

General Certificate of Education
(advanced level)

Chemistry

Syllabus (Revisited)

For G.C.E.(A/L) Examinations to be held in 2012 and onwards



**Department of Science, Health and Physical Education
Faculty of Science and Technology
National Institute of Education**

1.0 Introduction

This syllabus has 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 (AL) in various other spheres.

The syllabus comprises 16 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 practical 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 the result of revisiting the syllabus implemented in 2009. It is effective for the G.C.E.(A/L) Examination from 2012 onwards. The following changes to the syllabus implemented in 2009 have been made.

- The number of periods was reduced from 600 to 468.
- Unit 1 was divided into two units.
- The content of Unit 3 was reduced and rearranged.
- Unit 3 was renamed as Gaseous State of Matter.
- Quantitative analysis of cations and anions was shifted from Unit 14 to Unit 5. In addition to the listed mono-dentate ligands OH^- ion was added and a practical on the reaction of salicylic acid with iron(III) ions was introduced.
- Acylation of benzene was introduced to Unit 7.
- Reaction of esters with Grignard reagents and LiAlH_4 and the reaction of amides with LiAlH_4 were introduced.

- The contents given under competency levels 11.1 and 11.6 were removed from Unit 11.
- Some contents were removed from Unit 12 and rearranged.
- Six practical activities and some contents were removed from Unit 13.
- Some selected contents from Unit 14 were shifted to the other units and the rest was omitted from the syllabus.
- Some selected industries were removed from Unit 15 and competency level 15.5 was rewritten.
- Some selected contents were omitted from Unit 16 and the number of competency levels was reduced from 7 to 4.

2.0 Aims

At the end of this course students 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 if topics and allocated number of periods

	Topic	Number of periods
Unit 01	Atomic Structure	29
Unit 02	Structure and Bonding	26
Unit 03	Chemical calculations	15
Unit 4	Gaseous state of matter	18
Unit 05	Energetics	26
Unit 06	Chemistry of <i>s</i> , <i>p</i> and <i>d</i> block elements	69
Unit 07	Basic concepts of organic chemistry	17
Unit 08	Hydrocarbons	26
Unit 09	Alkyl halides	12
Unit 10	Oxygen containing organic compounds	35
Unit 11	Nitrogen containing organic compounds	15
Unit 12	Chemical kinetics	27
Unit 13	Equilibrium	62
Unit 14	Electrochemistry	26
Unit 15	Chemistry and industry	41
Unit 16	Environmental Chemistry	24
Total		= 468

Proposed term-wise breakdown of the syllabus

Grade	Term	Competency Levels
Grade 12	First Term	From 1.1 to 4.5 (16 Competency levels)
	Second Term	From 5.1 to 6.9 (13 Competency levels)
	Third Term	From 7.1 to 10.7 (18 Competency levels)
Grade 13	First Term	From 11.1 to 13.4 (11 Competency levels)
	Second Term	From 13.5 to 15.4 (12 Competency levels)
	Third Term	From 15.5 to 16.4 (06 Competency levels)

3.0 Syllabus

3.1 Grade 12

Unit 01: Atomic Structure

Periods 29

Competency	Competency Level	Content	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.	- Revisit the atom and subatomic particles - Rutherford's nuclear model - Bohr model - Relative atomic mass and Isotopes - Introduction to radio activity - Properties of α, β and γ radiations <i>Testing properties of cathode rays</i>	06
	1.2 Investigates the different types of electromagnetic radiation.	- Electromagnetic radiation - Properties [velocity (c), wavelength (λ), frequency (ν), energy (E)] $c = \nu \lambda$ $E = h \nu$ - Electromagnetic spectrum - Properties of radiation belonging to different ranges of the electromagnetic spectrum and their applications <i>Observing the components of the visible range</i>	03
	1.3 Analyses evidence for electronic energy levels of atoms.	- Variation of successive ionization energies of elements - Hydrogen spectrum - Explanation of hydrogen spectrum using Bohr theory s, p, d and f sub energy levels - Wave- particle nature of electrons - Shapes of orbitals (s and p only) - Quantization of energy - Brief introduction to four quantum numbers - The principal quantum number (n) - Azimuthal quantum number (l)	08

		- The magnetic quantum number (m_l) - The spin quantum number (m_s) (Specification of all 4 quantum numbers for a given electron will not be tested)	
	1.4 Analyses 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 pattern of electrons - Hund's rule - Pauli exclusion principle - Aufbau principle - Ground state electronic configurations of isolated gaseous atoms of elements of atomic numbers from 1 to 38 and their ions - Stable electronic configurations of sub energy levels (s^1, s^2, p^3, p^6, d^5 and d^{10} only) - Explaining the variation of successive ionization energies and first ionization energies of elements	04
	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 - Formation of cations and anions - Reducing ability/ oxidizing ability - Electronegativity (Pauling scale) - Oxidation states - Ionization energy - Electron affinity - Atomic radius; shielding effect (Qualitative discussion only) - Covalent radius - van der Waals' radius - Metallic radius - Ionic radius	08

Unit 02: Structure and Bonding**Periods 26**

Competency	Competency Level	Content	No. of Periods
2.0 Relates bonding and structure to properties of matter.	2.1 Analyses the primary interactions of polyatomic systems as a means of determining the structure and properties of matter.	• Formation of chemical bonds • Electronegativity differences to determine bond type • Primary interactions • Covalent bonding • Non- polar covalent bonding (eg - H_2, Cl_2, O_2, N_2) • Polar covalent bonding (eg - HCl, H_2O, NH_3) • Co- ordinate (Dative covalent) bonding (eg - H_3O^+, NH_4^+, $NH_3 \cdot BF_3$) • Ionic bonding • Covalent character of ionic bonds – polarizing power of cations and polarizability of anions • Metallic bonding	06
	2.2 Analyses the shapes of covalent and polar covalent molecules and simple ion groups.	• Determining the structure of molecules and ions • Lewis structures • Valence shell electron pair repulsion (VSEPR) theory • Predicting the shape of molecules/ions using Lewis structure and VSEPR theory (central atom surrounded by the maximum of six pairs of electrons only) • Geometrical shapes • Linear • Trigonal planar • Tetrahedral • Trigonal pyramidal • Angular • Trigonal bipyramid • Distorted tetrahedral (See saw shape) • T-shape • Octahedral	10

		• Square pyramid • Square planar • Hybridization (sp, sp^2 and sp^3 only, excluding compounds containing unpaired electrons) • Resonance of selected molecules and ions (O_3, N_2O, CO_2, CO_3^{2-}, NO_3^-, NO_2^- and similar simple molecules and ions) • Nature of bonds in molecules/ions (σ and π bonds) • <i>Understanding the shapes by making models</i>	
	2.3 Analyses the secondary interactions existing in various systems as a means of determining the structure and properties of matter.	• Polarity and dipole moment • Polarizability • Secondary interactions (van der Waals interactions) • Hydrogen bonding • Dipole - dipole interactions • Ion - dipole interactions • Ion - induced dipole interactions • Dipole - induced dipole interactions • Dispersion interactions (London forces) (All are to be considered qualitatively only)	06
	2.4 Analyses how the structure of the solid state of substances relates to their physical properties.	• Relating physical properties of substances to their solid state structure • Melting point • Electrical conductivity • Thermal conductivity • Hardness • Different types of lattices • Homoatomic (Diamond, Graphite) • Heteroatomic (SiO_2) • Non - polar molecular lattices (I_2) • Polar molecular lattices (Ice) • Ionic lattices (NaCl) • Metallic lattices	04

Unit 03: Chemical calculations
Periods 15

Competency	Competency Levels	Content	No. of Periods
3.0 Works out chemical calculations accurately.	3.1 Formulates chemical formulae using physical quantities related to atoms and molecules and works out relevant calculations using relevant constants.	• Avogadro constant • Faraday constant • Composition • Mass fraction • Volume fraction • Mole fraction • Empirical formula and molecular formula • Relationships between different types of units expressing composition and concentration • Weight/volume • mg dm^{-3} • $\mu\text{g dm}^{-3}$ • mol/volume • mol dm^{-3} • mmol dm^{-3} • Parts per million	06
	3.2 Carries out calculations associated with balanced chemical equations.	• Mass and charge conservation • Writing balanced nuclear equations • Balancing chemical equations • Inspection method • Redox method • Oxidation number • Oxidation, reduction and half ionic equations • Calculations involving precipitation • <i>Experimental determination of the concentration of SO_4^{2-} solution using Ba^{2+}</i>	09

Unit 4: Gaseous state of matter

Periods 18

Competency	Competency Level	Content	No. of Periods
4.0 Investigates the behaviour of the gaseous states 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 - Compressibility	01
	4.2 Uses the model of ideal gas as a means of describing the behavioural patterns of real gases.	- Introduction to ideal gas (P, V, T and n as variables) - Ideal gas equation - Boyle law, Charles law and Avogadro law - Consistency of Boyle law, Charles law and Avogadro law with the ideal gas equation - Molar volume <i>Experimental determination of molar volume of a gas</i> <i>Experimental determination of relative atomic mass of Mg</i>	08
	4.3 Uses molecular kinetic theory of gases as a means of describing the behaviour of real gases.	- Molecular kinetic theory of gases - Pressure of a gas - Root mean square speed and mean speed - Kinetic molecular equation (Proof is not necessary.) - Factors affecting gas diffusion - Maxwell - Boltzmann distribution (graphically) - Variation of the distribution with temperature	04

	4.4 Uses Dalton law of partial pressure to explain the behaviour of a gas mixture.	• Mole fraction • Total pressure and partial pressure • Dalton's law of partial pressures	03
	4.5 Analyses amendments to the ideal gas equation to enable it to be applied for 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)	02

Unit 05: Energetics**Periods 26**

Competency	Competency Level	Content	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, surrounding and boundary • Standard states of pure substances • Standard conditions • State of a system and state functions • Heat and enthalpy • Enthalpy changes associated with changes of state and chemical reactions	04
	5.2 Predicts the feasibility of conversions by analysing the enthalpy changes associated with them.	• Heat changes and heat of reaction • Endothermic (energy absorbing) and exothermic (energy releasing) processes • Enthalpy as a state function • Enthalpy changes and standard enthalpy changes • Enthalpy of formation • Enthalpy of combustion • Enthalpy of bond dissociation • Enthalpy of neutralization • Enthalpy of solvation (hydration only) • Enthalpy of dissolution • Enthalpy diagrams and enthalpy cycles of different processes • Hess's Law • Calculations of enthalpy changes associated with processes • <i>Experimental determination of the enthalpy of neutralization of an acid/base</i> • <i>Validation of Hess's law through experiments</i>	14

	5.3 Predicts the stability of ionic systems using Born-Haber cycle.	• Born - Haber cycle and calculating enthalpy of formation of ionic compounds • Enthalpy of sublimation • Enthalpy of vapourization • Enthalpy of fusion • Enthalpy of atomization • Enthalpy of ionization • Enthalpy of electron gain (Electron affinity) • Lattice enthalpy	04
	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 as • $\Delta G = \Delta H - T\Delta S$ • Determination of spontaneity of a reaction using ΔG • $\Delta G = 0$, equilibrium • $\Delta G < 0$, spontaneous • $\Delta G > 0$, non spontaneous	04

Unit 06: Chemistry of *s*, *p* and *d* block elements
Periods 69

Competency	Competency Level	Content	No. of Periods
6.0 Investigates the elements and compounds of <i>s</i>, <i>p</i> and <i>d</i> blocks to be familiar with their properties.	6.1 Investigates chemical properties of elements in <i>s</i> block.	- Reactions of selected <i>s</i> block elements - with water - with air/ O₂ - with acid - with N₂ - with H₂ <i>Comparison of the reactions of metals with water and acids</i>	06
	6.2 Investigates the properties of compounds and their trends associated with <i>s</i> and <i>p</i> block elements.	- Trends shown by compounds of <i>s</i> and <i>p</i> block elements across the periods and down the groups. - Comparing solubilities of hydroxides, carbonates, bicarbonates, nitrites, nitrates, halides, sulphides, sulphites and sulphates of <i>s</i> block elements - Comparing thermal stability of nitrates, bicarbonates and carbonates - Acid/base/amphoteric nature of oxides, halides, hydroxides and hydrides <i>Testing solubility of salts of <i>s</i> and <i>p</i> block elements</i> <i>Testing thermal stability of nitrates, bicarbonates and carbonates of <i>s</i> block elements</i>	08
	6.3 Investigates elements and compounds of <i>p</i> block.	<i>p</i> block elements (Groups 13- 18) - Properties of selected elements - Aluminium - Amphoteric properties - Electron deficiency of aluminium chloride - Carbon - Allotropes - Oxides of carbon - Carbonic acid	16

		• Nitrogen • Oxo acids • Ammonia and ammonium salts • Oxygen and sulphur • Allotropes • Acyclic oxo acids • H_2O, H_2O_2 • H_2S, SO_2, SO_3 • Halogens • Hydrolysis of chlorides of group 14 and 15 • Acidity of hydrogen halides in aqueous media • Disproportionation of chlorine and chlorate(I) ion • Relative strength of halogens as oxidizing agent • Noble gases • Xenon fluoride • <i>Preparation of allotropes of sulphur</i> • <i>Preparation of sulphur dioxide and testing its properties</i> • <i>Preparation of chlorine and testing properties of halogens</i> • <i>Identification of halides</i>	
	6.4 Investigates properties of elements of <i>d</i> block and their variation across the period.	• Comparison of the following properties of <i>d</i> block elements with <i>s</i> and <i>p</i> block elements • Metallic properties • Variable oxidation states • Electronegativity values • Ionization energy • Ionic radii • Catalytic action • Formation of coloured compounds (Explanation of how the colours are produced is not required)	05

	6.5 Investigates properties of compounds of <i>d</i> block.	• Acidic/basic/amphoteric nature of oxides of vanadium, chromium and manganese • Oxo-anions of chromium and manganese • CrO_4^{2-}, $\text{Cr}_2\text{O}_7^{2-}$ and MnO_4^- ions as oxidizing agents • <i>Determining the concentration of an oxalate ion solution using acidic potassium permanganate</i> • <i>Determining the concentration of a ferrous ion solution using acidic potassium permanganate</i>	06
	6.6 Investigates properties of complex compounds of <i>d</i> block.	• Complex compounds of Cr, Mn, Fe, Co, Ni and Cu formed with the following monodentate ligands and their colours • H_2O, OH^-, NH_3, Cl^- • Factors affecting the colour of complex compounds • Central metal ion • Oxidation state • Ligand system • Hydroxides of the above elements • <i>Observing the reactions of Cu(II), Ni(II) and Co(II) salts with hydrochloric acid and ammonia</i> • <i>Observing the colours of manganese ions corresponding to oxidation numbers +2, +4, +6 and +7</i> • <i>Reaction of salicylic acid with iron(III) ions (Spectrometry – visual method)</i>	10
	6.7 Names simple inorganic compounds and complex compounds of <i>d</i> block elements.	• IUPAC Nomenclature • Compounds selected • Simple inorganic compounds • Complex cation with simple anion • Complex anion with simple cation	03

	6.8 Identifies cations by qualitative analysis.	• Cations which can be identified by flame test Li^+, Na^+, K^+, Ca^{2+}, Ba^{2+}, Sr^{2+}, Cu^{2+} • Separation procedure of a mixture of cations into five analytical groups by precipitation (separation of ions belonging to a particular group is not required) • Principles associated with the separation of cations into groups • Identification of NH_4^+ • <i>Testing for selected cations by the flame test / by precipitation method</i>	10
	6.9 Identifies anions by qualitative analysis.	• Anions which can be identified by precipitation • Halides, PO_4^{3-}, SO_4^{2-}, SO_3^{2-} • Anions which can be identified by other methods • S^{2-}, CO_3^{2-}, NO_3^-, NO_2^-, $\text{S}_2\text{O}_3^{2-}$ • <i>Testing for selected anions</i>	05

Unit 07: Basic concepts of organic chemistry**Periods 17**

Competency	Competency Level	Content	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	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 benzene only) • Alkyl halides and aryl halides • Alcohols and phenols • Ethers • Aldehydes and ketones • Carboxylic acids • Acid chlorides • Esters • Aliphatic amines and aryl amines • Amides • Amino acids	04
	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 should be connected to the main chain • The total number of double bonds and triple bonds of an unsaturated compound should not exceed one	06

		• The double bond or triple bond is not considered to be a substituent but is a part of the main chain. • The number of substituent groups on the main carbon chain should not exceed two. • Only the following groups should be present as substituent groups -F, -Cl, -Br, -I, -CH₃, -CH₂CH₃, -OH, -NH₂, -NO₂, -CN, -CHO, >C=O • Only the following groups should be present as the principal functional group -OH, -CHO, >C=O, -COOH, -COOR, -NH₂, -CONH₂ • The principal functional group should not occur more than once	
	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) • Enantiomers (optical isomers with one chiral center only)	05

Unit 08: Hydrocarbons
Periods 26

Competency	Competency Level	Content	No. of Periods
8.0 Investigates the relationship between structure and properties of hydrocarbons.	8.1 Investigates the structure, physical properties and nature of bonds of aliphatic hydrocarbons.	- Types - Alkanes - Alkenes - Alkynes - Homologous series - Physical properties - Inter - molecular 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	04
	8.2 Investigates the nature of bonding in benzene.	- Structure of benzene - Hybridization of carbon atoms - Delocalization of electrons - Concept of resonance - Stability of benzene	04
	8.3 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 and bromine - Mechanism of chlorination of methane - Homolytic cleavage of bonds - Free radicals as reaction intermediates - Reactions of Alkenes - Electrophilic additions as characteristic reactions of alkenes - Addition of hydrogen halides to simple alkenes and its mechanism	10

		• 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 ethene • Addition of sulphuric acid and the hydrolysis of the addition product • Reaction with cold alkaline KMnO_4 (Baeyer's test) • Catalytic addition of hydrogen • 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 • Acidic nature of terminal alkynes explained by the nature of bonding • Reactions of terminal alkynes with • Na or NaNH_2 • Ammoniacal CuCl • Ammoniacal AgNO_3 • <i>Observing reactions of alkenes and alkynes</i>	
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	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 ($\text{X} = \text{Cl}, \text{Br}$) • Resistance to oxidation • Oxidation of alkyl benzene • Difficulty of hydrogenation compared with alkenes • Catalytic addition of hydrogen	07
	8.5 Analyses the directing ability of substituent groups of mono substituted benzene.	• Ortho, para directing groups -OH, -NH₂, -NHR, -R, -Cl, -Br, -OCH₃ • Meta directing groups -COOH, -CHO, -COR, -NO₂	01

Unit 09: Alkylhalides**Periods 12**

Competency	Competency Level	Content	No. of Periods
9.0 Investigates the relationship between the structure and properties of alkyl halides.	9.1 Investigates the structure, polar nature of C-X bond and reactions of alkyl halides.	• Types • Primary • Secondary • Tertiary • Polar nature of C-X bond (X = F, Cl, Br, I) • Nucleophilic substitution reactions of alkyl halides • Hydroxyl ion as a nucleophile • Elimination as a competing reaction • Cyanide ion as a nucleophile • Acetylide (alkynide) ion of terminal alkynes as a nucleophile • Alkoxide ion as a nucleophile • Non reactivity of chlorobenzene and vinyl chloride under conditions where alkyl halides undergo nucleophilic substitution reactions • Reaction of alkyl halides with magnesium (Preparation of Grignard reagent) • The need for anhydrous conditions • Nature of metal-carbon bond • Reactions with proton donors • Acids • Alcohols • Amines	11

	9.2 Analyses the nucleophilic substitution reactions of alkyl halides 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) (Evidences for these mechanisms and classification of reactions based on the above two processes are not required.)	01
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Unit 10 : Oxygen containing organic compounds

Periods 35

Competency	Competency Levels	Content	No. of Period
10.0 Investigates the relationship between the structure and properties of oxygen containing organic compounds.	10.1 Investigates the structure, polar nature of carbon-oxygen bond and oxygen-hydrogen bond and reactions of alcohols.	- Types - Primary - Secondary - 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 - HI PCl_3 PCl_5 - Reactions with ZnCl_2 and conc. HCl acid (Lucas test) (Explained by the relative stability of the carbocations formed by the cleavage of C-O bond) - Reaction of benzyl alcohol is not necessary - Elimination reaction with concentrated sulphuric acid (dehydration to give alkenes) - Oxidation with H^+/KMnO_4	08

		• $\text{H}^+/\text{K}_2\text{Cr}_2\text{O}_7$ • H^+/CrO_3 • Pyridinium chlorochromate (primary alcohols to aldehydes and secondary alcohols to ketones) • <i>Testing properties of alcohols</i>	
	10.2 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 • <i>Testing properties of phenol</i>	04
	10.3 Investigates the effect of the -OH group on the reactivity of the benzene ring in phenol.	• Electrophilic substitution reactions • Bromination • Nitration	02
	10.4 Investigates the polar nature and unsaturated nature of $>\text{C}=\text{O}$ 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.) • Reaction with • NaBH_4 • LiAlH_4 (Detailed mechanism and intermediate products are not necessary) • Reaction with Zn(Hg)/concentrated HCl (Clemmenson reduction of carbonyl group to methylene group)	08

		• Oxidation of aldehydes • By ammoniacal AgNO_3 (Tollens' reagent) • By Fehling's solution • By H^+/KMnO_4 • By $\text{H}^+/\text{K}_2\text{Cr}_2\text{O}_7$ or H^+/CrO_3 (Compare with the non reactivity of ketones) • <i>Tests for aldehydes and ketones</i>	
	10.5 Recognizes the reactivity of the alpha position of aldehydes and ketones as exemplified by self-condensation reactions.	• Self-condensation reactions of acetaldehyde and acetone in the presence of sodium hydroxide (Mechanism of reactions is not necessary)	04
	10.6 Compares 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 $-\text{COOH}$ group with $>\text{C}=\text{O}$ group in aldehydes and ketones and $-\text{OH}$ 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 bases • Reactions with • Na • NaOH • NaHCO_3 • Reactions involving cleavage of the C - O bond • Reaction with PCl_3 or PCl_5 • Reaction with alcohol	06

		• Reduction of carboxylic acids with LiAlH_4 • <i>Testing some properties of carboxylic acids</i>	
	10.7 Investigates the characteristic reactions of acid derivatives.	• Acid chloride • Reaction with aqueous sodium hydroxide and its mechanism • Reactions with • Water • primary amines • alcohols • phenol • ammonia • Esters • Reaction with dilute mineral acids • Reaction with aqueous sodium hydroxide • Reaction of esters with Grignard reagent • Reduction with LiAlH_4 • Amides • Reaction with aqueous sodium hydroxide • Reduction with LiAlH_4	03

3.2 Grade 13

Unit 11: Nitrogen containing organic compounds

Periods 15

Competency	Competency Level	Content	No. of Periods
11.0 Investigates the relationship between structure and properties of nitrogen containing organic compounds.	11.1 Analyses amines and aniline in terms of their characteristic reactions and properties.	- Types - Aliphatic and aromatic amines - Primary amines - Secondary amines - Tertiary amines - Aniline as an aromatic amine - Reaction of aniline with bromine - Reactions of primary amines - with alkyl halides - with aldehydes and ketones - with acid chlorides - with nitrous acid	06
	11.2 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	05
	11.3 Investigates the reactions of diazonium salts.	- Reactions in which the diazonium group is replaced by an atom or another group - Reactions with - water - CuCl - CuBr - hypophosphorous acid - CuCN - KI - Reactions in which the diazonium ion acts as an electrophile - Coupling reaction with phenol - Coupling reaction with 2 - naphthol	04

Unit 12 : Chemical kinetics

Periods 27

Competency	Competency Level	Content	No. of Periods
12.0 Uses the principles of chemical kinetics in determining the rate of a chemical reaction and in controlling the rate of reaction.	12.1 Determines the factors affecting the rate of chemical reactions.	- Factors affecting the rate of chemical reactions - Temperature - Concentration (pressure) - Physical nature (surface area of reactants) - Catalysts - Homogeneous - Heterogeneous	05
	12.2 Controls the rate of a reaction by appropriately manipulating the concentration of reactants.	- Rate of reaction - Rate with respect to 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 D = $\left(\frac{\Delta C_D}{\Delta t}\right)$ - Effect of concentration on rate - Rate law, order with respect to components, order of reaction (overall order) - Rate constant - Initial rate - Average rate - Classification of reactions based on overall order (Zero- order, first order and second order only) - Half - life for a first order reaction and its graphical representation (Equation is not required)	14

		• Methods to determine the order of a reaction and rate constant • Initial rate method • <i>Experimental determination of the effect of acid concentration on the reaction between Mg and acids</i> • <i>Experimental determination of the effect of concentration on the reaction between $\text{Na}_2\text{S}_2\text{O}_3$ and HNO_3</i> • <i>Experimental determination of the effect of concentration on the reaction between Iron(III) and KI</i>	
	12.3 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 for the occurrence of a reaction • Collision of molecules • Having an appropriate orientation • Having exceeded the activation energy • Effect of temperature, concentration, catalysts and physical nature in satisfying the above needs (Arrhenius equation is not required)	04
	12.4 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	04

Unit 13: Equilibrium

Periods 62

Competency	Competency Level	Content	No. of Periods
13.0 Uses the concept of equilibrium and its principles to determine the macroscopic properties of closed systems in dynamic equilibrium.	13.1 Quantitatively determines the macroscopic properties of systems with the help of the concept of equilibrium.	• Systems (closed, open, isolated) • Systems in the steady state • Dynamic processes and reversibility • Macroscopic properties • Systems in equilibrium • Chemical • Phase • Ionic • Electrode • Equilibrium law • Equilibrium constant • Chemical equilibrium • K_p and K_c • Equilibrium point • Le - Chatelier's Principle • <i>Experimental study of the characteristics of a dynamic equilibrium system using Fe^{3+}/SCN^- system</i> • <i>Experimental determination of distribution coefficient of ethanoic acid in water and butanol</i> • <i>Experimental study of the effect of temperature on the equilibrium system of NO_2 and N_2O_4</i>	14
	13.2 Investigates how liquid - gas equilibrium varies in single component systems.	• Pure liquid systems • Equilibrium between liquid and vapour • Describing equilibrium in a liquid-vapour system in terms of molecular motion • Variation of vapour pressure of water and other liquids with temperature • Vapour pressure and boiling point	05

		• Critical point of a substance • Triple point	
	13.3 Investigates the variation of liquid - vapour equilibrium in binary liquid systems.	• Liquid - Liquid systems • Totally miscible liquid - liquid systems • Partially miscible liquid - liquid systems • Totally immiscible liquid- liquid systems • Raoult's law • Ideal liquid systems • Non- ideal liquid systems • Phase diagrams for totally miscible systems without azeotropes • Vapour pressure ÷ composition phase diagrams • Temperature ÷ composition phase diagrams • Fractional distillation	10
	13.4 Quantifies properties of equilibrium systems related to sparingly soluble ionic compounds.	• Ionic product (K_{sp}) $\text{AgCl(s)} \rightleftharpoons \text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq})$ • Precipitation • Solubility • Common ion effect • Application in qualitative analysis of cations • <i>Experimental determination of the solubility product of Ca(OH)_2</i>	06
	13.5 Quantifies properties of equilibrium systems related to weak acids, weak bases, acidic salts and basic salts.	• Acids, bases and salts • Conjugate acids and bases • Poly basic acids • Dissociation constants, K_w, K_a, K_b • pH value • Calculation of the pH value of acids (monobasic and dibasic), bases (monoacidic) and salt solutions • Theory of indicators	22

		• Acid ĩ base titrations • Titration curves • Determination of the equivalence point (visual methods - using indicators only) • Selection of suitable indicators for titrations based on pK_{in} values • <i>Preparation of an indicator using flowers provided and experimental determination of its pH range</i> • <i>Experimental determination of the acidic/basic/neutral nature of aqueous solutions of salts by testing pH</i> • <i>Determination of approximate pH value of a given solution using pH indicators</i>	
	13.6 Prepares buffer solutions according to the requirements.	• Buffer solutions (qualitatively and quantitatively) • Derivation of Henderson equation and its applications (Monobasic systems only; calculations involving quadratic equations are not required.) • pH of a buffer system	05

Unit 14 : Electrochemistry

Periods 26

Competency	Competency Level	Content	No. of Periods
14.0 Investigates practical importance of electrochemical systems.	14.1 Uses conductivity to understand the nature of solutes and their concentration in an aqueous solution.	• Conductance • Conductivity • Factors affecting conductivity • Nature of solute : Aqueous solutions of strong, weak and non electrolytes, molten electrolytes • Concentration • Temperature	04
	14.2. 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. - : $Pt(s)/Fe^{2+}(aq), Fe^{3+}(aq)$	02
	14.3 Determines the properties of electrochemical cells.	• Liquid junction • Salt bridge • Separator • Cells without a liquid junction • Electrode potential (E) • Standard electrode potential (E^θ) • 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	06

		- Cell reactions - Electromotive force of a cell $E_{\text{cell}} = E_{\text{RHS (Cathode)}} - E_{\text{LHS (Anode)}}$ (Nernst equation is not needed) <i>Measuring the electromotive force of different cells</i>	
	14.4 Investigates different types of cells.	- Primary cells - Daniel cell - Leclanche cell - Fuel cell (H₂/O₂ fuel cell only) - Secondary cells - Lead accumulator	04
	14.5 Identifies the requirements to be fulfilled in the process of electrolysis and carries out related calculations using Faraday constant.	- Principle of electrolysis - Electrolysis of water - Electrolysis of aqueous CuSO₄ using Cu electrodes - Electrolysis of aqueous CuSO₄ using Pt electrodes - Electrolysis of aqueous NaCl using carbon electrodes - Electrolysis of molten NaCl (principle only) - Application of Faraday's law <i>Preparation of H₂ and O₂ by electrolysis of water</i> <i>Electroplating of Cu and Ag</i>	06
	14.6 Investigates ways to control corrosion.	- Bimetal corrosion - Cathodic protection - Passivation <i>Experimental study of corrosion as an electrochemical process</i>	04

Unit 15: Chemistry and industry

Periods 41

Competency	Competency Level	Content	No. of Periods
15.0 Investigates the occurrence, industrial extraction/production and uses of some elements and compounds.	15.1 Investigates occurrence, industrial extraction/production and uses of <i>s</i> -block elements and their compounds.	- Extraction of Na (Downs cell method) and uses - Production of - Common salt - NaOH - Soap - Na₂CO₃ - Solvay process - Quick lime, bleaching powder and CaC₂ (Using CaCO₃ as a raw material)	08
	15.2 Investigates industrial extraction /production and uses of <i>p</i> -block elements and their compounds.	- Production and uses of - Ammonia (Haber process) - Urea - Nitric acid (Ostwald process) - Phosphate fertilizers - Sulphuric acid (Contact process)	06
	15.3 Investigates occurrence, extraction and uses of <i>d</i> -block elements and their compounds.	Iron extraction	02
	15.4 Uses of polymeric substances in day to day life effectively.	- Addition and condensation polymers and polymerization processes - Structure, properties and uses of natural rubber (NR) - NR vulcanization - Compounding of natural rubber - Structure, properties and uses of synthetic polymers - Polyethylene (PE) - Polyvinyl chloride (PVC) - Polystyrene (PS)	10

		• Polyamides • Polyesters • Teflon • Bakelite • Urea formaldehyde	
	15.5 Investigates some chemical industries based on plant materials.	• Overview of plants as the source of carbon compounds • Some plant based industries (other than the food industry) • Paper - Use of cellulose • Essential oils - Use of volatile compounds • Soap - Use of fats and oils • Pharmaceuticals - Use of medicinal compounds • Ethanol - Use of starch and sugar • Extraction of compounds from plants • Steam distillation ĩ essential oils • Solvent extraction ĩ medicinal compounds (Structural formulae of specific compounds will not be tested) • Analysis and separation of mixtures of compounds by chromatography ĩ basic principles of adsorption and partition chromatography • Use of gas chromatography in essential oils • <i>Separation of mixture of leaf pigments using paper chromatography</i>	10
	15.6 Investigates some chemical industries based on mineral resources.	• Chemistry involved in the production of cement • Extraction of Ti and TiO₂ from rutile/ilmanite • Crude oil and cracking/production of petroleum	05

Unit 16: Environmental Chemistry
Periods 24

Competency	Competency Level	Content	No. of Periods
16.0 Applies the knowledge of chemistry to understand the earth's environment	16.1 Investigates the composition of the ecosphere and its relation to maintain life on earth.	• Constituents of the ecosphere and their significance • Atmosphere • Hydrosphere • Lithosphere • Role of biogeochemical processes in maintaining the life on earth • Oxygen cycle • Carbon cycle • Nitrogen cycle • Hydrological cycle	06
	16.2 Investigates the changes in atmosphere due to human activities	• Air pollution and health effects due to CO_x, NO_x, SO_x, C_xH_y and particulate matter • Greenhouse effect • Understanding the problems due to air pollution • Global warming • Acid rain • Photochemical smog • Ozone layer depletion • <i>Investigating the acidity of rain water</i>	06
	16.3 Investigates the contamination of hydrosphere and drinking water	• Sources of water pollution • Water Quality • Physical parameters (temperature, pH, conductivity, turbidity) • Dissolved oxygen • Biological oxygen demand • Dissolved ionic compounds • Water purification processes • Sedimentation	08

		• Coagulation • Flocculation • Disinfection processes • Use of chlorine • Use of ozone • Use of UV radiation • <i>Determination of dissolved oxygen level by Winkler's method</i>	
	16.4 Investigates contamination of soil and the solid waste	• Natural inputs and soil fertility • Sources of soil pollution • Household waste • Agrochemicals • Accumulation of heavy metals in soil • e-waste (computers, electronic equipments, mobile phones, batteries, CFL bulbs etc) • Waste management • 3R system • Biogas production • Composting • Incineration	04

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 made on the following aspects.

- It is advised to cover the content through 5E- model activities as far as possible.
- Allow the students to acquire hands on experience.
- Direct students to acquire knowledge and information through reliable sources wherever necessary.

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 extend learning beyond the classroom activities and to highlight the students's special abilities, it is expected to 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.
- School 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 of 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 determining the activities to be undertaken during a particular year, the school will need to identify priorities and consider feasibility in relation to time and resource constraints.

6.0 Assessment and Evaluation

Assessment and Evaluation conforms to the standards set by the Department of Examinations.