CHEMISTRY

1. INTRODUCTION

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

The following assumptions were made in 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 carry out as many of the suggested activities and project work as possible, and consequently develop the intended competencies and skills as spelt out in the relevant Chemistry teaching syllabuses;

(3) That schools which offer the subject have well-equipped laboratories.

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 syllabus are to assess candidates'

(1) understanding of basic chemistry concepts;
(2) level of acquisition of laboratory skills including awareness of hazards and safety measures;
(3) level of awareness of the inter-relationship between chemistry and other disciplines;
(4) level of awareness of the linkage between chemistry and industry/environment/everyday life in terms of benefits and hazards;
(5) skills of critical and logical thinking.

3. EXAMINATION SCHEME

There shall be three papers - Papers 1, 2 and 3 all of which must be taken. Paper 1 and 2 shall be a composite paper to be taken at one sitting.

PAPER 1: Will consist of fifty multiple choice objective questions drawn from Section A of the syllabus (i.e. the portion of the syllabus which is common to all candidates) . Candidates will be required to answer all the questions within 1 hour for 50 marks.

PAPER 2: Will be a 2-hour essay paper covering the entire syllabus and carrying 100 marks. The paper will be in two sections; Sections A and B.

Section A: Will consist of ten short structured questions drawn from the common portion of the syllabus. (i.e. Section A of the syllabus). Candidates will be required to answer all the questions for 25 marks.

Section B: Will consist of two questions from the common portion of the syllabus (i.e. Section A of the syllabus) and two other questions from the section of the syllabus which is peculiar to the country of the candidate (i.e. either Section B or C of the syllabus). Candidates will be required to answer any three of the questions. Each question shall carry 25 marks.

PAPER 3: This shall be a 2-hour practical test for school candidates or 1 hour 30 minutes alternative to practical work test for private candidates. Each version of the paper shall contain three compulsory questions and carry 50 marks.

The questions shall be on the following aspects of the syllabus:

- 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 syllabuses.

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

SECTION A

(For all candidates)

CONTENT	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.
(b) Scientific Methods	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.	(1) Short account of Dalton's atomic theory and limitations, J.J. Thomson's experiment and Bohr's model of the atom. (2) Outline description of the Rutherford's alpha scattering experiment to establish the structure of the atom.
(b) (i) Atomic number/proton number, number of neutrons, isotopes, atomic mass, mass number.	Meaning and representation in symbols of atoms and sub-atomic particles.

CONTENT	NOTES
(ii) Relative atomic mass (Ar) and relative molecular mass (Mr) 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.
(iii) Characteristics and nature of matter.	Atoms, molecules and ions. Definition of particles and treatment of particles as building blocks of matter.
(c) Particulate nature of matter: physical and chemical changes.	Explain physical and chemical changes with examples. Physical change- melting of solids, magnetization of iron, dissolution of salt etc. Chemical change- burning of wood, rusting of iron, decay of leaves etc.
(d) (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. (2) Abbreviated and detailed electron configuration in terms of s, p, and d.

CONTENT	NOTES
3.0 STANDARD SEPARATION TECHNIQUES FOR MIXTURES	
(a) Classification of mixtures.	Solid-solid, solid-liquid, liquid-liquid, gas-gas with examples.
(b) Separation techniques	Crystallization, distillation, precipitation, magnetization, chromatography, sublimation etc.
(c) Criteria for purity.	Boiling point for liquids and melting point for solids.
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 metals, alkaline earth metals and transition metals as metals.
(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 element; (ii) ionic to covalent bonding in compounds.

CONTENTS	NOTES
	(2) Differences and similarities in the properties between the second and the third period elements should be stated.
(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. (4) pH of solutions of the metallic oxides and trioxocarbonates.
(e) Periodic gradation of elements in group seven, the halogens: F, Cl, Br and I.	Recognition of group variations noting any anomalies. Treatment should include the following: (a) physical states, melting and boiling points; (b) variable oxidation states; (c) redox properties of the elements; (d) displacement reaction of one halogen by another; (e) 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).

CONTENT	NOTES
	(4) Other properties of transition metals should include: (a) variable oxidation states; (b) formation of coloured compounds; (c) complex formation; (d) catalytic abilities; (e) paramagnetism; (f) hardness.
5.0 CHEMICAL BONDS (a) Interatomic 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 influencing formation: 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 and compounds.	Factors influencing covalent bond formation. Electron affinity, ionization energy, atomic size and electronegativity.
(e) (i) Properties of covalent compounds.	Solubility in polar and non-polar solvents, melting point, boiling point and electrical conductivity.
(ii) Coordinate (dative) covalent bonding.	Formation and difference between pure covalent and coordinate (dative) covalent bonds.

CONTENT	NOTES
(f) Shapes of molecular compounds.	Linear, planar, tetrahedral and shapes for some compounds e.g. $BeCl_2$, BF_3, CH_4, NH_3, CO_2.
(g) (i) Metallic Bonding	
(ii) Factors influencing its formation.	Factors should include: atomic radius, ionization energy and number of valence electrons. Types of specific packing not required.
(iii) Properties of metals.	Typical properties including heat and electrical conductivity, malleability, lustre, ductility, sonority and hardness.
(h) (i) Intermolecular bonding	Relative physical properties of polar and non-polar compounds.
(ii) Intermolecular forces in covalent compounds.	Description of formation and nature should be treated. Dipole-dipole, induced dipole-dipole, induced dipole-induced dipole forces should be treated under van der Waals forces.
(iii) Hydrogen bonding	Variation of the melting points and boiling points of noble gases, halogens and alkanes in the homologous series explained in terms of van der Waals forces; and variation in the boiling points of H_2O, and H_2S explained using Hydrogen bonding.
(iii) van der Waals forces	
(iv) Comparison of all bond types.	

CONTENT	NOTES
6.0 STOICHIOMETRY AND CHEMICAL REACTIONS	
(a) (i) Symbols, formulae and equations.	Symbols of the first thirty elements and other common elements that are not among the first thirty elements.
(ii) chemical symbols	
(iii) Empirical and molecular formulae.	Calculations involving formulae and equations will be required. Mass and volume relationships in chemical reactions and the stoichiometry of such reactions such as: calculation of percentage composition of element.
(iv) Chemical equations and IUPAC names of chemical compounds.	(1) Combustion reactions (including combustion of simple hydrocarbons) (2) Synthesis (3) Displacement or replacement (4) Decomposition (5) Ionic reactions
(v) Laws of chemical combination.	(1) Laws of conservation of mass. (2) Law of constant composition. (3) Law of multiple proportions. Explanation 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's constant, L= 6.02×10^{23} entities mol^{-1}. (3) Molar quantities and their uses. (4) Moles of electrons, atoms, molecules, formula units etc.

CONTENT	NOTES
(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. (2) Distinguishing between dilute solution and concentrated solution. (3) Basic, acidic and neutral solutions.
(ii) Concentration terms	Mass (g) or moles (mol) per unit volume. Emphasis on current IUPAC chemical terminology, symbols and conventions. Concentration be expressed as mass concentration, g dm^{-3}, molar concentration, mol dm^{-3}.
(iii) Standard solutions.	(1) Preparation of some primary standards e.g anhydrous Na_2CO_3, $(COOH)_2$, $2H_2O/H_2C_2O_4.2H_2O$. (2) Meaning of the terms primary standard, secondary standard and standard solution.
(e) Preparation of solutions from liquid solutes by the method of dilution.	Dilution factor

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CONTENT	NOTES
7.0 STATES OF MATTER (a) (i) Kinetic theory of matter.	(1) Postulates of the kinetic theory of matter. (2) Use of the kinetic theory to explain the following processes: melting of solids, boiling of liquids, evaporation of liquids, dissolution of solutes, Brownian motion and diffusion.
(ii) Changes of state of matter.	(1) Changes of state of matter should be explained in terms of movement of particles. It should be emphasized that randomness decreases (and orderliness increases) from gaseous state to liquid state and to solid state and vice versa. (2) Illustrations of changes of state using the different forms of water, iodine, sulphur, naphthalene etc. (3) Brownian motion to be illustrated using any of the following experiments: (a) pollen grains/powdered sulphur in water (viewed under a microscope); (b) smoke in a glass container illuminated by a strong light from the side; (c) a dusty room being swept and viewed from outside under sunlight.
(iii) Diffusion	(1) Experimental demonstration of diffusion of two gases. (2) Relationship between speed at which different gas particles move and the masses of particles. (3) Experimental demonstration of diffusion of solute particles in liquids.
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CONTENT	NOTES
(b) Gases:	
(i) Characteristics and nature of gases;	Arrangement of particles, density, shape and compressibility.
(ii) The gas laws;	The Gas laws: Charles'; Boyle's; Dalton's law of partial pressure; Graham's law of diffusion, Avogadro's law. 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 law PV= nRT Ideal and Real gases Factors responsible for the deviation of real gases from ideal situation.
(iii) Laboratory preparation and properties of some gases.	(1) Preparation of the following gases: H_2, NH_3 and CO_2. Principles of purification and collection of gases. (2) Physical and chemical properties of the gases.
(c) (i) Liquids	Characteristics and nature of liquids based on the arrangement of particles, shape, volume, compressibility, density and viscosity.
(ii) Vapour and gases.	(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.

CONTENT	NOTES
(d) Solids: (i) Characteristics and nature;	(1) Ionic, metallic, covalent network and molecular solids. Examples in each case. (2) Arrangements of particles ions, molecules and atoms in the solid state.
(ii) Types and structures;	Relate the properties of solids to the type of interatomic and intermolecular bonding in the solids. Identification of the types of chemical bonds in graphite and differences in the physical properties.
(iii) Properties of solids.	
(e) Structures, properties and uses of diamond and graphite.	The uses of diamond and graphite related to the structure. The use of iodine in everyday life.
(f) Determination of melting points of covalent solids.	Melting points as indicator of purity of solids e.g. Phenyl methanedioic acid (benzoic acid), ethanedioic acid (oxalic) and ethanamide.
8.0 ENERGY AND ENERGY CHANGES (a) Energy and enthalpy	Explanation of the terms energy and enthalpy. Energy changes associated with chemical processes.
(b) Description, definition and illustrations of energy changes and their 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.

CONTENT	NOTES
9.0 ACIDS, BASES AND SALTS (a) Definitions of acids and bases.	(1) Arrhenius concepts of acids and bases in terms of H_3O^+ and OH^- ions in water. (2) Effects of acids and bases on indicators, metal Zn, Fe and trioxocarbonate (IV) salts and hydrogentrioxocarbonate (IV) salts.
(b) Physical and chemical properties of acids and bases.	Characteristic properties of acids and bases in aqueous solution to include: (a) conductivities, taste, litmus/indicators, feel etc.; (b) balanced chemical equations of all reactions.
(c) Acids, bases and salts as electrolytes.	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. (4) Behaviour of weak acids and weak bases in water as example of equilibrium systems.
(e) Concept of pH	(1) Definition of pH and knowledge of pH scale. (2) Measurement of pH of solutions using pH meter, calometric methods or universal indicator. (3) Significance of pH values in everyday life e.g. acid rain, pH of soil, blood, urine.

CONTENT	NOTES
(f) Salts:	Meaning of salts. Types of salts: normal, acidic, basic, double and complex salts.
(i) Laboratory and industrial preparation of salts; (ii) Uses;	(1) Description of laboratory and industrial production of salts. (2) Mining of impure sodium chloride and conversion into granulated salt. (3) Preparation of NaOH, Cl_2 and H_2.
(iii) Hydrolysis of salt.	(1) Explanation of how salts forms acidic, alkaline and neutral aqueous solutions. (2) Behaviour of some salts (e.g NH_4Cl, $AlCl_3$, 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 aqueous solution. Examples to be taken from group 1, group 2, group 3 and the d-block element.
(g) Deliquescent, efflorescent and hygroscopic compound.	Use of hygroscopic compounds as drying agent should be emphasized.
(h) Acid-Base indicators	(1) Qualitative description of how acid-base indicator works. (2) Indicators as weak organic acids or bases (organic dyes). (3) Colour of indicator at any pH dependent on relative amounts of acid and forms. (4) Working pH ranges of methyl orange and phenolphthalein.
(i) Acid-Base titration	(1) Knowledge and correct use of relevant apparatus. (2) Knowledge of how acid-bases indicators work in titrations.

CONTENT	NOTES
	(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	(1) Meaning of Solubility. (2) Saturated and unsaturated solutions. (3) Saturated solution as an equilibrium system. (4) Solubility expressed in terms of: mol dm^{-3} and g dm^{-3} of solution/solvent. (5) Solubility curves and their uses. (6) Effect of temperature on solubility of a substance. (7) Relationship between solubility and crystallization. (8) Crystallization/recrystallization as a method of purification. (9) Knowledge of soluble and insoluble salts of stated cations and anions.
(b) Practical application of solubility.	(10) Calculations on solubility. Generalization about solubility of salts and their applications to qualitative analysis. e.g. 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-}

	Explanation of solubility rules.
CONTENT	**NOTES**
11.0 CHEMICAL KINETICS AND EQUILIBRIUM SYSTEM	
(a) Rate of reactions:	(1) Definition of reaction rate. (2) Observable physical and changes: colour, mass, temperature, pH, formation of precipitate etc.
(i) Factors affecting rates;	(1) Physical states, concentration/ pressure of reactants, temperature, catalysts, light, particle size and nature of reactants. (2) Appropriate experimental demonstration for each factor is required.
(ii) Theories of reaction rates;	(1) Collision and transition state theories to be treated qualitatively only. (2) Factors influencing collisions: temperature and concentration. (3) Effective collision. (4) Activation energy. (5) Energy profile showing activation energy and enthalpy change.
(iii) Analysis and interpretation of graphs.	Drawing of graphs and charts.
(b) Equilibrium: (i) General Principle;	Explanation of reversible and irreversible reactions. Reversible reaction 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 reactions.

CONTENT	NOTES
(ii) Le Chatelier's principle.	Prediction of the effects of external influence of concentration, temperature pressure and volume changes on equilibrium systems.
12.0 REDOX REACTIONS (a) Oxidation and reduction process.	(1) Oxidation and reduction in terms of: (a) addition and removal of oxygen and hydrogen; (b) loss and gain of electrons; (c) change in oxidation numbers/states. (2) Determination of oxidation numbers/states.
(b) Oxidizing and reducing agents.	
(c) Redox equations	
(d) Electrochemical cells: (i) Standard electrode potential;	(1) Description of oxidizing and reducing agents in terms of: (a) addition and removal of oxygen and hydrogen; (b) loss and gain of electrons; (c) change in oxidation numbers/state.
(ii) Drawing of cell diagram and writing cell notation.	Balancing redox equations by: (a) ion, electron or change in oxidation number/states; (b) half reactions and overall reaction.
CONTENT	Definition/Explanation (1) Standard hydrogen electrode: meaning of standard electrode potential ($E^{\ominus}$) and its measurement. (2) Only metal/metal ion systems should be used.

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(iii) e.m.f of cells;	(1) Electrochemical cells as a combination of two half-cells. (2) The meaning of magnitude and sign of the e.m.f.
(iv) Application of Electrochemical cells.	(1) Distinction between primary and secondary cells (2) Daniell cell, lead acid battery cell, dry cells, fuel cells and their use as generators of electrical energy from chemical reactions.
(e) Electrolysis: (i) Electrolytic cells;	Definition.
(ii) Principles of electrolysis;	Comparison of electrolytic and electrochemical cells; weak and strong electrolyte.
(iii) Factors influencing discharge of species;	Mechanism of electrolysis.
(iv) Faraday's laws;	Limit electrolytes to molten $PbBr_2$ and NaCl, dilute NaCl solution, concentrated NaCl solution, $CuSO_{4(aq)}$, dilute H_2SO_4, $NaOH_{(aq)}$ and $CaCl_{2(aq)}$ (using platinum or graphite and copper electrodes).
(v) Practical application; **CONTENT**	Simple calculations based on the relation 1F= 96,500 C and mole ratios to determine mass, volume of gases, number of entities, charges etc. using half and overall reactions. Electroplating, extraction and purification of metals.

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(vi) Corrosion of metals.	(1) Corrosion treated as a redox process. (2) Rusting of iron and its economic costs. (3) Prevention based on relative magnitude of electrode potentials and preventive methods like galvanizing, sacrificial/cathodic protection and non-redox methods (painting, greasing/oiling etc.).
13.0 CHEMISTRY OF CARBON COMPOUNDS (a) Classification (b) Functional group	Broad classification into straight chain, branched chain, aromatic and alicyclic compounds.
(b) Separation and purification of organic compounds. (c) Petroleum/crude oil	Systematic nomenclature of compounds with the following functional groups: alkanes, alkenes, alkynes, hydroxyl compounds (aliphatic and aromatic), alkanoic acids, alkyl alkanoates (esters and salts) and amines.
CONTENT	Methods to be discussed should include: distillation; crystallization; drying and chromatography. (1) Composition and classification. (2) Fractional distillation and major products. (3) Cracking and reforming. (4) Petro-chemicals: sources; uses e.g. as starting materials of organic synthesis. (5) Quality of petrol, meaning of octane number and its importance to the

	petroleum industry. **NOTES**
(d) Determination of empirical and molecular formulae and molecular structures of organic compounds. (e) General properties of organic compounds: (i) Homologous series;	
(ii) Isomerism.	(1) Gradation in physical properties. (2) Effects on the physical properties by introduction of active groups into the inert alkane.
(f) Alkanes: (i) Sources, properties;	(1) Examples should be limited to compounds having maximum of five carbon atoms. (2) Differences between structural and geometric/stereo isomerism.
(ii) Uses.	
(g) Alkenes: (i) Sources and properties; **CONTENT**	(1) Laboratory and industrial preparations and other sources. (2) Nomenclature and structure. (3) Reactivity: (a) combustion; (b) substitution reactions; (c) cracking of large alkane molecules. As fuels, as starting materials for synthesis. Uses of haloakanes and pollution effects.
	(1) Laboratory preparation. (2) Nomenclature and structure.

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(ii) Uses; (iii) Laboratory detection.	(3) Addition reactions with halogens hydrogen, bromine water, hydrogen halides and acidified water. (4) Oxidation: hydroxylation with aqueous $KMnO_4$. (5) Polymerization.
(h) Alkynes: (i) Sources, characteristic properties and uses;	Use of reaction with Br_2/water, Br_2/CCl_4 and $KMnO_{4(aq)}$ as means of characterizing alkenes.
(ii) Chemical reactions.	(1) Nomenclature and structure. (2) Industrial production of ethyne. (3) Uses of ethyne. (4) Distinguishing test between terminal and non-terminal alkynes. (5) Test to distinguish between alkane, alkene and alkyne.
(i) Benzene: (i) Structure and physical properties; (ii) Chemical properties.	Chemical reactions: halogenation, combustion, hydration and hydrogenation.
CONTENT	Resonance in benzene. Stability leading to substitution reactions.
	(1) Addition reactions: hydrogenation and halogenation (mechanism not required). (2) Compare reactions with those of alkenes.

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(J) Alkanols: (i) Sources, nomenclature and structure;	
	(1) Laboratory preparation including hydration of alkenes. (2) Industrial and local production of ethanol including alcoholic beverages,
(ii) Classification;	(3) Harmful impurities and methods of purification should be mentioned.
(iii) Physical properties;	
(iv) Chemical properties;	(4) Recognition of the structure of mono-, di- and triols.
	Primary, secondary and tertiary alkanols.
	Boiling point, solubility in water. Including hydrogen bonding effect.
(v) Laboratory test; (vi) Uses.	
(k) Alkanoic acids:	(1) Reaction with: (a) Na; (b) alkanoic acids (esterification); (c) conc. H_2SO_4.
(i) Sources, nomenclature and structure; (ii) Physical properties;	(2) Oxidation by: (a) $KMnO_{4(aq)}$; (b) $K_2Cr_2O_{7(aq)}$; (c) I_2 in $NaOH_{(aq)}$.
CONTENT	Laboratory test for ethanol.
	Methanoic acid –insect bite. Ethanoic acid – vinegar.
	Recognition of mono and dioic acid.
	Boiling point, solubility in water. Including hydrogen bonding effect.
	NOTES

(iii) Chemical properties; (iv) Laboratory test; (iv) Uses.	Acid properties only i.e. reactions with H_2O, NaOH, NH_3, $NaHCO_3$, Zn and Mg. Reaction with $NaHCO_3$, Na_2CO_3.
(l) Alkanoates as derivatives of alkanoic acids: (i) Sources, nomenclature, preparation and structure; (ii) Physical properties; (iii) Chemical properties; (iv) Uses.	Uses of ethanoic and phenyl methanoic (benzoic) acids as examples of aliphatic and aromatic acids respectively. Preparation of alkyl alkanoates (esters) from alkanoic acids. Solubility, boiling and melting point. Hydrolysis of alkyl alkanoates (mechanism not required). Uses of alkanoates to include production of soap, flavouring agent, plasticizers, as solvents and in perfumes.
14.0 CHEMISTRY, INDUSTRY AND THE ENVIRONMENT (a) Chemical industry	
CONTENT	(1) Natural resources in candidate's own country. (2) Chemical industries in candidate's own country and their corresponding raw materials. (3) Distinction between fine and heavy chemicals.
	NOTES

	(4) Factors that determine location of chemical industries. (5) Effect of industries on the community.
(b) Pollution: air, water and soil pollution;	
(c) Biotechnology.	(1) Sources, effects and control. (2) Greenhouse effect and depletion of the ozone layer. (3) Biodegradable and non-biodegradable pollutants.
15.0 BASIC BIOCHEMISTRY AND SYNTHETIC POLYMERS (a) Proteins:	
(i) Sources and properties;	Food processing, fermentation including production of gari, bread and alcoholic beverages e.g. Local gin.
(ii) Uses of protein. (b) Amino acids	Proteins as polymers of amino acids molecules linked by peptide or amide linkage.
CONTACT	Physical properties e.g. solubility Chemical properties to include: (a) hydrolysis of proteins; (b) laboratory test using Ninhydrin/Biuret reagent/Millons reagent.
	(1) Nomenclature and general structure of amino acids. (2) Difunctional nature of amino acids.
	NOTES
(c) Fats/oils:	As alkyl alkanoates (esters).

(i) Sources and properties;	From animals and plants. Physical properties such as solubility. Chemical properties: (a) acidic and alkaline hydrolysis; (b) hydrogenation; (c) test for fats and oil.
(ii) General structure of fats/oils;	
(iii) Preparation of soap;	As mono-, di-, and tri- esters of propane-1,2,3-triol (glycerol).
(iv) Uses of fats/oils.	
(d) Carbohydrates: (i) Sources and nomenclature;	(1) Preparation of soap (saponification) from fats and oils. (2) Comparison of soapless detergents and their action on soft and hard water.
(ii) Properties;	
CONTENT	(1) Classes of carbohydrates as: (a) monosaccharides; (b) disaccharides; (c) polysaccharides. (2) Name and components of various classes of carbohydrates. (1) Physical properties such as solubility of sugars. (2) Chemical properties- Hydrolysis of disaccharides into monosaccharides. (3) Test for reducing sugars using sugar strips, Fehling's or Benedict's solution or Tollens' reagent. **NOTES**
(iii) Carbohydrate as examples of polymer;	(1) Starch as a polymer made up of glucose units.

(iv) Uses.	(2) Condensation of monosaccharides to form disaccharides and polysaccharides.
(e) Synthetic polymers:	
(i) Properties;	(1) Definition of terms: monomers, polymers and polymerization. (2) Addition and condensation polymerization. (3) Classification and preparation based on the monomers and comonomers.
(ii) Uses of polymers.	(1) Thermoplastics and thermosets. (2) Modification of properties of polymers. (3) Plastics and resins. (4) Chemical test on plastics using: (a) heat; (b) acids; (c) alkalis.

SECTION B

(For candidates in Ghana only)

CONTENTS	NOTES
1.0 STRUCTURE OF THE ATOM (a) Elementary treatment of mass	(1) Qualitative knowledge of the mass

spectrometer.	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 electrons. (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 bombs. Balanced equations of nuclear reactions
(v) Effects and application of radioactivity	(1) Carbon dating (qualitative treatment only). (2) Use of radioactivity in agriculture, medicine and industries. (3) Hazards associated with nuclear radiations.
	Factors affecting stability of nuclides: Binding energy, neutron-proton ratio, and half life. 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.
CONTENTS	**NOTES**
(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.

(c) Physical and chemical properties of period 3 elements and their compounds.	(1) Comparison 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/$LiCO_3$/$CuSO_4$.
(d) Silicon	(1) Structures for SiO_2 and CO_2 account for the differences between physical and chemical properties of the two oxides. (2) Uses of silicon and its compounds e.g. ceramics, glass, silica gel and microchips.
(e) Periodic gradation of elements in group seven i.e. the halogens.	(1) Inter- atomic bond energies. (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 ions 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 e.g. $(Fe(CN)_6]^{3-}$, $[Cu(NH_3)_4]^{2+}$, $[Ag)NH_3)_2]^+$ $[Cu)CN)_4]^2$
(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.
CONTENTS	**NOTES**
(ii) Covalent character in ionic bond; (iii) Polar covalent bonds.	(1) Ionic character (polarity) in covalent bonds based on electronegativity difference between the species involved. (2) Effects of covalent and ionic character in

	ionic and covalent bonds on the solubility, thermal stability and boiling points of ionic and covalent compounds.
(b)(i) Hybridization of atomic orbitals.	Definition 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, BCl_3, C_2H_2, $BeCl_2$, 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_6H_6.
4.0 SOLUTIONS	
(a) Preparation of solutions from liquid solutes by the method of dilution.	(1) Outline of steps involved in the preparation of solutions from liquid solutes. (2) Determination of concentration of liquid solutes (stock solution) given the density, w/v, w/w), specific gravity, relative molecular mass, molar mass, and % purity. (3) 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 and closed. (2) Enthalpy change involved in the following processes: combustion, atomization, sublimation, hydration/salvation and dissolution.
(b) Hess's Law of heat summation and Born-Haber cycle.	Explanation of Hess's law and its application in the development of the Born-Haber cycle. (1) Use of difference cycles to illustrate Hess's law.
CONTENTS	**NOTES**
	(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. (2) Examples of buffers from the laboratory. (3) Preparation of buffer solutions.
CONTENTS	**NOTES**
(e) Acid base titrations	Double indicator titrations (continuous and Discontinuous) and back titration. Calculations involving concentration, composition and % purity. Graphs for acid-based 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**.**	(1) Explanation of solubility products (Ksp) of sparingly soluble ionic compounds. (2) Calculations involving solubility and solubility products. (3) Factors affecting solubility**.**
(c) 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 rate law from experimental data. (2) Simple relationship between rates and concentration of zero, first and second order reactions. Graphical representation of zero, first and second order reactions. (3) Half-life for first order reactions 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	
CONTENTS	**NOTES**
(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 heterogeneous equilibrium systems.
9.0 CHEMISTRY OF CARBON COMPOUNDS (a) Separation and Purification.	Other methods should include solvent extraction and melting point determinations.
(b) Determination of empirical and molecular formulae.	Outline of steps in: (a) Detection of N, S and the halogens. (b) 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 alkenes towards certain reagents. Uses of hexachlorocyclohexane and benzene hexachloride (BHC).
CONTENT	**NOTES**
10.0 CHEMICAL INDUSTRY AND ENVIRONMENT	
(a) (i) Sources of raw materials (ii) Mining of mineral as ore.	Location of mineral deposits and their nature.

(iii) Extraction of metals Mineral deposits in Ghana.	(1) Metals – gold, bauxite, manganese and iron. (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) Sources of raw materials for cement 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)

CONTENT	NOTES

1.0 NON METALS AND THEIR COMPOUNDS	
(a) Carbon:	
(i) Allotropes of carbon;	(1) Graphite, diamond and amorphous Carbon; (2) Structures, properties and uses. (3) The uses of the allotropes should be correlated with their properties and structures. (4) Combustion of allotropes.
(ii) Coal:	
I. Types;	Different types should include anthracite, peat and lignite.
II. Destructive distillation of coal and uses of the products.	
(iii) Coke:	
I. Classification and uses; II. Manufacture of synthetic gas and uses.	Water gas and producer gas.
(iv) Oxides of carbon	
I. Carbon (IV) oxides;	(1) Laboratory preparation. (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.
CONTENT	**NOTES**
(b) Oxygen:	
(i) Laboratory and industrial preparation;	
(ii) Properties and uses;	Test for oxygen will be required.

(iii) Binary compounds of oxygen: acidic, basic, amphoteric and neutral oxides.	
(c) Hydrogen: (i) Laboratory preparations; (ii) Properties and uses.	Test for hydrogen will be required.
(d) Water and solution: (i) Composition of water;	Test for water will be required. Reference should be made to the electrolysis of acidified water.
(ii) Water as a solvent; (iii) Hardness of water, causes and methods of removing it;	(1) Advantages and disadvantages of hard water and soft water. (2) Experiments to compare the degrees of hardness in different samples of water.
(iv) Treatment of water for town supply.	
(e) Halogens:	Redox properties of the elements; displacement reaction of one halogen by another**.**
(i) Chlorine: I. Laboratory preparation; II. Properties and reactions.	Properties should include: (a) variable oxidation states; (b) reaction with water and alkali (balanced equation required).
(f) Hydrogen chloride gas: (i) Laboratory preparation; (ii) Properties and uses;	(1) Test for HCl gas. (2) Fountain experiment.
CONTENT	**NOTES**
(iii) Uses of halogen compounds.	Uses should include silver halide in photography and sodium oxochlorate (I) as a bleaching agent.
(g) Nitrogen:	Both laboratory and industrial preparations

(i) Preparation and properties;	from liquefied air are required.
(ii) Uses of nitrogen;	
(iii) Compounds of nitrogen:	
I. Ammonia;	(1) Laboratory and industrial preparations. (2) Properties and uses. (3) Test for ammonia. (4) Fountain experiment.
II. Trioxonitrate (V) acid;	(1) Laboratory preparation. (2) Properties and uses.
III. Trioxonitrate (V) salts.	(1) Action of heat will be required. (2) Test for trioxonitrate (V) ions.
(h) Sulphur: (i) Allotropes and uses; (ii) Compound of sulphur; (iii) Trioxosulphate (IV) acids and its salts; (iv) Tetraoxosulphate (VI) acid: industrial preparation, reactions and uses.	Contact process should be discussed.
(i) The noble gases: properties and uses.	(1) Raw materials, processing, main products and by-products. (2) Uses of metals.
2.0 METALS AND THEIR COMPOUNDS (a) Extraction of metals: (i) Aluminium; (ii) Iron; (iii) Tin.	Common alloys of Cu, Al, Pb, Fe, Sn and their uses.
(b) Alloys.	**NOTES**
CONTENT	
(c) Properties and uses of sodium and its compounds.	Compounds must be limited to NaCl, NaOH, Na_2CO_3, $NaNO_3$, Na_2SO_4 and NaClO.
(d) Properties and uses of calcium and its	The compounds must be limited to $CaCO_3$, CaO, $CaSO_4$, $CaCl_2$, and

compounds. (e) Reactivity of iron and aluminium with air, water and acids. (f) Properties and uses of copper and its compounds.	$Ca(OH)_2$ The compounds must be limited to $CuSO_4$, CuO and $CuCl_2$.

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) Filtration, recrystallisation and melting point determination;

(iv) Measurement of heats of neutralization and solutions;

(v) Determination of pH value of various solutions by colorimetry;

(vi) Determination of rates of reaction from concentration versus 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 methods (Ghanaians only).
(vi) Stoichiometry of reactions.

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 KI versus $S_2O_3^{2-}$.

(d) QUALITATIVE ANALYSIS

No formal scheme of analysis is required**.**

(i) Characteristic tests of the following cations with dilute $NaOH_{(aq)}$ and $NH_{3(aq)}$;

NH_4; Ca^{2+}; Pb^{2+}; Cu^{2+}; Fe^{2+}; Fe^{3+}; Al^{3+}; and Zn^{2+}.

(ii) Confirmatory tests for the above cations.

(iii) Characteristic reaction of dilute HCl on solids or aqueous solutions and conc. H_2SO_4 on solid samples of the following:
Cl^- ; 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 tests for the following gases: H_2; NH_3; CO_2; HCl and SO_2.

(vii) Characteristic test tube reactions of the functional groups in the following simple organic compounds: Alkenes; alkanols; alkanoic acids, sugars (using Fehling's and Benedict's solutions only); starch (iodine test only) and proteins (using the Ninhydrin test, Xanthoproteic test, Biuret test and Millon's test only).