CHEMISTRY

1. INTRODUCTION

This syllabus is drawn purposely for examinations; hence the topics are not necessarily arranged in the order in which they should be taught.

The following assumptions were made in the drawing of the syllabus:

(1) that candidates must have covered the Integrated Science/Basic Science or General Science and Mathematics syllabuses at the Junior Secondary School (JSS) / Junior High School (J.H.S) level;

(2) that candidates would have carried out as many of the suggested activities and project work as possible, and consequently would have developed the intended competencies and skills as spelt out in the respective teaching Syllabuses.

(3) that each school has a well-equipped laboratory;

Note: Candidates are required to have the knowledge of the significant figures, S.I. units and the conventional/IUPAC system of nomenclature.

2. AIMS

The aims and objectives of the syllabuses are to assess candidates:

(1) understanding of basic chemistry concepts;

(2) level of acquisition of laboratory skills including awareness of harzards and safety measures;

(3) level of awareness of the inter-relationship between chemistry and other discipline;

(4) level of awareness of the linkage between chemistry and industry/environment/everydaylife in terms of benefits and harzards;

(5) skills of critical and logical thinking.

3. EXAMINATION SCHEME

There shall be three papers - Paper 1, Paper 2 and Paper 3.

PAPER 1: shall contain fifty objective questions drawn from Section A of the syllabus. Candidates will be required to answer all the questions within 1 hour for 50 marks. i.e. 25% of the total marks for the examination.

PAPER 2: shall be a 2 hour essay paper covering the entire syllabus and carrying a total of 100 marks. i.e. 50% of the total marks for the examination. The paper shall have two Sections; I and II.

Section I: shall consist of ten short structured questions drawn from Section A of the syllabus. Candidates will be required to answer all the questions for 25 marks.

Section II: shall consist of four essay questions drawn from the entire syllabus. Two questions from Section A and two questions from Section B or C of the syllabus. Candidates are required to answer any three of the questions. Each question shall carry 25 marks.

PAPER 3: This shall be a 2 hours practical test for school candidates or 1 hour 30 minutes test of practical knowledge for private candidates. The paper shall contain three questions for 50 marks and shall form 25% of the total marks for the examination.

Candidates will be required to answer all the three questions.
The question shall be distributed as follows:

- one question on quantitative analysis;
- one question on qualitative analysis;
- the third question shall test candidates familiarity with the practical activities suggested in their teaching syllabus.

4. CONTINUOUS ASSESSMENT

The continuous assessment component shall form 30% of the total marks for the assessment of candidates.

Details of the input into the continuous assessment shall be given by the Council.

CONTENTS	NOTES
1.0 INTRODUCTION TO CHEMISTRY	
(a)(i) Measurement of physical quantities	
(ii) Scientific Measurements and their importance in chemistry	(1) Measurement of mass, length, time, temperature and volume (2) Appropriate SI units and significant figures (3) Precision and accuracy in measurement

(iii) Scientific Method	Outline the scientific method to include: observation, hypothesis, experimentation, formulation of laws and theories
2.0 STRUCTURE OF THE ATOM (a) Gross features of the atom	Short account of Dalton's atomic theory and limitations, J.J. Thompson's experiment should be given and Bohr's model of the atom.
(b)(i) Atomic number/ proton number, number of neutrons, isotopes atomic mass, mass number	(2) Outline description of the Rutherford's alpha scattering experiment to establish the structure of the atom. Meaning and representation in symbols of atoms and sub-atomic particles.
(ii) Relative Atomic mass(A_r) and relative molecular mass (M_r) based on Carbon-12 scale.	(1) Atomic mass as the weighted average mass of isotopes. Calculation of relative mass of chlorine should be used as an example. (2) Carbon-12 scale as a unit of measurement Definition of atomic mass unit. (u)
(iii) Characteristics and nature of matter	Atoms, molecules and ions. Definition of particles and treatment of particles as building blocks of matter
(c)(i) Electron Configuration	Detailed electron configurations (s, p, d) for atoms of the first thirty elements.
(ii) Orbitals	Origin of s,p,and d orbitals as sub-energy levels; shapes of s and p orbitals only.
(iii) Rules and principles for filling in electrons.	(1) Aufbau Principle, Hund's Rule of Maximum Multiplicity and Pauli Exclusion Principle. (3) Abbreviated and detailed electron configuration in terms of s, p, and d Explanation of the differences in stability between half filled,

	partially filled and fully filled orbitals in sub-n shells.
3.0 Standard separation techniques for mixtures	solid-solid, solid-liquid, liquid-liquid
(a) Classification of mixtures	Crystallization, distillation, precipitation, magnetism, chromatography, sublimation etc
(b) Separation techniques	Boiling point for liquids and melting point for solids
(c) Criteria for purity	
4.0 PERIODIC CHEMISTRY	
(a) Periodicity of the elements	Electron configurations leading to group and periodic classifications.
(b) Different categories of elements in the periodic table	Metals, semi-metals, non metals in the periodic table and halogens. Alkali table metals, alkaline earth metals and transition metals as metals. Halogens and noble gases as non-metals. Physical and chemical properties (reactions with water of the elements Na, Mg, Fe, Si and Cl)
(c) Periodic law	Explanation of the periodic law.
(i) Trends on periodic table	Periodic properties; atomic size, ionic size, ionization energy, electron affinity and electronegativity. Simple discrepancies should be accounted for in respect to beryllium, boron, oxygen and nitrogen.
(ii) Periodic gradation of the elements in the third period (Na Ar)	(1) Progression from: (i) metallic to non-metallic character of elements; (ii) ionic to covalent bonding in compounds compounds.
(d) Reactions between acids and metals, their oxides and trioxocarbonates(IV)	(1) Period three metals (Na, Mg, Al) (2) Period four metals (K, Ca)

	(3) Chemical equations
(e) Periodic gradation of elements in group seven the halogens: F, Cl Br and I.	(4) pH of solutions of the metallic oxides and trioxocarbonates Recognition of group variations noting any anomalies. Treatment should include the following: (i) physical states, melting and boiling points (ii) variable oxidation states; (iii) Redox properties of the elements; displacement reaction of one halogen by another; (iv) reaction of the elements with water and alkali (balanced equations required)
(f) Elements of the first transition series. $_{21}Sc$ - $_{30}Zn$	(1) Their electron configurations, physical properties and chemical reactivity of the elements and their compounds. (2) Physical properties should include; physical states, metallic properties and magnetic properties. (3) Reactivity of the metals with air, water, acids and comparison with S-block elements (Li, Na, Be, Mg). (b) Other properties of the transition metals should include: (i) Variable oxidation states; (ii) Formation of coloured Compounds; (iii) Complex formation; (iv) Catalytic abilities; (v) Paramagnetism. (vi) Hardness
5.0 CHEMICA BONDS (a) Inter-atomic bonding	Meaning of chemical bonding Lewis dot structure for simple ionic and covalent compounds.
(b) (i) Formation of Ionic bonds and compounds.	Formation of stable compounds from ions Factors influencingformation: Ionization energy; electron affinity and electronegativity difference.
(ii) Properties of ionic compounds	Solubility in polar and non polar solvents, electrical conductivity, hardness and melting point.
(c) Naming of ionic compounds	IUPAC system for simple ionic compounds.
(d) Formation of Covalent bonds	Factors influencing covalent bond formation.

and compounds.	Electron affinity, ionization energy, atomic size and electrone-gativity.
(e)(i) Properties of covalent compounds	Solubility in polar and non compounds. polar solvents, melting point, boiling point and electrical conductivity.
(ii) Dative covalent (g) Shapes of molecular compounds.	Formation and difference between pure and dative covalent bond.
	Linear, planar, tetrahedral and shapes for some compounds e.g. $BeCl_2$, BF_3, CH_4, NH_3, CO_2 .
(h)(i) Metallic Bonding	
(ii) Factors influencing its formation.	(1) Factors should include: atomic radius, ionization energy and number of valence electrons. Type of specific packing not required.
(iii) Properties of metals	(2) Typical properties including heat and electrical conductivity, malleability, lustre, ductility sonority and hardness.
(j)(i) Inter molecular Bonding: (ii) Intermolecular forces in covalent compounds (iii) Hydrogen bonding (iv) van der Waals forces	(1) Relative physical properties of polar and non-polar compounds. Description of formation and nature should be treated. Dipole-dipole and induced dipole-induced dipole forces should be treated under Van der Waal's forces.
(k) Comparison of all bond types	(2) Variation of the melting points and boiling points of noble gases, halogens and alkanes in a homologous series explained in terms of Van der Waal's forces; and variation in the boiling points of H_2O, and H_2S explained using Hydrogen bonding.
6.0 STOICHIOMETRY AND CHEMICAL REACTIONS	
(a)(i) Symbols, Formulae and equations	Symbols of the first twenty elements (H_1 - 20Ca)
(ii) Chemical symbols.	Calculations involving formulae and equations will be required. Mass and volume relationships in chemical reactions and the stoichiometry of such reactions as:

(iii) Empirical and molecular formulae	Calculation of percentage composition of elements.
(iv) Chemical equations and IUPAC name of chemical compounds	(i) Combustion reactions (including combustion of simple hydrocarbons) (ii) Synthesis (iii) displacement or replacement (iv) decomposition (v) ionic reactions
(v) Laws of chemical combination.	(1) Law of conservation of mass. (2) Law of constant composition. (3) Law of multiple proportions. Explanation of the laws and application of the laws to balance given equations. (4) Experimental illustration of the law of conservation of mass.
(b) Amount of substance.	(1) Mass and volume measurements. (2) The mole as a unit of measurement; Avogadro Constant, L = 6.02×10^{23} entities mol^{-1} (3) Molar quantities and their uses. (4) Moles of electrons, atoms, molecules formula units etc.
(c) Mole ratios	Use of mole ratios in determining stoichiometry of chemical reactions. Simple calculations to determine the number of entities, amount of substance, mass, concentration, volume and percentage yield of product.
(d) (i) Solutions	1) Concept of a solution as made up of solvent and solute.
(ii) Concentration terms	Basic, acidic and neutrals solutions Mass (g) or moles (mol) per unit volume emphasis on current IUPAC chemical terminology, symbols and conventions. Concentration be expressed as mass concentration, gdm^{-3}, moral concentration, $moldm^{-3}$, ppm.
(iii) Standard solutions	(1) Preparation of some primary standards

	e.g anhydrous Na_2CO_3, $(COOH)_2.2H_2O$/$H_2C_2O_4.2H_2O$
(e) Preparation of solutions from liquid solutes by the method of dilution.	(2) Meaning of the terms primary standard, secondary standard and standardized solution Dilution factor
7.0 STATES OF MATTER (a)(i) Kinetic theory of matter	
(ii) Diffusion	(1) Postulates of the kinetic theory of matter. (2) Use of the kinetic theory to explain the following processes of : Melting of solids, boiling of liquids, evaporation of liquids, dissolution of solutes, Brownian motion, diffusion (1) Experimental demonstration of diffusion of two gases. (2) Relationship between speed at which different gas particles move and the masses of particles.
(b) The Gases (i) Characteristics and nature of gases	(3) Experimental demonstration of diffusion of solute particles in liquids
(ii) The Gas Laws	Arrangement of particles, density, shape and compressibility The Gas laws: Charles'; Boyle's; Dalton's law of partial pressure; Graham's, Law of diffusion Avogadro's and the ideal gas equation of state. Qualitative explanation of each of the gas laws using the kinetic model. The use of Kinetic molecular theory to explain changes in gas volumes, pressure, temperature. Mathematical relations of the gas laws. Application of the general gas law PV = nRT Ideal and Real gases Factors that promote deviation of real gases from ideal situation
(iii) Laboratory preparation and properties of some gases.	

(c)(i) Liquids	(1) Preparation of the following gases: H_2, NH_3 and CO_2 and to illustrate the principles of purification and collection of the gases. (2) Physical and chemical properties of the gases.
(ii) Vapour and gases	(1) Characteristics and nature of liquids based on arrangement of particles, shape, volume, compressibility, density, viscosity and
(d) Solids (i) Characteristics and nature	(1) Concept of vapour, vapour pressure, saturated vapour pressure, boiling and evaporation. (2) Distinction between vapour and gas. (3) Effect of vapour pressure on boiling points of liquids. (4) Boiling at reduced pressure.
(ii) Types and structures	Characteristics of solids based on shape, volume, density, forces of attraction and repulsion, compressibility and melting point.
(iii) Properties solids	(1) Ionic, metallic, covalent network and molecular solids. Examples in each case. (3) Arrangements of particles ions, molecules and atoms in the solid state.
(e) Structures, properties and uses of diamond and graphite	Relate the properties of solids to the type of Interatomic or intermolecular bonding in the solids. Identification of the types of chemical bonds in Fe, NaCl, SiO_2, I_2, diamond and graphite and differences in the physical properties. The uses of diamond and graphite related to the structure and iodine in everyday life.
(f) Determination of melting points of covalent solids.	The use of iodine in everyday life.
8.0 ENERGY AND ENERGY CHANGES (a) Energy and enthalpy	Melting points as indicator of purity of solids. Eg. phenyl methanedioc acid (benzoic acid) ethanedioc (Oxalic) and ethanamide.
(b) Description, definition and illustrations of	Explanation of the terms energy and enthalpy. Energy changes associated with chemical processes.

energy changes and effects.	(1) Exothermic and endothermic processes (2) Total energy of a system as the sum of various forms of energy e.g. kinetic, potential, electrical, heat, sound etc. (3) Enthalpy changes involved in the following processes: combustion, dissolution and neutralization.
9.0 ACIDS, BASES AND SALTS (a) Definitions of acids and bases.	(1) Arrhenius concept of acids and bases in terms of H_3O^+ and OH^- ions in water.
(b) Physical and Chemical properties of acids and bases	(2) Effects of acids and bases on indicators, metals Zn, Fe and trioxocarbonate (IV) salts and HCO_3^-. Characteristic properties of acids and bases in aqueous solutions to include: (1) Conductivities, taste, litmus/indicators,feel etc.
(c) Acids, Bases and Salts as electrolytes	(2) Balanced chemical equations of all reactions. Electrolytes and non electrolytes; strong and weak electrolytes.Evidence from conductivity and enthalpy of neutralization.
(d) Classification of acids and bases	(1) Strength of acids and bases (2) Classify acids and bases into strong and weak (3) Extent of dissociation reaction with water and Conductivity.
(e) Concept of pH	(4) Behaviour of weak acids and weak bases in water as example of equilibrium systems (1) Definition of pH and knowledge of pH scale. (2) Measurement of pH of solutions using pH meter, calorimetric methods or universal indicator.
(f)(i) Salts (ii) Laboratory and industrial preparation of salts.	(3) Significance of pH values in everyday life. e.g. acid rain, pH of soil, blood, urine Meaning of salt. Types of salts: normal, acidic basic, double and complex salts.
(iii) Chemicals from Sodium Chloride solution	1. Description of laboratory and industrial production of salts. 2. Mining of impure sodium chloride and

(iv) Hydrolysis of salt	conversion into granulated and iodated salts. 3. Uses of NaCl, NaOH, Cl_2 and H_2.
(g) Acid-Base indictors	(1) Explanation of how salt forms acidic, alkaline and neutral aqueous solutions (2) Behaviour of some salts (e.g NH_4CI, $AlCl_3$, Na_2CO_3, CH_3COONa) in water as examples of equilibrium systems. (3) Effects of charge density of some cations and anions on the hydrolysis of their ioaqueous solution. Examples to be taken from group1, group 2, group 3 and the d-block elements.
(h) Acid-base titrations	Qualitative description of how acid-base indicator works. (1) Indicators as weak organic acids or bases (organic dyes). (2) Colour of indicator at any pH dependant on relative amounts of acid and base forms. (3) Working pH ranges of methyl-orange, and phenolphthalein. (1) Knowledge and correct use of relevant apparatus. (2) Knowledge of how acid-base indicators work in titrations. (3) Acid-base titration experiments involving HCl, HNO_3, H_2SO_4 and NaOH, KOH, $Ca(OH)_2$, CO_3^{2-}, HCO_3^- (4) Titration involving weak acids versus strong bases, strong acids versus weak bases and strong acids versus strong bases using the appropriate indicators and their applications in quantitative determination; e.g. concentrations, mole ratio, purity, water of crystallization and composition.
10.0 SOLUBILITY OF SUBSTANCES (a) General principles	Meaning of Solubility (1) Saturated and unsaturated solutions. (2) Saturated solution as an equilibrium system. (3) Solubility expressed in concentration terms: $moldm^{-3}$ and gdm^{-3}. (4) Solubility curves and their uses. (5) Relationship between solubility and crystallization. (5) Crystallization/recrystalization as a method of purification.

(b) Practical application of solubility.	(6) Knowledge of soluble and insoluble salts of stated cations and anions. (7) Solubility of sparingly soluble salts and complete dissociation of the portion that dissolves.
11.0 CHEMICAL KINETICS AND EQUILIBRIUM SYSTEMS.	Generalizations about solubility of salts and their applications to qualitative analysis. Eg. Pb^{2+}, Ca^{2+}, Al^{3+}, Cu^{2+}, Fe^{2+}, Fe^{3+}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, S^{2+} and CO_3^{2-} Zn^{2+}, NH_4^{+}, SO_3^{2-}
(a)(i) Rate of a reaction	Explanation of solubility rules.
(ii) Factors affecting rates	(1) Definition of reaction rates (2) Observable physical changes: Colour, mass, temperature, pH, formation of precipitate etc
(iii) Theories of reaction rates.	(1) Physical states, concentration/pressure of reactants, temperature, catalysts, light, particle size and nature of reactants.
(iv) Analysis and interpretation of graphs	(2) Appropriate experimental demonstration of for each factor is required. (1) Drawing of graphs and charts
(b) Equilibrium (i) General principles	(2) Collision and transition state theories to be treated qualitatively only Factors influencing collisions: (3) temperature and concentration. (4) Effective collision (5) Activation energy (6) Energy profile showing activation energy and ethaphy change.
(ii) Le Chatelier's Principle	Explanation of reversible and irreversible reactions. Reversible reactions i.e. dynamic equilibrium. Equilibrium constant K must be treated qualitatively. It must be stressed that K for a system is constant at constant temperature. Simple experiment to demonstrate reversible reaction Prediction of the effects of external

12.0 REDOX REACTIONS (a) Oxidation and reduction process.	influence of concentration, temperature and pressure volume changes on equilibrium system. (1) Oxidation and reduction in terms of: (i) addition and removal of oxygen and hydrogen; (ii) Loss and gain of electrons; (iii) change in oxidation numbers/ states. (2) Determination of oxidation numbers/ states.
(b) Oxidizing and reducing	(1) Description of oxidizing agents and reducing agents in terms of: (i) addition and removal of oxygen and hydrogen; (ii) loss and gain of electrons; (iii) change in oxidation numbers/state.
(c) Redox equations	Balancing redox equations by: (i) ion, electron or change in oxidation number/state method; (ii) half reactions and overall reactions.
(d) (i) Electrochemical Cells (ii) Standard Electrode Potential	Definition (1) Standard hydrogen electrode: meaning of standard electrode potential (E^{θ}) and its measurement.
(ii) Drawing of cell diagrams and writing of cell notations.	(2) Only metal/metal ion systems should be used.
(iii) e.m.f of Cells	(1) Electrochemical cells as a combination of two half-cells. (2) The meaning of the magnitude and sign of the e.mf
(iv) Application of Electrochemical cells.	(1) Distinction between primary and secondary cells. (2) Daniel cell, lead acid battery cell, dry cells, fuel cells and their use as generators of electrical energ from chemical reactions.

(e)(i) Electrolytic cells (ii) Principles of electrolysis	Definition Mechanism of electrolysis: Comparison of electrolytic and electrochemical cells. Strong and weak electrolyte
(iii) Factors influencing discharge of species.	(1) Limit electrolytes to conc. NaCl, (Brine) $CuSO_4$(aq) dil H_2SO_4, $NaOH_{(aq)}$ $KI_{(aq)}$ $CaCl_2$ (2) Faraday's Laws of electrolysis (3) Simple calculation based on the relation F = Le = 96,500 C and mole ratios to determine mass, volume of gasses number of entities, charges etc. using half and overall reactions.
(iv) Practical Applications	Electroplating, extraction of metals and purification etc.
(v) Corrosion of metals.	(1) Corrosion treated as Redox process. (2) Rusting of iron and its economic cost (3) Prevention based onrelative magnitude of electrode potentials and preventive methods like galvanizing, alloying, electroplating sacrificial cathodic protection and non-redox methods eg painting, greasing/oiling etc.
13.0 CHEMISTRY OF CARBON COMPOUNDS	
(a) Classification and nomenclature	(1) Broad classification into straight chain, branched chain, aromatic and alicyclic compounds. (2) Systematic nomenclature of compounds with the following functional groups: alkanes, alkenes, alkynes, hydroxyl compounds(aliphatic and aromatic), alkanoic acids, alkanoates (esters and salts), amines.
(b) Separation and Purification of organic compounds.	The following methods should be considered: Distillation, crystallization, drying, chromatography.

(c) Petroleum/crude oil	(1) Composition and classification (2) Fractional distillation and major products (3) Cracking and reforming. (4) Petro-chemicals: sources, uses and as starting materials of organic synthesis. (5) Quality of petrol, meaning of Octane number and its importance to the petroleum industry.
(d) Determination of empirical and molecular formulae and molecular structures of organic compounds.	
(f)(i) Functional group chemistry properties.	(1) Gradation in physical
(ii) Homologous series	(2) Effects on the physical properties by introduction of active groups into the inert alkane.
(iii) Isomerism	Differences between structural and stereo isomerism
(g) Alkanes	
(i) Sources and properties	(1) Laboratory preparations and other sources (2) Physical properties (3) Nomenclature and structure. Isomers of C_4H_{10} and C_5H_{12} (4) Reactivity: (i) halogenation; (ii) combustion; (iii) substitution
(ii) Uses	Uses of alkanes and their contribution to the greenhouse effect.
(h) Alkenes	
(I) Sources, properties and chemical reactions.	(1) Laboratory preparation; from alkanes, haloalkanes and alkanols (2) Physical properties. (3) Nomenclature and structure (4) Isomerism in alkenes: structural and geometric isomers for butene and pentene (5) Addition reactions of symmetrical and unsymmetrical alkenes with

	halogen halides, water, hydrogen and bromine (6) Hydration of alkenes in the manufacture of ethanol
(i) Uses	
(ii) Laboratory detection	Use of reaction with Br_2/water and $KMnO_4$(aq) as means of characterizing alkenes.
(j) Alkynes:	
(i) Sources, characteristic properties and Uses	(1) Nomenclature and isomerism. (2) Preparation from calcium cabide.
(ii) Preparation and chemical reactions.	(3) Chemical reactions: Halogenation, Combustion, hydration, hydrogenation, Na, -RX (alkylhalides) (4) Distinguishing test between terminal and Non terminal alkynes . (5) Uses of ethyne.
(k) Benzene	
(i) Structure and stability not	Resonance structures of benzene by Kekule. Stability leading to substitution reactions Halogenations (mechanism required)
(ii) Reactions of benzene	(1) Compare reactions with those of alkenes. (2) Addition reactions: hydrogenation and halogenation. (3) Simple test of benzene and alkene with acidified $KMnO_4$
(l) Alkanols	
(i) Sources, nomenclature and structure.	(1) Preparation including hydration of alkenes, hydrolysis of haloalkanes (2) Industrial and local production of ethanol from palm wine, sugarcane juice and other alcoholic beverages. Harmful impurities and methods of purification should be mentioned.

	(3) Structures of mono-,di-and triols
(ii) Classification	Primary, Secondary and tertiary alkanols.
(iii) Physical properties	Boiling point, solubility in water. Including hydrogen bonding effect.
(iv) Chemical properties	(1) Reaction with: (i) Na (ii) alkanoic acids (esterification) (iii) conc. H_2SO_4
	(2) Oxidation by: (i) $KMnO_4$ (aq); (ii) $K_2Cr_2O_7$ (aq) (iii) I_2 / $NaOH_{(aq)}$
(v) Uses of alkanols	
(vi) Lab test for alkanols	
(m) Alkanoic acids	Methanoic - insect bites Ethanoic acid - vinegar
(i) Sources, Nomencla ture and structure	Identification of mono and dioic acid
	Boiling point and solubility in water
(ii) Physical properties	Including hydrogen bonding effect
(iii) Chemical properties	Acid properties only: i.e reactions with NaOH, $NaHCO_3$, Na_2CO_3. Zn, Mg and NH_3 . Effect of substituent groups on acid strengut.
(iv) Laboratory test	Reaction with $NaHCO_3$, Na_2CO_3
(v) Uses	Uses of ethanoic and phenyl-Methanoic (benzoic acid)
(n) Alkanoic acid (Alkanoates) derivatives	Alkyl Alkanoates (esters) Flavours fruits and flower
(i) Sources, nomenclature, preparation and structure	Preparation of the following from alkanoic acids: alkyl alkanoates(esters) Hydrolysis of esters.
(ii) Physical properties	Solubility, boiling and melting point

(iii)	Chemical properties	Hydrolysis with alkali / acids
(iv)	Uses	Uses of alkanoates to include soap production, flavouring agent, plasticizers as solvents and in perfume.

14.0 CHEMISTRY, INDUSTRY AND THE ENVIRONMENT

(a) Chemical Industry	(1) Meaning of the terms: industry and chemical Industry. (2) National and chemical industries in candidate's own country and their corresponding raw materials. (3) Chemical plants: crude Oil refinery, cement production, soap making, brewery, steel, aluminium etc and their corresponding raw material (4) Factors that determine siting of chemical industries. (5) Effect of industries on the environment/community.
(b) Environmental Pollution	(1) Meaning and types of pollution: Air, water and land (2) Sources, and effects of pollution on the environment. (3) Acid rain, Greenhouse effect and Ozone Depletion. (4) Degradable and non-degradable substances.
(c) Biotechnology, concept, services	(1) Definition and applications in the products following industries.Food and drink, treatment of waste, mining, fuel, Genetic engineering, medical products/pharmaceuticals. (2) Biotechnology products should include: (i) Food and drinks:gari, bread, Mushroom, brewing etc (ii) Medical products eg.hormone-insulin drugs, antibiotics-penicillin (iii) chemicals eg. Ethanol, polymers etc

		(iv) fuel eg. Biogas(methane), gasohol (ethanol-gasoline)
		(3) Biotechnology services (i) mining- extraction of metals by bioleaching. (ii) treatment of waste (iii) enzyme technology
15.0 BASIC BIOCHEMISTRY AND SYNTHETIC POLYMERS		
Protein	Protein as polymers of amino acids (a) molecules linked by peptide or amide linkage	
	(b) sources and properties	Physical properties e.g. solubility Chemical properties to include: (1) Hydrolysis of proteins (2) Laboratory test using ninhydrin reagent/Biuret reagent/Millons reagent. (3) Basic and acid properties including zwitterions
	(c) Uses of protein	
	(d) Amino acids	(1) Nomenclature and general structure of amino acids (2) Difunctional nature of amino acids
	(e)(i) Fats and oils	As alkyl alkanoates (esters)
	(ii) Sources Properties.	From animals and plants Physical properties such as solubility Chemical Properties (1) Acidic and alkaline hydrolysis (2) Hydrogenation Test for fats/oils
	(f)(i) General structure of fats and oils	As mono-, di-, and tri-esters of propan-1,2,3-triol (glycerol). General structure for fats and oils: palm oil, coconut oil.

(ii) Preparation of soap	(1) Preparation of soap(saponification) from fats and oils (2) Comparison of soapless detergents with soapy detergents and their action on soft and hard water. Uses of fats and oil.
(g) CARBOHYDRATES	
(i) Sources and properties	(1) Physical properties such as solubility of sugars (2) Chemical properties - Hydrolysis of disaccharides into monosaccharides or simple sugar. (3) Test for reducing sugars using sugar strips, Fehling's or Benedicts solution Tollens' reagent.
(ii) Nomenclature and structure	(1) classes of carbohydrates as (i) monosaccharides (ii) disaccharides (iii) polysaccharides (2) Name and components of the various classes of carbohydrates
(iii) Carbohydrate as polymer	(1) Starch as a polymer made up of glucose units. (2) Condensation of monosaccharide to form disaccharides and polysaccharides. Uses of carbohydrates
(h) SYNTHETIC POLYMERS	Definitions of terms: (1) Monomer, polymer and polymerization (2) Addition and condensation polymerization. (3) Classification and preparation based on the monomers and co monomers
(i) Important properties of polymers	(1) Thermoplastics and thermosets (2) Modification of properties of

polymers
(3) Plastics and resins
(4) Chemical test on plastics using:
(i) heat
(ii) acids
(iii) alkalis
(5) Uses of polymers

16.0 PRACTICALS

(a) GENERAL SKILLS AND PRINCIPLES

Candidates will be expected to be familiar with the following skills and principles:

(i) Measurement of mass and volume;
(ii) Preparation and dilution of standard solutions;
(iii) Separation and purification of compounds (Filtration, recrystallization and melting point determination)
(iv) Measurement of heats of neutralization and solution;
(v) Determination of pH's of various solutions by colorimetry;
(vi) Determination of rates of reaction from concentration vs. time curves;
(vii) Determination of equilibrium constants for simple systems.

(b) QUANTITATIVE ANALYSIS

Acid-base titrations

The use of standard solutions of acids and alkalis and the indicators; Methyl orange, methyl red and phenolphthalein to determine the following:

(i) The concentrations of acid and alkaline solutions;
(ii) The molar masses of acids and bases and water of crystallization;
(iii) The solubility of acids and bases;
(iv) The percentage purity of acids and bases;
(v) Analysis of $Na_2CO_3/NaHCO_3$ mixture by double indicator method;
(vi) Stoichiometry of reactions.

Redox titrations

Titrations of the following systems to solve analytical problems:

(i) Acidic MnO_4 versus. Fe^{2+}
(ii) 1_2/KI versus $S_2O_3^{2-}$
(iii) Acid MnO^-_4 verses C_2O_4

(c) QUALITATIVE ANALYSIS

No formal scheme of analysis is required.

(i) Characteristic tests of the following cations with H_2S and dilute NaOH and NH_3:

Ca^{2+}; Pb^{2+}; Cu^{2+}; Fe^{2+} Fe^{3+}; $A1^{3+}$ Zn^{2+}, and NH_4^+

(ii) Confirmatory tests for the above cations.

(iii) Characteristic reaction of dilute HC1 on solids or aqueous solutions and conc H_2SO_4 on solid samples of the following:

$C1^-$; SO_3^{2-}; CO_3^{2-}; NO_{3-} and SO_4^{2-}.

(iv) confirmatory tests for the above anions

(v) Comparative study of the halogens; displacement reactions.

(vi) Characteristic test of the following gases:
H_2; NH_3; CO_2

(vii) Characteristic test tube reactions of the following functional groups in simple organic compunds:alkenes; alkanols; alkanoic acids, sugars, starch and proteins.

CONTENTS	NOTES
1.0 **STRUCTURE OF THE ATOM** (a) Elementary treatment of mass spectrometer	(1) Qualitative knowledge of the mass spectrometer principles and operations of the mass spectrometer; and its use to detect isotopes, determination of relative atomic and molecular masses only. (2) Wave nature of atom (3) Quantum numbers and their importance
(b) (i) Nuclear chemistry	Meaning of terms: Nucleons nuclide.
(ii) Types and nature of radiations: Alpha, beta particles and gamma radiation.	Charges, relative mass and penetrating power of radiations. Meaning of radioactivity. Difference between spontaneous nuclear reactions (radioactivity) and induced nuclear reactions
(iii) Radioactivity Induced/stimulated	Natural and artificial radioactivity. Detection of radiation by Geiger-Muller counter.
(iv) Nuclear reactions Fission and fusion in nuclear reactions.	Distinction between ordinary chemical reactions and nuclear reactions. Generations of electricity; atomic mombs. Balanced equations for nuclear reactions
(v) Effects and application of radioactivity	(1) Carbon dating (qualitative treatment only). (2) Use of radioactivity in agriculture, medicine and industry. (3) Hazards associated with nuclear radiations Factors affecting stability of nuclides: Binding energy, neutron-proton ratio, halfilife Calculations involving half-life

2.0 PERIODIC CHEMISTRY	
(a) Reactions between acids and metals their oxides and trioxocarbonates (IV)	(1) Period three metals (Na, Mg, Al) (2) Period four metals (K, Ca) (3) Chemical equations (4) pH of solutions of the metallic oxides and trioxocarbonates.
(b) Acidic properties of oxides of non-metals	(1) Oxides of carbon, nitrogen, sulphur, phosphorus and chlorine (2) pH of aqueous solutions of the oxides (3) Chemical equations
(b) Physical and chemical properties of period 3 (Na $\rightarrow$Cl) compunds	(1) Comparism of the physical and chemical properties of period three elements (2) Comparison of the physical and chemical properties of (hydrides, oxides, hydroxides and chlorides) compounds. (3) Thermal stability of CO_3^{2-} and NO_3^- of Li, Na, K, Mg and Ca. (4) Experiment to compare thermal stability of Na_2CO_3 / Li_2CO_3 / $CuCO_3$

(d) Silicon

(1) Structures for SiO_2 and CO_2 account for the differences between physical and chemical properties

(2) Uses of silicon and its compounds. Eg, ceramics, glass, silica gel and microchips

(e) Periodic gradation of elements

(1) Inter-atomic bond energies

in group seven i.e. the halogens. (2) Hydrides and their acid strength comparison of the Ka values of the hydrogen halides.

(3) variable oxidation states of the halogens

(f) Bonding in complex compounds

Definition of ligands and central ion

Examples of ligands

(1) Formation of coordination compounds

(2) Nomenclature of complex ions and compounds (Cl^-, F^-, I^-, NO_3^-, NH_3, H_2O, SO_4^{2-})

(g) Shapes of complex compounds

Tetrahedral, square planar, octahedral

Eg $[Fe(CN)_6]^{3-}$, $[Cu(NH_3)_4]^{2+}$, $[Ag(NH_3)_2]^+[Cu(CN)_4]^2$

(h) Elements of the first transition series.

Reactivity of the metals with air, water, acids and comparison with s-block elements (Li, Na, Be, Mg).

3.0. CHEMICAL BONDS

(a) Formation of Ionic bonds

(i) Factors that influence ionic bond formation.

Factors should include lattice energy.

(ii) Covalent character in ionic bond	
(iii) Polar covalent bonds.	(1) Ionic character (polarity) in covalent bonds based on electronegativity difference between the speciesinvolved.
	(2) Effects of covalent and ionic character in ionic and covalent bonds on the solubility, thermal stability and boiling points of ionic covalent compounds.
(b) (i) Hybridization of atomic orbitals	Meaning of Hybridization.
(ii) Formation of hybrid orbitals	(1) Description of sp, sp^2, sp^3 hybrid orbitals.
	(2) Shapes of sp, sp^2, sp^3 and sp^3d^2 hybrid orbitals.
	Treatment should be limited to the following molecules only. CH_4, H_2O, NH_3, BCI_3, C_2H_2, $BeCI_2$, C_2H_4 and SF_6.
(iii) Formation of sigma (σ) and pi (π) bonds	Description of sigma and pi bonds. Using C_2H_2 and C_3H_3

4.0 Solutions

(a)	Preparation of solutions from liquid solutes by the method of dilution	Outline of steps involved in the preparation of solutions from liquid solutes. (1) Determination of concentration of liquid solutes (stock solution) given the density, (w/v, w/w), specific gravity, relative molecular mass, molar mass, and % purity. (2) Primary standard, secondary standard and standardized solution

5.0 ENERGY AND ENERGY CHANGES

(a)	Energy changes in physical and isolated systems.	(1) Definition and understanding of the meaning of the energy terms: systems, surroundings, open, closed (2) Enthalpy change involved in the following processes: combustion, atomization, sublimation, hydration/ salvation and dissolution.
(b)	Hess's Law of heat	Explanation of Hess's law and its application

summation and Born- Haber cycle.		in the development of the Born-Haber cycle.
	(1)	Use of different cycles to illustrate Hess's law.
	(2)	Simple calculations using chemical equations, energy cycles or diagrams with given energy changes.
(c) Bond Energy		Explanation of bond energy and bond dissociation energy.
	(1)	Bond energy as an average value. Differences in bond energy and bond dissociation energy.
	(2)	Bond energy in molecules and its use in assessment of bond strength, energy content and enthalpy of reaction.
	(3)	Calculations using summation of bond energies in reactants and products as a measure of enthalpy of reaction.

6.0 ACIDS, BASES AND SALTS

(a) Definitions of acids and bases.	(1)	Bronsted – Lowry and Lewis concept of acids and bases.
	(2)	Conjugate acid-base pair concept in terms of equilibrium.
(b) pH, pOH and pK_W	(1)	Ionic product constant of water $K_W = [H^+_{(aq)}][OH^-_{(aq)}] = 1.0 \times 10^{-14}$ mol^2dm^{-6}

(2) pH and pOH as a measure of acidity and alkalinity

respectively pH = $- \log[H_3O^+]$

(3) knowledge of pH scale.

(4) Calculation of $[H^+]$, $[OH^-]$ and the corresponding pH and pOH of given solutions.

(c) Partial ionization of weak acids and weak bases.

Explanation of pKa and pKb of weak acids and bases.

(1) Behaviour of weak acids and weak bases in water as example of equilibrium systems.

(2) Calculations involving Ka, pKa and Kb, pKb.

(3) Ka, pKa and Kb ,pKb as measurements of acid and basic strengths respectively.

(d) Buffer Solutions

(1) Qualitative definition of buffers.

Examples of buffers from the laboratory and in living systems are required.

(2) Preparation of buffer solutions.

(e) Acid base titrations

Double indicator titrations (continuous and Discontinuous) and back titration.

Calculations involving concentration, composition and % purity.

Graphs for acid-base titrations. Nature of graphs of strong acid and strong base, Strong acid and weak base and strong base and weak acid.

7.0 SOLUBILITY OF SUBSTANCES

(a) Solubility and solubility product.

Explanation of solubility products (Ksp) of sparingly soluble ionic compounds.

(1) Calculations involving solubility and solubility products

(2) Factors affecting solubility.

(b) Crystallization and Recrystallization.

Explanation of the effect of lattice energy and hydration energy on crystallization and recrystallization

8.0 CHEMICAL KINETICS AND EQUILIBRIUM SYSTEMS

(a) Rate law and Order of reaction

(1) Deduction of order and hence rate law from experimental data.

(2) Simple relation between rates and second concentration of zero, first and order reactions. Graphical representation of zero, first and second order reactions.

(3) Half-life for first order reaction and its significance.

(4) General rate law equation.

(5) Derivation of the rate expression from experimentally determined rate data:

$r = k[A]^X [B]^y$ where k = rate constant.

(b) Rate determining step of a multi-step reaction.

(c) Equilibrium

(d) Equilibrium Law of Mass Action

(1) Mathematical expression for the determination of equilibrium constant K

(2) K is constant for a system at constant temperature.

(3) Relationship between K_p and K_c

(4) Calculation of K_p and K_c from given set of data.

(5) Difference between homogeneous and heterrogeneous systems.

9.0 CHEMISTRY OF

CARBON COMPOUNDS

(a)	Separation and Purification	Other methods should include solvent extraction and melting point determination.
(b)	Determination of empirical and molecular formulae.	Outline of steps in: (i) Detection of N,S and the halogens. (ii) Estimation of C, H and O.
(c)	Reactivity of Organic Compounds	(1) Inductive effect and mesomeric effect. (2) Resonance illustrated with benzene molecule. (3) Explanation of the terms : Nucleophiles, electrophiles, free radicals and ions. Homolytic fission, heterolytic fission
(d)	Alkanes	Halogenation – free radical mechanism.
(e)(i)	Reactions of benzene	Mono substituted reactions of benzene: toluene, phenol, aniline, benzoic acid and nitrobenzene.(IUPAC and trivial names)

(ii) Comparison of reactions of benzene and alkenes.	Differences between the reactivity of benzene and alkene towards certain reagents.
benzene hexachloride (BHC)	Uses of hexachlorocyclohexane and

10.0 CHEMICAL INDUSTRY AND ENVIRONMENT

(a) (i) Source of raw materials	
(ii) Meaning of mineral as ore	
(iii) Extraction of metals Mineral deposits in Ghana	Location of mineral deposits and their nature. (1) Metals - gold, bauxite, Mn and Fe (2) Precious stone - diamond (3) Industrial mining of limestone $CaCO_3$, clay Kaolin, solar salt (4) Processing of Au, Al, Fe as main products (5) Uses of the metals
(b) Cement and its uses	(1) Source of raw material for clinker production (2) Processes involved in the production of cement (3) Uses of cement (4) Environmental impact

SECTION C

(For candidates in Nigeria, Sierra Leone, Liberia and The Gambia)

CONTENTS	NOTES
1.0 Carbon:	Graphite, diamond and amorphous Carbon;
i. Allotropes of carbon other than diamond and granite	(1) Structures, properties and uses; (2) The uses of the allotropes should be correlated with their properties and structures;
ii. Coal:	(3) Combustion of allotropes.
I. Types;	
II. Destructive distillation of coal and uses of the products.	Different types should include anthracite, peat and lignite.
iii. Coke:	
I. Gasification and uses;	Water gas and producer gas.
II. Manufacture of synthetic gas and uses.	
iv. Oxides of carbon	(1) Laboratory preparation;
I. Carbon (IV) oxides;	(2) properties and uses; (3) Test for carbon (IV) oxides.
II. Carbon (II) oxides;	Properties and uses only.
III. Trioxocarbonate (IV) salt.	(1) Properties: solubility, action of heat, reaction with dilute acid;
	(2) Uses.
(b) Oxygen:	
i. Laboratory and industrial preparation;	
ii. Properties and uses;	
iii. Binary compounds of oxygen: acidic, basic, amphoteric and neutral oxides.	Test for oxygen will be required.
(c) Hydrogen:	
i. Laboratory preparations;	Test for hydrogen will be required.
ii. Properties and uses;	

(d) Water and solution: i. Composition of water; ii. Water as a solvent; iii. Hardness of water, causes and methods of removing it; iv. Treatment of water for town supply	Test for water will be required. Reference should be made to the electrolysis of acidulated water. (1) Advantages and disadvantages of hard water and soft water; (2) Experiments to compare the degrees of hardness in different samples of water. Redox properties of the elements; displacement reaction of one halogen by another.
(e) Halogens: i. Chlorine: I. Laboratory preparation; II. Properties and reactions. ii. Hydrogen chloride gas: I. Laboratory preparation; II. Properties and uses; III. Uses of halogen compounds.	Properties should include: (1) variable oxidation states; (2) reaction with water and alkali (balanced equation required) (1) Test for HCl gas; (2) Foundation experiment. Uses should include silver halide in photography and sodium oxochlorate (I) as a bleaching agent.
(f) Nitrogen i. Preparation and properties; ii. Uses of nitrogen; iii. Compounds of nitrogen I. Ammonia I. Trioxonitrate (V) acid; II. Trioxonitrate (V) salts.	Both laboratory and industries preparations from liquefied air are required. (1) Laboratory and industrial preparations; (2) Properties and uses; (3) Test for ammonia; (4) Foundation experiment.
(g) Sulphur i. Allotropes and uses; ii. Compounds and sulphur iii. Trioxosulphate (IV) acids and its salts; iv. Tetraoxosulphate (VI) acid: industrial preparation,	(1) Laboratory preparation; (2) Properties and uses. (1) Action of heat will be required; (2) Test for trioxonitrate (V) ions.

reactions and uses. (h) The noble gases: properties and uses. **2.0 METALS AND THEIR COMPOUNDS** (a) Extraction of metals: i. Aluminium; ii. Iron; iii. Tin. (b) Alloys (c) Properties and uses of sodium and its compounds. (d) Properties and uses of calcium and its compounds. (e) Reactivity of iron and aluminium with air, water and acids. (f) Properties and uses of copper and its compounds.	Contact process should be discussed. (1) Raw materials, processing, main products and by-products; (2) Uses of metals Common alloys of Cu, Al, Pb, Fe, Sn and their uses Compounds must be limited to NaCl, NaOH, Na_2CO_3 , $NaNO_3$, Na_2SO_4 and NaClO. The compounds must be limited to $CaCO_3$, CaO, $CaSO_4$, $CaCl_2$, $Ca(OH)_2$ The compound must be limited to $CuSO_4$, CuO and CuCl2.

PRACTICALS

(1) GENERAL SKILLS AND PRACTICALS

Candidates will be expected to be familiar with the following skills and principles:

(a) Measurement of mass and volume;
(b) Preparation and dilution of standard solutions;
(c) Filtration, recrystallisation and melting point determination;
(d) Measurement of heats of neutralization and solutions;
(e) Determination of pH value of various solutions by colorimetry;
(f) Determination of rates of reaction from concentration versus time curves;

(2) QUANTITATIVE ANALYSIS

(a) Acid-base titrations

The use of standard solutions of acids and alkalis and the indicators methyl orange and phenolphthalein to determine the following:

(i) The concentration of acid alkaline solutions;
(ii) The molar masses of acids and bases and water of crystallization.
(iii) The solubility of acids and bases;
(iv) The percentage purity of acids and bases;
(v) Stoichiometry of reactions.

(b) Redox titrations

Titrations of the following systems to solve analytical problems:

(i) Acidic MnO_4^- with Fe^{2+} ;

(ii) Acidic MnO_4^- with $C_2O_4^{2-}$;

(iii) I_2 in Kl versus $S_2O_3^{2-}$.

(3) QUALITATIVE ANALYSIS

No formal scheme of analysis is required.

(a) (i) Characteristics tests of the following cations with dilute $NaOH_{(aq)}$ and $NH3_{(aq)}$ NH_4; Ca^{2+}, Pb^{2+}, Cu^{2+}, Fe^{2+}; Al^{3+}; Al^{3+}; and Zn^{2+} .

(ii) Confirmatory tests for the above cations.

(b) (i) Characteristic reaction of dilute HCl on solids aqueous solutions and conc. H_2SO_4 on solid samples of the following:

(ii) Confirmatory tests for the above anions

(c) Comparative study of the halogens; displacement reactions.

(d) Characteristic test for the following gases: H_2 ; NH_3 ; CO2 ; HCl and SO_2 .

(e) Characteristic test tube reactions of the functional groups in the following simple organic compound: Alkenes; alkanols; alkanoic acids; sugars (using Fehiling's and Benedict's solutions only); starch (iodine test only) and proteins (using the Ninhydrin test, Xanthoporteic test, Biuret test and Million's test only).