavent tests.	

Competency	Competency level	Contents	Outcomes	No.of Periods

	9.5Compares the structure and properties of carboxylic acids with the other oxygen containing organic compounds	• Physical properties -Importance of H-bonding
		  • Melting points/ Boiling points
		  • Solubility in water and common organic solvents (Presence of dimeric structures)
		• Comparison of the reactivity pattern of a -COOH group with >C=O group in aldehydes and ketones and -OH group in alcohols and phenols
		• Reaction involving cleavage of the O - H bond
		  • Acidic nature of H bonded to O in carboxylic acids
		  • Comparison of acidic properties of carboxylic acids with that of alcohols and phenol, based on the relative stability of their conjugate base
		• Reactions with
		  • Na
		  • NaOH
		  • $NaHCO_3$ /Na_2CO_3
		• Reactions involving cleavage of the C - O bond
		  • Reaction with PCl_3 or PCl_5
		  • Reaction with alcohol
		• Reduction of carboxylic acids with $LiAlH_4$
		• ***Testing the properties of carboxylic acids***
			• relates the physical properties of carboxylic acids to their structure.
			• recognizes that the carboxylic acids contain a carbonyl group (> C = O).
			• compares the acidic properties of carboxylic acids, alcohols and phenol using the reactions with Na, NaOH , Na_2CO_3 and $NaHCO_3$.
			• recognizes that when reacting with nucleophiles, corboxylic acids give substitution reactions while aldehydes and ketones give addition reactions.
			• Tests the properties and reactions of carboxylic acids.
				10

Competency	Competency level	Contents	Outcomes	No.of Periods

	9.6 Investigates the characteristic reactions of acid derivatives	• Acid chloride
		  • Reaction with aqueous sodium hydroxide and its mechanism
		  • Reactions with
		    • Water
		    • Ammonia
		    • Primary amines
		    • Alcohols
		    • Phenol
		• Esters
		  • Reaction with dilute mineral acids
		  • Reaction with aqueous sodium hydroxide
		  • Reaction with Grignard reagent
		  • Reduction by $LiAlH_4$
		• Amides
		  • Reaction with aqueous sodium hydroxide
		  • Reduction with $LiAlH_4$
			• recognizes that the characteristic reactions of the acid derivatives are nucleophilic substitution reactions.
			• writes examples for the characteristic reactions of acid chlorides.
			• writes examples for the characteristic reactions of esters.
			• writes examples for the characteristic reactions of amides.
			• recognizes that all the reactions of acid derivatives involve and attack by a nucleophilie on the carbonyl carbon
			• writes the mechanism for the reaction between acid chloride and sodium hydroxide.
				06

3.2 Grade 13

Unit 10: Nitrogen containing organic compounds **Periods 14**

Competency	Competency level	Contents	Outcome	No. of Periods

10. Investigates the relationship between structure and properties of nitrogen containing organic compounds	10.1 Analyses amines and aniline in terms of their characteristic reactions and properties	• Types of amines
		  • Aliphatic and aromatic amines
		    • Primary amines
		    • Secondary amines
		    • Tertiary amines
		  • Aniline as an aromatic amine
		    • Reaction of aniline with bromine
		• Reactions of primary amines (only)
		  • with alkyl halides
		  • with aldehydes and ketones
		  • with acid chlorides
		  • with nitrous acid
			student should be able to:-
			• classifies the types of amines as primary, secondary and tertiary.
			• writes the reactions of primary amine with the reagents given in the syllabus.
			• applies the knowledge of given reactions in conversions relate to amine and other functional groups given in the syllabus.
			• explains the higher reactivity of aniline when compared to benzene towards electrophilic substitution.
			• writes the reactions of aniline with bromine.
				08

	10.2 Compares and contrasts the basicity of amines with other organic compounds	• Basicity of amines compared to alcohols • Comparison of the basicity of primary aliphatic amines with that of aniline • Basicity of amines compared to amides	• compares the basicity of primary amines with that of alcohols, aniline and primary amides in terms of the relative. availability of lone pair of electrons on N atom.	02

Competency	Competency level	Contents	Outcomes	No.of Periods

	10.3 Investigates the reactions of diazonium salts	• Reactions in which the diazonium group is replaced by an atom or another group
		  • Reactions with
		    • water
		    • hypophosphorous acid
		    • CuCl
		    • CuCN
		    • CuBr
		    • KI
		• Reactions in which the diazonium ion acts as an electrophile
		  • Coupling reaction with phenol
		  • Coupling reaction with 2 – naphthol
			• describes the preparation of diazoniaum salt.
			• writes down the reactions of diazonium salts with water, H_3PO_2, CuCl, CuCN, CuBr and KI.
			• recognizes that the $N \equiv N^+$ group can be easily replaced by various other groups as N_2 is a good leaving group.
			• recognizes that the $N \equiv N^+$ group can act as electrophile.
			• tests for aniline using diazonium salt and records observations.
				04

Competency	Competency level	Contents	Outcome	No. of Periods

11.0 Uses the principles of chemical kinetics in determining the rate of a chemical reaction and in controlling the rate of reactions	11.1 Introduces reaction rate and determines the factors affecting the rate of chemical reactions	• Rate of a reaction
		• Rate in terms of concentration
		$aA + bB \rightarrow cC + dD$
		• Rate of reaction with respect to reactant A
		$-\left(\frac{\Delta C_A}{\Delta t}\right)$
		• Rate of reaction with respect to product
		$= \left(\frac{\Delta C_D}{\Delta t}\right)$
		• Factors affecting the rate of chemical reactions
		  • Temperature
		  • Concentration /pressure
		  • Physical nature (surface area of reactants)
		  • Catalysts
			Student should be able to:
			• provides examples for chemical reactions taking place at various rates and compares the rates of different reactions.
			• states the factors affecting the rate of a reaction - temperature, concentration, pressure, physical nature (surface area of reactants), catalysts.
			• generalizes a chemical reaction as $aA + bB \rightarrow cC + dD$
			• states that the change in the concentration of a substance is the fundamental factor in measuring the rate of a reaction.
			• defines rate of reaction as rate with respect to the change of concentration of the reactant A $-\left(\frac{\Delta C_A}{\Delta t}\right)$ or rate with respect to the change of concentration of the product D $\left(\frac{\Delta C_D}{\Delta t}\right)$
				06

Competency	Competency level	Contents	Outcomes	No.of Periods
			• expresses that in a given reaction, the rate of removal of each reactant and rate of formation of each product are not equal. • states that the rate of removal of a reactant or formation of a product depends on the stoichiometric coefficients of the respective substances. • states accordingly that the generalized rate of a reaction $= -\frac{1}{a}\left(\frac{\Delta C_A}{\Delta t}\right) = \frac{1}{d}\left(\frac{\Delta C_D}{\Delta t}\right)$ • states that for any type of change, rate is the change of concentration per unit time. • illustrates with examples that time taken for a given constant change can be used in rate measurements (rate α 1/t) • expresses that properties (colour intensity, turbidity etc.) which depend on the amount of a substance or concentration can also be used to compare rates. • provides examples for slow reactions where time can be easily measured for the determination of rates.	

Competency	Competency level	Contents	Outcomes	No.of Periods

	11.2 Uses molecular kinetic theory to explain the effect of factors affecting the rate of chemical reactions	• Energy diagram for a single step reaction
		  • Activation energy
		• Requirements to be satisfied by reactant molecules for the occurrence of a reaction
		  • Collision of molecules
		  • An appropriate orientation
		  • Surmounting the activation energy
		• Effect of temperature on reaction rate
			• draws energy diagrams for a single step reactions .
			• defines the term activation energy.
			• lists the requirements essential for a reaction to occur.
			• states that when temperature increases kinetic energy of molecules is also increased.
			• draws the simplified form of Boltzmann distribution curve for gaseous molecules at two different temperatures and compares the kinetic energy of molecules at different temperatures.
			• explains the increase in rate of a reaction with temperature in terms of the increase of kinetic energy of molecules and thereby the number of collisions.
			• explains the increase of the number of collisions per unit volume per unit time using the concept of concentration.
			• states that collisions having appropriate orientation is proportional to the total number of collisions.
				06

Competency	Competency level	Contents	Outcomes	No.of Periods
	11.3 Controls the rate of a reaction by appropriately manipulating the concentration of reactants.	• Ways of express the rate of reaction • Initial rate • Instantaneous rate • Average rate • Effect of concentration on reaction rate • Rate law, order with respect to components, order of a reaction (overall order) • Rate constant • Classification of reactions based on order (zeroth order, first order and second order only) • Half life for a first order reaction and its graphical representation (Equation is not required) • Methods to determine the order of a reaction and rate constant • Initial rate method • ***Experimental determination of the effect of acid concentration on the reaction rate between Mg and acids reaction***	• displays initial rate, instantaneous rate and average rate of a reaction using suitable graphs. • explains how the order of the reaction with respect to a given reactant and concentration of that reactant affects the rate of the reaction. • defines the rate law for reactions as, rate = $k [A]^x [B]^y$. • defines the terms in the rate law. • writes the rate law (equation) for zeroth, first and second order reactions. • derives the units of the rate constant (coherent SI units and non-coherent SI units) for zeroth, first and second order reactions. • interprets the overall order of a reaction. • demonstrates graphically how the rate changes with concentration for a zero order, first order and second order reaction. • defines and interprets half-life of a reaction.	16

Competency	Competency level	Contents	Outcomes	No.of Periods
		• ***Experimental determination of the effect of concentration on the reaction rate between $Na_2S_2O_3$ and HNO_3 reaction***	• explains that half life of first order reactions does not depend on the initial concentration. • provides examples for reactions of different orders. • conducts experiments to illustrate zeroth order, first order and second order reactions. • determines order of reactions with respect to various reactants by handling appropriately the information obtained from experiments. • solves problems related to rate law and order of reactions.	
	11.4 Investigates the effect of physical nature and catalysts on reaction rate	• Explanations of physical nature and catalysts on reaction rate	• states that when surface area of a solid reactant increases rate of reaction also increases due to the increase of number of collisions. • describes the effect of catalyst in terms of the activation energy for the reaction.	02

Competency	Competency level	Contents	Outcomes	No.of Periods

	11.5 Uses reaction mechanisms to describe the rate of chemical reactions.	• Elementary reactions
		• Multistep reactions
		  • Energy diagrams
		  • Transition state and intermediates
		• Rate determining step and its effect on the rate of overall reaction
		• ***Experimental determination of the order of reaction with respect to Fe^{3+} for the reaction between Fe^{3+} and I^-***
			• distinguishes elementary reactions from multistep reactions.
			• explains the relationship between the mechanism of a reaction and the order of a reaction.
			• draws energy profiles.
			• writes the intermediates and transitions states of the energy diagram.
			• explains the molecularity and the order of the elementary and multistep reactions.
			• constructs energy profiles for reactions to explain the events that follow collisions using basic principles of energetics.
			• explains the effect of concentration of iron(III) ions on the reaction rate of the reaction between Fe^{3+} and I^-
			• explains the relationship between the mechanism of a reaction and the order of a reaction.
			• determines the rate determining step and reaction mechanisms using energy profiles.
				11

Unit 12: Equilibrium **Periods 94**

Competency	Competency level	Contents	Outcome	No. of Periods

12.0 Uses the concept of equilibrium and its principles to determine the macroscopic properties of closed systems in dynamic equilibrium	12.1 Quantitatively determines the macroscopic properties of systems with the help of the concept of equilibrium	• Systems in equilibrium (dynamic processes and reversibility)
		• Systems in equilibrium (heterogeneous and homogeneous)
		  • Chemical
		  • Ionic
		  • Solubility
		  • Phase
		  • Electrode
		• Equilibrium law
		  • Equilibrium constant
		• Chemical equilibrium
		  • K_p K_c and Q
		  • $K_p = K_c(RT)^{\Delta n}$
		• Equilibrium point
		  • Factors affecting the equilibrium point
		  • Le - Chatelier Principle
		• ***Experimental study of the characteristics of a dynamic equilibrium system using Fe^{3+} /SCN^- system.***
			Student should be able to:
			• explains the dynamic equilibrium using the reversible reactions in closed systems.
			• states macroscopic properties of a system remains unchanged after reaching the equilibrium.
			• uses physical and chemical processes such as changes of state, equilibria in solutions, chemical systems, ionic systems, sparingly soluble systems and electrodes as examples to describe the systems in equilibrium.
			• states the equilibrium law.
			• writes the equilibrium constants (K_c, K_p) for the homogeneous and heterogeneous systems given.
			• defines Q.
			• compares Q and K.
			• states that the equilibrium constant of a system remains unchange with the constart temperature.
			• derives the relationship between K_p and K_c.
			• explains the equilibrium point.
			.• describs how concentration pressure, temperature and catalysts affect the equilibrium point.
				19

Competency	Competency level	Contents	Outcomes	No.of Periods
		• ***Experimental study of the effect of temperature on the equilibrium system of NO_2 and N_2O_4.***	• states the Le Chatelier Principle . • predicts the effect of Le Chatelier Principle on equlibrium system, which disturbed by an external effect of concentration, pressure and temperature. • solves problems based on K_p , K_c. and $K_p=K_c(RT)^{\Delta n}$ • examines the effect of concentration on the equilibrium system Fe^{3+}/ SCN^-. • examines the effect of pressure on the equilibrium system NO_2/N_2O_4.	

	12.2 Quantifies properties of ionic equilibrium systems related to weak acids, weak bases, acidic salts and basic salts	• Acids, bases and salts
		  • Theories of acids and bases
		  • Conjugate acids and bases
		• Dissociation constants K_w, K_a, K_b
		• Ostwald law of dilution
		• pH value
		• Calculation of the pH value of acids (monobasic), bases (monoacidic)
		• Calculation of the pH values of salts
		• Acid – base titrations
		  • Simple calculations based on titrations
		  • Titration curves
			• describes Arrhenius theory, Bronsted-Lowry theory and Lewis theory giving appropriate examples.
			• categorizes acid, bases as weak and strong.
			• explains conjugate acids and bases with example.
			• writes expression for K_w by considering self ionization of water.
			• gives expressions for K_a and K_b.
			• derives equations for K_a and K_b and the law of dilution.
			.• derives the relationship between K_a and K_b of conjugate acid-base pairs.
				26

Competency	Competency level	Contents	Outcomes	No.of Periods
		• Theory of indicators • Determination of the equivalence point (visual methods -using indicators only) • Selection of suitable indicators for titrations based on pK_{In} values • ***Experimental determination of the acidic/basic/neutral nature of aqueous solutions of salts by testing pH*** • ***Titration between Na_2CO_3 and HCl using phenolphthalein and methyl orange***	• solves problems using K_w, K_a and K_b. • defines *pH*. • clarifies the hydrolysis of salts. • calculates *pH* of aqueous solutions of acids and bases. • calculates *pH* values of salt solutions considering hydrolysis of cations and anions. • solves problems using titrations. • states that *p*H indicators are either weak acids or weak bases. • expresses that indicators exhibit different colours for their unionized and ionized forms. • states that *pH* range (colour change interval) of an indicator depends on the value of dissociation constant of the indicator (K_{In}). • points out that the selection of an indicator depends on its pK_{In} value which corresponds to the equivalence point *pH* of the titration or *pH* range in which abrupt *pH* change occurs. • applies theory of indicators to choose the correct indicator for a particular titration. • calculates the *pH* value of acid/ base reactions at the equivalence point.	

Competency	Competency level	Contents	Outcomes	No.of Periods
			• sketches the titration curves for different types of acid base titrations. • states that near the equivalence point an abrupt *pH* change occurs for a small volume of the solution added. • discusses qualitatively the main features of the titration curve between Na_2CO_3 and HCl. • determines experimentally, the acidic/basic/ neutral nature of aqueous solutions of salts by testing *pH*. • titrates between Na_2CO_3 and HCl using phenolphthalein and methyl orange.	
	12.3 Prepares buffer solutions according to the requirements	• Buffer solutions (qualitatively and quantitatively) • Derivation of Henderson equation and its applications (monobasic and monoacidic systems only; calculations involving quadratic equations are not required.) • *pH* of a buffer system	• define a buffer solution. • investigates buffer solutions qualitatively and quantitatively. • derives Henderson equation for monobasic and monoacidic buffer systems. • uses Henderson equation for simple calculations. • explains *pH* of a buffer system qualitatively and quantitatively.	12

Competency	Competency level	Contents	Outcomes	No.of Periods

	12.4 Quantifies properties of equilibrium systems related to sparingly soluble ionic compounds (Heterogeneous ionic equilibria)	• Solubility product and ionic product (K_{sp})
		  • Precipitation
		  • Solubility
		  • Common ion effect
		• Application in qualitative analysis of cations (group analysis)
		• ***Experimental determination of the solubility product of $Ca(OH)_2$***
			• states that some ionic compounds are very soluble in water but some are less soluble.
			.• applies the principle of equilibrium for a sparingly soluble electrolyte, *Ksp*.
			• states requirements for precipitation of ionic compound from the aqueous solution.
			• solves the problems related to *Ksp* of a springly soluble electrolyte.
			• applies common ion effect .
			• identifies the cations by precipitation and subsequent solubility of the precipitate in different reagents.
			• explains the solubility of the precipitate based on solubility product principle.
			• divides the cations listed into five groups, based on the solubility products of the ionic compounds of the cations under different conditions.
			• determines the not Halic Ksp of $Ca(OH)_2$ experiemtaly
				12

Competency	Competency level	Contents	Outcomes	No.of Periods

	12.5 Investigates how liquid - vapour equilibrium varies in single component systems. (Phase equilibria)	• Pure liquid systems
		  • Equilibrium between liquid and vapour
		  • Describing equilibrium in a liquid-vapour system in terms of molecular motion
		  • Saturated vapour pressure and boiling point
		  • Variation of vapour pressure of water and other liquids with temperature
		  • Critical temperature
		  • Phase diagram of single xomponent system.
		    • Phase diagram of water
		    • Triple point
		• Vapour pressure and boiling point
			• states a phase, giving suitable examples.
			• identifies pure liquid systems.
			• explains liquid-vapour equilibrium on the basis of molecular motion.
			• defines the saturated vapour pressure.
			• defines the boiling temperature.
			• explains the variation of vapour pressure of liquids with temperature.
			• identifies the relationship between the vapour pressure and the boiling point.
			• defines the critical temperature
			• names the triple point of water uing the phase diagram.
				04

Competency	Competency level	Contents	Outcomes	No.of Periods

	12.6 Investigates the variation of liquid - vapour equilibrium in binary liquid systems	• Liquid - Liquid systems
		  • Totally miscible liquid - liquid systems
		• Raoult law
		• Ideal solutions
		• Non- ideal solutions
		• Phase diagrams for totally miscible liquid systems excluding azeotropes
		  • Vapour pressure – composition variation graphs
		• Temperature – composition phase diagrams and fractional distillation
			• classifies the liquid - liquid systems as totally miscible, partially miscible and totally immiscible by given examples.
			• applies the principles of equilibrium and chemical kinetics to a binary liquid system to derive Raoult law.
			• defines an ideal solution.
			• explains how and why non-ideal solutions deviate from Raoult law, using graphs between composition and vapour pressure.
			• applies Raoult law to find liquid and vapour phase compositions at equilibrium.
			• describes ideal and non-ideal behaviours of binary systems.
			• states that simple distillation can be used to separate non volatile components in a volatile liquid.
			• gives examples for a simple distillation and fractional distillation.
			• states that fractional distillation can be used to separate volatile components in a volatile liquid mixture.
				12

Competency	Competency level	Contents	Outcomes	No.of Periods
	12.7 Investigates the distribution of substances between two immiscible liquid systems	• Totally immiscible liquid- liquid systems • Partition coefficient • ***Experimental determination of distribution coefficient of ethanoic acid between water and 2 -butanol***	• gives examples for totally immiscible liquids CCl_4 / H_2O, $CHCl_3 / H_2O$, C_6H_6 / H_2O • explain the partition coefficient K_D. • states the requirements to apply the Nernst distribution law. • solves problems using K_D. • determines experimentally, the distribution coefficient of ethanoic acid between water and 2- butanol.	09

Unit 13 :Electrochemistry **Periods 33**

Competency	Competency level	Contents	Outcome	No. of Periods

13.0 Investigates the importance of electrochemical systems.	13.1Uses conductivity to understand the nature of solutes and their concentration in an aqueous solution.	• Tupes of electrolytes
		• Conductance (1/R)
		• Conductivity (as reciprocal of resistivity)
		$k = \frac{l}{AR}$
		• Factors affecting conductivity
		  • Nature of solute: Aqueous solutions of strong, weak and non electrolytes, molten electrolytes.
		  • Concentration
		  • Temperature
			Student should be able to:
			• states the terms strong electrolyte,weak electrolyte and non electrolyte.
			• states examples for strong electrolyte, weak electrolyte and non electrolyte in an aqueous medium.
			• compares electrical conductors and ionic conductors in terms of current carrying entities
			.• expresses that the electrode reactions at both electrodes are necessary to pass a current through an electrolyte
			• defines the terms resistance and resistivity.
			• defines the terms conductance and conductivity.
			• states the factors that affect the conductivity of an electrolyte solution.
				04

Competency	Competency level	Contents	Outcome	No. of Periods
	13.2 Investigates electrodes in equilibrium and electrode reactions related to them	• Reversible electrodes in equilibrium and electrode reactions • Metal - metal ions • Metal - insoluble salts • Gas electrodes (O_2, H_2, Cl_2) • Redox electrodes eg. - $Pt(s) \mid Fe^{3+}(aq), Fe^{2+}(aq)$	• sketches metal- metal ions electrode. • writes the reversible electrode reactions for common metal-metal ion electrodes by giving examples • describes the existence of a potential difference between an electrode and its solution at the electrode/electrolyte interface. • illustrates different types of electrodes (gas electrodes, metal- metal ion electrodes, metal-insoluble salt, redox electrodes). • writes the reversible electrode reactions for different types of electrodes. • defines the standard electrode. • denotes electrodes using the standard notation.	06

Competency	Competency level	Contents	Outcomes	No.of Periods

	13.3 Determines the properties of electrochemical cells.	• Liquid junction
		  • Salt bridge
		  • Separator
		• Cells without a liquid junction
		• Electro chemical cells
		  • Cell reactions
		  • Electromotive force of a cell
		• Electrode potential (E)
		• Standard electrode potential (E°)
		$E^\circ_{cell} = E^\circ_{(Cathode)} - E^\circ_{(Anode)}$
		(Nernst equation is not required)
		• Different types of practical cells
		  • Daniel cell
		• Electrochemical series
		  • Properties of elements in relation to their position in the series
		  • Relationship between position of metals in the electrochemical series and their occurrence and extraction
		• ***Experimental determination of the relative position of commonly available metals in the electrochemical series.***
			• states the use of liquid junction, salt bridge/ separator.
			• gives examples for a cell without a liquid junction.
			• describes the term electrode potential of an electrode.
			• introduces the standard hydrogen electrode as a reference electrode.
			• defines the standard electrode potential of an electrode.
			• explains how to measure the standard electrode potential of an electrode.
			• states the factors affecting the electrode potential.
			• states the silver-silver chloride and calomel electrode as a practical reference electrodes.
			• gives examples for electrochemical cells with diagrammatical representation
			.• presents the conventional notation of an electrochemical cell with standard rules.
				15

Competency	Competency level	Contents	Outcomes	No.of Periods
		• ***Preparation of standard* Ag(s), AgCl(s)/Cl^-(aq)*electrode.***	• writes the electrode reactions in a simple electrochemical cell. • defines the term electromotive force. • solves simple problems related to electromotive force. • describes the factors affecting electromotive force. • names the cells uses in daily life.(Leclanche cell, Lead accumulator) • draws the diagram of Daniel cell • constructs the electrochemical series using the standard electrode potentials. • describes relationships between the position of metals in the electrochemical series and their existence, method of extraction and chemical properties. • determines the relative position of commonly available metals in the electrochemical series experimentally. • prepares the standard Ag(s),AgCl(s)/Cl^-(aq) electrode in the laboratory	

Competency	Competency level	Contents	Outcomes	No.of Periods
	13.4 Identifies the requirements to be fulfilled in the process of electrolysis and carries out related calculations using Faraday constant.	• Principles of electrolysis • Electrolysis of water • Electrolysis of aqueous $CuSO_4$/ $CuCl_2$ using copper electrodes • Electrolysis of aqueous $CuSO_4$ using platinum electrodes • Electrolysis of aqueous NaCl/ Na_2SO_4 using carbon electrodes • Electrolysis of molten NaCl (principle only) • Application of Faraday constant to electrochemical calculations	• defines electrolysis. • describes principles of electrolysis. • predicts the products of simple electrolytic systems . • solves simple problems based on Faraday constant.	08

Unit 14: Industrial chemistry and Environmental pollution **Periods 65**

Competency	Competency level	Contents	Outcome	No. of Periods

14.0 Investigates the selected chemical industries to understand the applications of principles and identify industrial pollutants.	14.1 Investigates the production and uses of elements and compounds of s block	• Basic factors to be considered for designing a chemical industry
		• Selection of raw materials
		• Production of
		  • magnesium from bittern solution (Dow process)
		  • NaOH (membrane cell method)
		  • soap
		  • Na_2CO_3 - Solvay process
		• ***Preparation of a soap sample in the laboratory***
			Student should be able to
			• listsout the factors to be considered for designing a chemical industry.
			• describes factors to be considered to select natural raw materials for an industry.
			• describes physico-chemical principles involved in the production of Mg, NaOH, Na_2CO_3 and their uses.
			• prepares a soap sample in the laboratory and describes how to improve the quality of the product.
				11

	14.2 Investigates the production and uses of the compounds and elements of p block elements	• Production and uses of
		  • Ammonia (Haber process)
		  • Nitric acid (Ostwald process)
		  • Sulphuric acid (Contact process)
			• describes the physico- chemical principles involved in the production of ammonia, nirtic acid sulphuric acid and identifies their uses.	08

Competency	Competency level	Contents	Outcomes	No.of Periods
	14.3 Investigates production and uses of d-block elements and their compounds	• Production and uses of titanium dioxide from rutile (chloride process). • Production and uses of iron using blast furnance	• describes production and physico-chemical principles used in the production of titanium dioxide. • describes the uses of TiO_2 • describes physico-chemical principles used in extraction of iron by blast furnance method.	04

	14.4 Investigates the chemistry of polymeric substances	• Addition and condensation polymers and polymerization processes
		  • Polythene, Polyvinyl chloride (PVC),polystyrene, teflon
		  • Polyesters and nylon
		  • Bakelite
		  • Plastic additives
		  • Natural polymers
		• Structure, properties and uses of natural rubber (NR)
		  • Coagulation of rubber latex and prevention of coagulation
		  • NR vulcanization
			• introduces polymers, monomers and repeating unit.
			• classifies polymers as natural and synthetic with examples.
			• classifies polymers according to the type of the polymerization reaction as addition and condensation.
			• identifies the structures (monomer, polymer and repeating unit), properties and uses for given polymers.
			• describes the types of plastic additives and their effects on the environment.
			• describes structure, properties and uses of natural rubber.
			• describes the process of vulcanization of rubber.
			• explains the process of coagulation of rubber and prevention of coagulation
				08

Competency	Competency level	Contents	Outcomes	No.of Periods
	14.5 Investigates some chemical industries based on plant materials	• Some plant based industries - ethanol, vinegar, biodiesel • Extraction and separation of compounds from plants by steam distillation (essential oils)(structural formulae of specific compounds will not be tested) • Uses of ethanol, vinegar essential oils and biodieseal • ***Extracting cinnamon oil from cinnamon leaves by steam distillation*** • ***Preparation of and biodiesel*** • ***Determination of the percentage of acetic acid in vinegar***	• describes plants as a renewable raw material. • writes the equations for the reactions of formation of ethanol and vinegar from glucose. • describes the production of biodiesel. • describes essential oils as complex mixtures of volatile constituents of plants. • explains the principles of steam distillation used to extract essential oils. • states the uses of ethanol, vinegar, essential oils and biodiesel • extracts cinnamon oil from cinnamon leaves in the laboratory. • prepares a sample biodiesel in the laboratory. • calculates the percentage of acetic acid in vinegar sample in the laboratory.	12

Competency	Competency level	Contents	Outcomes	No.of Periods
	14.6 Chemistry of the air pollution by industrial emissions.	• Air quality parameters ($COx, NOx, SOx, CxHy$, particulars matter in air) • Acid rains • Photo- chemical smog • Ozone layer depletion • Global warming	• names air quality parameters such as $COx, NOx, SOx, CxHy$, particulars matter in air • explains the chemistry of acid rains and their effect on the environment. • explains the chemistry of photo chemical smog and their effect on the environment. • explains the ozone layer depletion and their effect on the environment. • explains the chemistry of greenhouse effect, global warming and their effect on the environment. • describes precautionary measures that can minimize air pollution.	07

Competency	Competency level	Contents	Outcomes	No.of Periods
	14.7 Chemistry of water pollution by industrial discharges	• Water quality parameters (pH, temperature conductivity, turbibity, hardness, dissolved oxygen *(DO),* chemical oxygen demand *(COD),* of water. • Eutrophication by NO_3^- and PO_4^{3-} mainly caused by excessive use of fertilizers • Dissolved organic compounds effluent from industries (e.g. latex industry) • Heavy metal ions (Cd, As, Pb, Hg) • Chemical oxygen demand (COD) and dissolved oxygen(DO) • Thermal pollution • Acidity /Basicity • Turbidity and hardness of water • ***Determination of dissolved oxygen level in water by Winkler method***	• names water quality parameters such as pH, temperature, conductivity, turbidity, hardness, dissolved oxygen *(DO),* chemical oxygen demand *(COD)* of water. • records physical parameters such as pH, temperature conductivity, turbidity, hardness of water for given polluted water sample. • describes eutrophication and its consequences caused by NO_3^- and PO_4^{3-}. • describes the consequences of dissolved organic pollutants. • explains the common heavy metals causing water pollution and their effect on the environment. • explains how to identify water pollution using chemical parameters such as *DO* and *COD.* • explains water pollution using physical parameters such as acidity/basicity, thermal pollution, turbidity and hardness of water. • describes the precautional measures that can be taken to minimize pollution by industrial discharge. • determines experimentally the dissolved oxygen level in (fresh) water.	15

4.0 Teaching - Learning Strategies

Global trend in present day education is to introduce competency based curricula which promote collaborative learning through student-centred activities where learning predominates over teaching. It is intended for the students to actively participate in activities which enhance the development of individual, social and mental skills. Emphasis is laid on the following aspects.

- Recommend to teach the subject content with relevant activities as mush as possible.
- Allow the students to acquire hands on experience.
- Direct students to acquire knowledge and information through reliable sources wherever necessary.
- Subject content should be introduced in relation with theiir day-to-day life.
- Show the possible future avenues that opens for carrier opportunities in learning chemistry.

5.0 School policy and programmes

- The teacher has the liberty to follow any suitable teaching learning method to achieve the relevant learning outcomes.
- It is expected that the theoretical components of each unit will be dealt with the relevant practical components, **which are given in italics**.
- Capacity of students should be enhanced through extra-curricular activities, extensive use of supplementary reading materials and learning teaching aids such as Computer Assisted Learning (CAL) software.
- With a view to extending learning beyond the classroom activities and to highlight the students' special abilities, it is expectedto involve students in co-curricular activities such as;
    - setting up school societies or clubs to pursue various aspects of chemistry
    - field trips to places where applications of chemistry can be observed and preparation of reports subsequently
    - organizing school exhibitions and competitions
    - organizing guest lectures on relevant topics by resource persons
    - producing school publications
    - organizing events such as debates, science days, etc.
    - directing them to internationally recognized examinations
- Shool management is responsible in providing services such as lab equipments, computer facilities, etc. and assistance within the school and from outside resources.
- In order to develop school policy and programmes it would be desirable to form a committee comprising relevant teachers and students.
- Most importantly, the school should serve as a role model to be followed by the students.
- School will develop its annual programmes, consisting of a variety of activities for achieving policy goals. In determiningthe activities to be undertaken during a particular year, the school will need to identify priorities and consider feasibility inrelation to time and resource constraints.

6.0 Assessment and Evaluation

Assessment and Evaluation should conform to the standards set by the Department of Examinations. However, school-based assessment should also be part and parcel as it paves way to give direct feedback to learners.