

# **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 discipline;
- (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 (ie 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
<b>1.0 INTRODUCTION TO CHEMISTRY</b> (a) (i) Measurement of physical quantities.  (ii) Scientific measurements and their importance in chemistry.  (b) Scientific Methods	(1) Measurement of mass, length, time, temperature and volume. (2) Appropriate SI units and significant figures. (3) Precision and accuracy in measurement.  Outline the scientific method to include: Observation, hypothesis, experimentation, formulation of laws and theories.
<b>2.0 STRUCTURE OF THE ATOM</b> (a) Gross features of the atom.  (b) (i) Atomic number/proton number, number of neutrons, isotopes, atomic mass, mass number.	(1) Short account of Dalton's atomic theory and limitations, J.J. Thompson'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.  Meaning and representation in symbols of atoms and sub-atomic particles.

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<p>(ii) Relative atomic mass (<math>A_r</math>) and relative molecular mass (<math>M_r</math>) based on Carbon-12 scale.</p> <p>(iii) Characteristics and nature of matter.</p> <p>(c) Particulate nature of matter: physical and chemical changes.</p> <p>(d) (i) Electron Configuration</p> <p>(ii) Orbitals</p> <p>(iii) Rules and principles for filling in electrons.</p>	<p>(1) Atomic mass as the weighted average mass of isotopes. Calculation of relative mass of chlorine should be used as an example.</p> <p>(2) Carbon-12 scale as a unit of measurement. Definition of atomic mass unit.</p> <p>Atoms, molecules and ions. Definition of particles and treatment of particles as building blocks of matter.</p> <p>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.</p> <p>Detailed electron configurations (s,p,d) for atoms of the first thirty elements.</p> <p>Origin of s,p and d orbitals as sub-energy levels; shapes of s and p orbitals only.</p> <p>(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.</p>

CONTENT	NOTES
<p><b>3.0 STANDARD SEPARATION TECHNIQUES FOR MIXTURES</b></p> <p>(a) Classification of mixtures.</p> <p>(b) Separation techniques</p> <p>(c) Criteria for purity.</p> <p><b>4.0 PERIODIC CHEMISTRY</b></p> <p>(a) Periodicity of the elements.</p> <p>(b) Different categories of elements in the periodic table.</p> <p>(c) Periodic law:</p> <p>(i) Trends on periodic table;</p> <p>(ii) Periodic gradation of the elements in the third period (Na - Ar).</p>	<p>Solid-solid, solid-liquid, liquid-liquid, gas-gas with examples.</p> <p>Crystallization, distillation, precipitation, magnetization, chromatography, sublimation etc.</p> <p>Boiling point for liquids and melting point for solids.</p> <p>Electron configurations leading to group and periodic classifications.</p> <p>Metals, semi-metals, non-metals in the periodic table and halogens. Alkali metals, alkaline earth metals and transition metals as metals.</p> <p>Explanation of the periodic law.</p> <p>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.</p> <p>(1) Progression from:</p> <p>(i) metallic to non-metallic character of element;</p> <p>(ii) ionic to covalent bonding in compounds.</p>

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<p>(d) Reactions between acids and metals, their oxides and trioxocarbonates (IV).</p> <p>(e) Periodic gradation of elements in group seven, the halogens: F, Cl, Br and I.</p> <p>(f) Elements of the first transition series.  <math>_{21}\text{Sc} - _{30}\text{Zn}</math></p>	<p>(2) Differences and similarities in the properties between the second and the third period elements should be stated.</p> <p>(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.</p> <p>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).</p> <p>(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).</p>

CONTENT	NOTES
<p><b>5.0 CHEMICAL BONDS</b></p> <p>(a) Interatomic bonding</p> <p>(b)(i) Formation of ionic bonds and compounds.</p> <p>(ii) Properties of ionic compounds.</p> <p>(c) Naming of ionic compounds.</p> <p>(d) Formation of covalent bonds and compounds.</p> <p>(e) (i) Properties of covalent compounds.</p> <p>(ii) Coordinate (dative) covalent bonding.</p>	<p>(4) Other properties of transition metals should include:</p> <ul style="list-style-type: none"> <li>(a) variable oxidation states;</li> <li>(b) formation of coloured compounds;</li> <li>(c) complex formation;</li> <li>(d) catalytic abilities;</li> <li>(e) paramagnetism;</li> <li>(f) hardness.</li> </ul> <p>Meaning of chemical bonding. Lewis dot structure for simple ionic and covalent compounds.</p> <p>Formation of stable compounds from ions. Factors influencing formation: ionization energy; electron affinity and electronegativity difference.</p> <p>Solubility in polar and non-polar solvents, electrical conductivity, hardness and melting point.</p> <p>IUPAC system for simple ionic compounds.</p> <p>Factors influencing covalent bond formation. Electron affinity, ionization energy, atomic size and electronegativity.</p> <p>Solubility in polar and non-polar solvents, melting point, boiling point and electrical conductivity.</p> <p>Formation and difference between pure covalent and coordinate (dative) covalent bonds.</p>

CONTENT	NOTES
(f) Shapes of molecular compounds.	Linear, planar, tetrahedral and shapes for some compounds e.g. $\text{BeCl}_2$ , $\text{BF}_3$ , $\text{CH}_4$ , $\text{NH}_3$ , $\text{CO}_2$ .
(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) Inter molecular 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 Waal's 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 Waal's forces; and variation in the boiling points of $\text{H}_2\text{O}$ , and $\text{H}_2\text{S}$ explained using Hydrogen bonding.
(iii) van der Waals forces	
(iv) Comparison of all bond types.	



CONTENT	NOTES
<p><b>6.0 STOICHIOMETRY AND CHEMICAL REACTIONS</b></p> <p>(a) (i) Symbols, formulae and equations.</p> <p>(ii) chemical symbols</p> <p>(iii) Empirical and molecular formulae.</p> <p>(iv) Chemical equations and IUPAC names of chemical compounds.</p> <p>(v) Laws of chemical combination.</p> <p>(b) Amount of substance.</p>	<p>Symbols of the first thirty elements and other common elements that are not among the first thirty elements.</p> <p>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.</p> <p>(1) Combustion reactions (including combustion of simple hydrocarbons)</p> <p>(2) Synthesis</p> <p>(3) Displacement or replacement</p> <p>(4) Decomposition</p> <p>(5) Ionic reactions</p> <p>(1) Laws of conservation of mass.</p> <p>(2) Law of constant composition.</p> <p>(3) Law of multiple proportions. Explanation of the laws to balance given equations.</p> <p>(4) Experimental illustration of the law of conservation of mass.</p> <p>(1) Mass and volume measurements.</p> <p>(2) The mole as a unit of measurement; Avogadro's constant, <math>L = 6.02 \times 10^{23}</math> entities <math>\text{mol}^{-1}</math>.</p> <p>(3) Molar quantities and their uses.</p> <p>(4) Moles of electrons, atoms, molecules, formula units etc.</p>

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, $\text{g dm}^{-3}$ , molar concentration, $\text{mol dm}^{-3}$ .
(iii) Standard solutions.	(1) Preparation of some primary standards e.g anhydrous $\text{Na}_2\text{CO}_3$ , $(\text{COOH})_2 \cdot 2\text{H}_2\text{O}$ / $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ . (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



CONTENT	NOTES
<p>(b) Gases:</p> <p>(i) Characteristics and nature of gases;</p> <p>(ii) The gas laws;</p> <p>(iii) Laboratory preparation and properties of some gases.</p> <p>(c) (i) Liquids</p> <p>(ii) Vapour and gases.</p>	<p>Arrangement of particles, density, shape and compressibility.</p> <p>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 <math>PV = nRT</math></p> <p>Ideal and Real gases</p> <p>Factors responsible for the deviation of real gases from ideal situation.</p> <p>(1) Preparation of the following gases: <math>H_2</math>, <math>NH_3</math> and <math>CO_2</math>. Principles of purification and collection of gases.</p> <p>(2) Physical and chemical properties of the gases.</p> <p>Characteristics and nature of liquids based on the arrangement of particles, shape, volume, compressibility, density and viscosity.</p> <p>(1) Concept of vapour, vapour pressure, saturated vapour pressure, boiling and evaporation.</p> <p>(2) Distinction between vapour and gas.</p> <p>(3) Effect of vapour pressure on boiling points of liquids.</p> <p>(4) Boiling at reduced pressure.</p>

CONTENT	NOTES
<p>(d) Solids:</p> <p>(i) Characteristics and nature;</p> <p>(ii) Types and structures;</p> <p>(iii) Properties of solids.</p> <p>(e) Structures, properties and uses of diamond and graphite.</p> <p>(f) Determination of melting points of covalent solids.</p>	<p>(1) Ionic, metallic, covalent network and molecular solids. Examples in each case.</p> <p>(2) Arrangements of particles ions, molecules and atoms in the solid state.</p> <p>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.</p> <p>The uses of diamond and graphite related to the structure.</p> <p>The use of iodine in everyday life.</p> <p>Melting points as indicator of purity of solids e.g. Phenyl methanedioic acid (benzoic acid), ethanedioic acid (oxalic) and ethanamide.</p>
<p><b>8.0 ENERGY AND ENERGY CHANGES</b></p> <p>(a) Energy and enthalpy</p> <p>(b) Description, definition and illustrations of energy changes and their effects.</p>	<p>Explanation of the terms energy and enthalpy. Energy changes associated with chemical processes.</p> <p>(1) Exothermic and endothermic processes.</p> <p>(2) Total energy of a system as the sum of various forms of energy e.g. kinetic, potential, electrical, heat, sound etc.</p> <p>(3) Enthalpy changes involved in the following processes: combustion, dissolution and neutralization.</p>



CONTENT	NOTES
<p>(f) Salts:</p> <p>(i) Laboratory and industrial preparation of salts;</p> <p>(ii) Uses;</p> <p>(iii) Hydrolysis of salt.</p> <p>(g) Deliquescent, efflorescent and hygroscopic compound.</p> <p>(h) Acid-Base indicators</p> <p>(i) Acid-Base titration</p>	<p>Meaning of salts.</p> <p>Types of salts: normal, acidic, basic, double and complex salts.</p> <p>(1) Description of laboratory and industrial production of salts.</p> <p>(2) Mining of impure sodium chloride and conversion into granulated salt.</p> <p>(3) Preparation of NaOH, Cl<sub>2</sub> and H<sub>2</sub>.</p> <p>(1) Explanation of how salts forms acidic, alkaline and neutral aqueous solutions.</p> <p>(2) Behaviour of some salts (e.g NH<sub>4</sub>Cl, AlCl<sub>3</sub>, Na<sub>2</sub>CO<sub>3</sub>, CH<sub>3</sub>COONa) in water as examples of equilibrium systems.</p> <p>(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.</p> <p>Use of hygroscopic compounds as drying agent should be emphasized.</p> <p>(1) Qualitative description of how acid-base indicator works.</p> <p>(2) Indicators as weak organic acids or bases (organic dyes).</p> <p>(3) Colour of indicator at any pH dependent on relative amounts of acid and forms.</p> <p>(4) Working pH ranges of methyl orange and phenolphthalein.</p> <p>(1) Knowledge and correct use of relevant apparatus.</p> <p>(2) Knowledge of how acid-bases indicators work in titrations.</p>







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

CONTENT	NOTES
(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:	Definition.
(i) Electrolytic cells;	Comparison of electrolytic and electrochemical cells; weak and strong electrolyte.
(ii) Principles of electrolysis;	Mechanism of electrolysis.
(iii) Factors influencing discharge of species;	Limit electrolytes to molten $\text{PbBr}_2$ and $\text{NaCl}$ , dilute $\text{NaCl}$ solution, concentrated $\text{NaCl}$ solution, $\text{CuSO}_4(\text{aq})$ , dilute $\text{H}_2\text{SO}_4$ , $\text{NaOH}(\text{aq})$ and $\text{CaCl}_2(\text{aq})$ (using platinum or graphite and copper electrodes).
(iv) Faraday's laws;	Simple calculations based on the relation $1\text{F} = 96,500\text{ C}$ and mole ratios to determine mass, volume of gases, number of entities, charges etc. using half and overall reactions.
(v) Practical application;	Electroplating, extraction and purification of metals.

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<p>(vi) Corrosion of metals.</p> <p><b>13.0 CHEMISTRY OF CARBON COMPOUNDS</b></p> <p>(a) Classification</p> <p>(b) Functional group</p> <p>(b) Separation and purification of organic compounds.</p> <p>(c) Petroleum/crude oil</p>	<p>(1) Corrosion treated as a redox process.</p> <p>(2) Rusting of iron and its economic costs.</p> <p>(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.).</p> <p>Broad classification into straight chain, branched chain, aromatic and alicyclic compounds.</p> <p>Systematic nomenclature of compounds with the following functional groups: alkanes, alkenes, alkynes, hydroxyl compounds (aliphatic and aromatic), alkanolic acids, alkyl alkanolates (esters and salts) and amines.</p> <p>Methods to be discussed should include: distillation; crystallization; drying and chromatography.</p> <p>(1) Composition and classification.</p> <p>(2) Fractional distillation and major products.</p> <p>(3) Cracking and reforming.</p> <p>(4) Petro-chemicals: sources; uses e.g. as starting materials of organic synthesis.</p> <p>(5) Quality of petrol, meaning of octane number and its importance to the petroleum industry.</p>

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

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<p>(ii) Uses;</p> <p>(iii) Laboratory detection.</p> <p>(h) Alkynes:</p> <p>(i) Sources, characteristic properties and uses;</p> <p>(ii) Chemical reactions.</p> <p>(i) Benzene:</p> <p>(i) Structure and physical properties;</p> <p>(ii) Chemical properties.</p>	<p>(3) Addition reactions with halogens hydrogen, bromine water, hydrogen halides and acidified water.</p> <p>(4) Oxidation: hydroxylation with aqueous <math>\text{KMnO}_4</math>.</p> <p>(5) Polymerization.</p> <p>Use of reaction with <math>\text{Br}_2/\text{water}</math>, <math>\text{Br}_2/\text{CCl}_4</math> and <math>\text{KMnO}_{4(\text{aq})}</math> as means of characterizing alkenes.</p> <p>(1) Nomenclature and structure.</p> <p>(2) Industrial production of ethyne.</p> <p>(3) Uses of ethyne.</p> <p>(4) Distinguishing test between terminal and non-terminal alkynes.</p> <p>(5) Test to distinguish between alkane, alkene and alkyne.</p> <p>Chemical reactions: halogenation, combustion, hydration and hydrogenation.</p> <p>Resonance in benzene. Stability leading to substitution reactions.</p> <p>(1) Addition reactions: hydrogenation and halogenation (mechanism not required).</p> <p>(2) Compare reactions with those of alkenes.</p>

CONTENT	NOTES
<p>(J) Alkanols:</p> <p>(i) Sources, nomenclature and structure;</p> <p>(ii) Classification;</p> <p>(iii) Physical properties;</p> <p>(iv) Chemical properties;</p> <p>(v) Laboratory test;</p> <p>(vi) Uses.</p> <p>(k) Alkanoic acids:</p> <p>(i) Sources, nomenclature and structure;</p> <p>(ii) Physical properties;</p>	<p>(1) Laboratory preparation including hydration of alkenes.</p> <p>(2) Industrial and local production of ethanol including alcoholic beverages,</p> <p>(3) Harmful impurities and methods of purification should be mentioned.</p> <p>(4) Recognition of the structure of mono-, di- and triols.</p> <p>Primary, secondary and tertiary alkanols.</p> <p>Boiling point, solubility in water. Including hydrogen bonding effect.</p> <p>(1) Reaction with:</p> <p>(a) Na;</p> <p>(b) alkanoic acids (esterification);</p> <p>(c) conc. <math>\text{H}_2\text{SO}_4</math>.</p> <p>(2) Oxidation by:</p> <p>(a) <math>\text{KMnO}_{4(\text{aq})}</math>;</p> <p>(b) <math>\text{K}_2\text{Cr}_2\text{O}_{7(\text{aq})}</math>;</p> <p>(c) <math>\text{I}_2</math> in <math>\text{NaOH}_{(\text{aq})}</math>.</p> <p>Laboratory test for ethanol.</p> <p>Methanoic acid –insect bite.</p> <p>Ethanoic acid – vinegar.</p> <p>Recognition of mono and dioic acid.</p> <p>Boiling point, solubility in water. Including hydrogen bonding effect.</p>

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<p>(iii) Chemical properties;</p> <p>(iv) Laboratory test;</p> <p>(iv) Uses.</p> <p>(l) Alkanoates as derivatives of alkanoic acids:</p> <p>(i) Sources, nomenclature, preparation and structure;</p> <p>(ii) Physical properties;</p> <p>(iii) Chemical properties;</p> <p>(iv) Uses.</p>	<p>Acid properties only i.e. reactions with <math>\text{H}_2\text{O}</math>, <math>\text{NaOH}</math>, <math>\text{NH}_3</math>, <math>\text{NaHCO}_3</math>, <math>\text{Zn}</math> and <math>\text{Mg}</math>.</p> <p>Reaction with <math>\text{NaHCO}_3</math>, <math>\text{Na}_2\text{CO}_3</math>.</p> <p>Uses of ethanoic and phenyl methanoic (benzoic) acids as examples of aliphatic and aromatic acids respectively.</p> <p>Preparation of alkyl alkanoates (esters) from alkanoic acids.</p> <p>Solubility, boiling and melting point.</p> <p>Hydrolysis of alkyl alkanoates (mechanism not required).</p> <p>Uses of alkanoates to include production of soap, flavouring agent, plasticizers, as solvents and in perfumes.</p>
<p><b>14.0 CHEMISTRY, INDUSTRY AND THE ENVIRONMENT</b></p> <p>(a) Chemical industry</p>	<p>(1) Natural resources in candidate's own country.</p> <p>(2) Chemical industries in candidate's own country and their corresponding raw materials.</p> <p>(3) Distinction between fine and heavy chemicals.</p>



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

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<p>(c) Fats/oils:</p> <p>(i) Sources and properties;</p> <p>(ii) General structure of fats/oils;</p> <p>(iii) Preparation of soap;</p> <p>(iv) Uses of fats/oils.</p> <p>(d) Carbohydrates:</p> <p>(i) Sources and nomenclature;</p> <p>(ii) Properties;</p>	<p>As alkyl alkanoates (esters).</p> <p>From animals and plants.</p> <p>Physical properties such as solubility.</p> <p>Chemical properties:</p> <p>(a) acidic and alkaline hydrolysis;</p> <p>(b) hydrogenation;</p> <p>(c) test for fats and oil.</p> <p>As mono-, di-, and tri- esters of propane-1,2,3-triol (glycerol).</p> <p>(1) Preparation of soap (saponification) from fats and oils.</p> <p>(2) Comparison of soap less detergents and their action on soft and hard water.</p> <p>(1) Classes of carbohydrates as:</p> <p>(a) monosaccharides;</p> <p>(b) disaccharides;</p> <p>(c) polysaccharides.</p> <p>(2) Name and components of various classes of carbohydrates.</p> <p>(1) Physical properties such as solubility of sugars.</p> <p>(2) Chemical properties- Hydrolysis of disaccharides into monosaccharides.</p> <p>(3) Test for reducing sugars using sugar strips, Fehling's or Benedicts solution or Tollen's reagent.</p>

CONTENT	NOTES
<p>(iii) Carbohydrate as examples of polymer;</p> <p>(iv) Uses.</p> <p>(e) Synthetic polymers:</p> <p>(i) Properties;</p> <p>(ii) Uses of polymers.</p>	<p>(1) Starch as a polymer made up of glucose units.</p> <p>(2) Condensation of monosaccharides to form disaccharides and polysaccharides.</p> <p>(1) Definition of terms: monomers, polymers and polymerization.</p> <p>(2) Addition and condensation polymerization.</p> <p>(3) Classification and preparation based on the monomers and comonomers.</p> <p>(1) Thermoplastics and thermosets.</p> <p>(2) Modification of properties of polymers.</p> <p>(3) Plastics and resins.</p> <p>(4) Chemical test on plastics using:</p> <p>(a) heat;</p> <p>(b) acids;</p> <p>(c) alkalis.</p>

## SECTION B

*(For candidates in Ghana only)*

CONTENTS	NOTES
<b>1.0 STRUCTURE OF THE ATOM</b> (a) Elementary treatment of mass spectrometer.  (b) (i) Nuclear chemistry  (ii) Types and nature of radiations: alpha, beta particles and gamma radiation.  (iii) Radioactivity: induced/stimulated.  (iv) Nuclear reactions: fission and fusion in nuclear reactions.  (v) Effects and application of radioactivity	(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 electrons. (3) Quantum numbers and their importance.  Meaning of terms: Nucleons, nuclide.  Charges, relative mass and penetrating power of radiations. Meaning of radioactivity. Difference between spontaneous nuclear reactions (radioactivity) and induced nuclear reactions.  Natural and artificial radioactivity. Detection of radiation by Geiger-Muller counter.  Distinction between ordinary chemical reactions and nuclear reactions. Generations of electricity; atomic bombs. Balanced equations of nuclear reactions  (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
<b>2.0 PERIODIC CHEMISTRY</b> (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 $\text{CO}_3^{2-}$ and $\text{NO}_3^-$ of Li, Na, K, Mg and Ca. (4) Experiment to compare thermal stability of $\text{Na}_2\text{CO}_3/\text{LiCO}_3/\text{CuSO}_4$ .
(d) Silicon	(1) Structures for $\text{SiO}_2$ and $\text{CO}_2$ 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 $K_a$ 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 <ol style="list-style-type: none"> <li>(1) Formation of coordination compounds.</li> <li>(2) Nomenclature of complex ions and compounds (<math>\text{Cl}^-</math>, <math>\text{F}^-</math>, <math>\text{I}^-</math>, <math>\text{NO}_3^-</math>, <math>\text{NH}_3</math>, <math>\text{H}_2\text{O}</math>, <math>\text{SO}_4^{2-}</math>).</li> </ol>
(g) Shapes of complex compounds.	Tetrahedral, square planar, octahedral e.g. $(\text{Fe}(\text{CN})_6)^{3-}$ , $[\text{Cu}(\text{NH}_3)_4]^{2+}$ , $[\text{Ag}(\text{NH}_3)_2]^+$ $[\text{Cu}(\text{CN})_4]^{2-}$
(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).
<b>3.0. CHEMICAL BONDS</b>	
(a) Formation of Ionic bonds:	
(i) Factors that influence ionic bond formation;	Factors should include lattice energy.

CONTENTS	NOTES
<p>(ii) Covalent character in ionic bond; (iii) Polar covalent bonds.</p> <p>(b)(i) Hybridization of atomic orbitals.</p> <p>(ii) Formation of hybrid orbitals.</p> <p>(iii) Formation of sigma (<math>\sigma</math>) and pi (<math>\pi</math>) bonds.</p>	<p>(1) Ionic character (polarity) in covalent bonds based on electronegativity difference between the species involved.</p> <p>(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.</p> <p>Definition of Hybridization.</p> <p>(1) Description of <math>sp</math>, <math>sp^2</math>, <math>sp^3</math> hybrid orbitals.</p> <p>(2) Shapes of <math>sp</math>, <math>sp^2</math>, <math>sp^3</math> and <math>sp^3d^2</math> hybrid orbitals. Treatment should be limited to the following molecules only. <math>CH_4</math>, <math>H_2O</math>, <math>NH_3</math>, <math>BCl_3</math>, <math>C_2H_2</math>, <math>BeCl_2</math>, <math>C_2H_4</math> and <math>SF_6</math>.</p> <p>Description of sigma and pi bonds. Using <math>C_2H_2</math> and <math>C_6H_6</math>.</p>
<p><b>4.0 SOLUTIONS</b></p> <p>(a) Preparation of solutions from liquid solutes by the method of dilution.</p>	<p>(1) Outline of steps involved in the preparation of solutions from liquid solutes.</p> <p>(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.</p> <p>(3) Primary standard, secondary standard and standardized solution.</p>
<p><b>5.0 ENERGY AND ENERGY CHANGES</b></p> <p>(a) Energy changes in physical and isolated systems.</p> <p>(b) Hess's Law of heat summation and Born-Haber cycle.</p>	<p>(1) Definition and understanding of the meaning of the energy terms: systems, surroundings, open and closed.</p> <p>(2) Enthalpy change involved in the following processes: combustion, atomization, sublimation, hydration/solvation and dissolution.</p> <p>Explanation of Hess's law and its application in the development of the Born-Haber cycle.</p> <p>(1) Use of difference cycles to illustrate Hess's law.</p>

CONTENTS	NOTES
(c) Bond Energy	<p>(2) Simple calculations using chemical equations, energy cycles or diagrams with given energy changes.</p> <p>Explanation of bond energy and bond dissociation energy.</p> <p>(1) Bond energy as an average value. Differences in bond energy and bond dissociation energy.</p> <p>(2) Bond energy in molecules and its use in assessment of bond strength, energy content and enthalpy of reaction.</p> <p>(3) Calculations using summation of bond energies in reactants and products as a measure of enthalpy of reaction.</p>
<b>6.0 ACIDS, BASES AND SALTS</b>	
(a) Definitions of acids and bases.	<p>(1) Bronsted – Lowry and Lewis concept of acids and bases.</p> <p>(2) Conjugate acid-base pair concept in terms of equilibrium.</p>
(b) pH, pOH and $pK_w$	<p>(1) Ionic product constant of water <math>K_w = [H^+_{(aq)}][OH^-_{(aq)}] = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}</math>.</p> <p>(2) pH and pOH as a measure of acidity and alkalinity respectively <math>pH = -\log[H_3O^+]</math>.</p> <p>(3) Knowledge of pH scale.</p> <p>(4) Calculation of <math>[H^+]</math>, <math>[OH^-]</math> and the corresponding pH and pOH of given solutions.</p>
(c) Partial ionization of weak acids and weak bases.	<p>Explanation of <math>pK_a</math> and <math>pK_b</math> of weak acids and bases.</p> <p>(1) Behaviour of weak acids and weak bases in water as example of equilibrium systems.</p> <p>(2) Calculations involving <math>K_a</math>, <math>pK_a</math> and <math>K_b</math>, <math>pK_b</math>.</p> <p>(3) <math>K_a</math>, <math>pK_a</math> and <math>K_b</math>, <math>pK_b</math> as measurements of acid and basic strengths respectively.</p>
(d) Buffer Solutions	<p>(1) Qualitative definition of buffers.</p> <p>(2) Examples of buffers from the laboratory.</p> <p>(3) Preparation of buffer solutions.</p>

CONTENTS	NOTES
(e) Acid base titrations	<p>Double indicator titrations (continuous and Discontinuous) and back titration.</p> <p>Calculations involving concentration, composition and % purity.</p> <p>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.</p>
<p><b>7.0 SOLUBILITY OF SUBSTANCES</b></p> <p>(a) Solubility and solubility product.</p> <p>(c) Crystallization and recrystallization.</p>	<p>(1) Explanation of solubility products (<math>K_{sp}</math>) of sparingly soluble ionic compounds.</p> <p>(2) Calculations involving solubility and solubility products.</p> <p>(3) Factors affecting solubility.</p> <p>Explanation of the effect of lattice energy and hydration energy on crystallization and recrystallization.</p>
<p><b>8.0 CHEMICAL KINETICS AND EQUILIBRIUM SYSTEMS</b></p> <p>(a) Rate law and Order of reaction</p> <p>(b) Rate determining step of a multi-step reaction.</p> <p>(c) Equilibrium</p>	<p>(1) Deduction of order and rate law from experimental data.</p> <p>(2) Simple relationship between rates and concentration of zero, first and second order reactions. Graphical representation of zero, first and second order reactions.</p> <p>(3) Half-life for first order reactions and its significance.</p> <p>(4) General rate law equation.</p> <p>(5) Derivation of the rate expression from experimentally determined rate data:  <math>R = k[A]^x [B]^y</math> where <math>k</math> = rate constant.</p>



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.
<b>9.0 CHEMISTRY OF CARBON COMPOUNDS</b>	
(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 or reactions of benzene and alkenes.	Differences between the reactivity of benzene and alkenes towards certain reagents. Uses of hexachlorocyclobenzene and benzene hexachloride (BHC).

CONTENT	NOTES
<p><b>10.0 CHEMICAL INDUSTRY AND ENVIRONMENT</b></p> <p>(a) (i) Sources of raw materials (ii) Mining of mineral as ore.</p> <p>(iii) Extraction of metals Mineral deposits in Ghana.</p> <p>(b) Cement and its uses</p>	<p>Location of mineral deposits and their nature.</p> <p>(1) Metals – gold, bauxite, manganese and iron. (2) Precious stone – diamond. (3) Industrial mining of limestone <math>\text{CaCO}_3</math>, clay Kaolin, solar salt (4) Processing of Au, Al, Fe as main products (5) Uses of the metals</p> <p>(1) Sources of raw materials for cement sproduction. (2) Processes involved in the production of cement. (3) Uses of cement. (4) Environmental impact.</p>

## SECTION C

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

CONTENT	NOTES
<p><b>1.0 NON METALS AND THEIR COMPOUNDS</b></p> <p>(a) Carbon:</p> <p>(i) Allotropes of carbon;</p> <p>(ii) Coal:</p> <p style="padding-left: 40px;">I. Types;</p> <p style="padding-left: 40px;">II. Destructive distillation of coal and uses of the products.</p> <p>(iii) Coke:</p> <p style="padding-left: 40px;">I. Classification and uses;</p> <p style="padding-left: 40px;">II. Manufacture of synthetic gas and uses.</p> <p>(iv) Oxides of carbon</p> <p style="padding-left: 40px;">I. Carbon (IV) oxides;</p> <p style="padding-left: 40px;">II. Carbon (II) oxides;</p> <p style="padding-left: 40px;">III. Trioxocarbonate (IV) salt.</p>	<p>(1) Graphite, diamond and amorphous Carbon;</p> <p>(2) Structures, properties and uses.</p> <p>(3) The uses of the allotropes should be correlated with their properties and structures.</p> <p>(4) Combustion of allotropes.</p> <p>Different types should include anthracite, peat and lignite.</p> <p>Water gas and producer gas.</p> <p>(1) Laboratory preparation.</p> <p>(2) Properties and uses.</p> <p>(3) Test for carbon (IV) oxides.</p> <p>Properties and uses only.</p> <p>(1) Properties: solubility, action of heat, reaction with dilute acid.</p> <p>(2) Uses.</p>

CONTENT	NOTES
<p>(b) Oxygen:</p> <ul style="list-style-type: none"> <li>(i) Laboratory and industrial preparation;</li> <li>(ii) Properties and uses;</li> <li>(iii) Binary compounds of oxygen: acidic, basic, amphoteric and neutral oxides.</li> </ul> <p>(c) Hydrogen:</p> <ul style="list-style-type: none"> <li>(i) Laboratory preparations;</li> <li>(ii) Properties and uses.</li> </ul> <p>(d) Water and solution:</p> <ul style="list-style-type: none"> <li>(i) Composition of water;</li> <li>(ii) Water as a solvent;</li> <li>(iii) Hardness of water, causes and methods of removing it;</li> <li>(iv) Treatment of water for town supply.</li> </ul> <p>(e) Halogens:</p> <ul style="list-style-type: none"> <li>(i) Chlorine: <ul style="list-style-type: none"> <li>I. Laboratory preparation;</li> <li>II. Properties and reactions.</li> </ul> </li> </ul> <p>(f) Hydrogen chloride gas:</p> <ul style="list-style-type: none"> <li>(i) Laboratory preparation;</li> <li>(ii) Properties and uses;</li> </ul>	<p>Test for oxygen will be required.</p> <p>Test for hydrogen will be required.</p> <p>Test for water will be required. Reference should be made to the electrolysis of acidified water.</p> <ul style="list-style-type: none"> <li>(1) Advantages and disadvantages of hard water and soft water.</li> <li>(2) Experiments to compare the degrees of hardness in different samples of water.</li> </ul> <p>Redox properties of the elements; displacement reaction of one halogen by another.</p> <p>Properties should include:</p> <ul style="list-style-type: none"> <li>(a) variable oxidation states;</li> <li>(b) reaction with water and alkali (balanced equation required).</li> </ul> <ul style="list-style-type: none"> <li>(1) Test for HCl gas.</li> <li>(2) Fountain experiment.</li> </ul>

CONTENT	NOTES
<p>(iii) Uses of halogen compounds.</p> <p>(g) Nitrogen:</p> <p>(i) Preparation and properties;</p> <p>(ii) Uses of nitrogen;</p> <p>(iii) Compounds of nitrogen:</p> <p>I. Ammonia;</p> <p>II. Trioxonitrate (V) acid;</p> <p>III. Trioxonitrate (V) salts.</p> <p>(h) Sulphur:</p> <p>(i) Allotropes and uses;</p> <p>(ii) Compound of sulphur;</p> <p>(iii) Trioxosulphate (IV) acids and its salts;</p> <p>(iv) Tetraoxosulphate (VI) acid: industrial preparation, reactions and uses.</p> <p>(i) The noble gases: properties and uses.</p> <p><b>2.0 METALS AND THEIR COMPOUNDS</b></p> <p>(a) Extraction of metals:</p> <p>(i) Aluminium;</p> <p>(ii) Iron;</p> <p>(iii) Tin.</p> <p>(b) Alloys.</p>	<p>Uses should include silver halide in photography and sodium oxochlorate (I) as a bleaching agent.</p> <p>Both laboratory and industrial preparations from liquefied air are required.</p> <p>(1) Laboratory and industrial preparations. (2) Properties and uses. (3) Test for ammonia. (4) Fountain experiment.</p> <p>(1) Laboratory preparation. (2) Properties and uses.</p> <p>(1) Action of heat will be required. (2) Test for trioxonitrate (V) ions.</p> <p>Contact process should be discussed.</p> <p>(1) Raw materials, processing, main products and by-products. (2) Uses of metals.</p> <p>Common alloys of Cu, Al, Pb, Fe, Sn and their uses.</p>

CONTENT	NOTES
<p>(c) Properties and uses of sodium and its compounds.</p> <p>(d) Properties and uses of calcium and its compounds.</p> <p>(e) Reactivity of iron and aluminium with air, water and acids.</p> <p>(f) Properties and uses of copper and its compounds.</p>	<p>Compounds must be limited to NaCl, NaOH, Na<sub>2</sub>CO<sub>3</sub>, NaNO<sub>3</sub>, Na<sub>2</sub>SO<sub>4</sub> and NaClO.</p> <p>The compounds must be limited to CaCO<sub>3</sub>, CaO, CaSO<sub>4</sub>, CaCl<sub>2</sub>, and Ca(OH)<sub>2</sub></p> <p>The compounds must be limited to CuSO<sub>4</sub>, CuO and CuCl<sub>2</sub>.</p>

## **.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 system.

### **(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  $\text{Na}_2\text{CO}_3/\text{NaHCO}_3$  mixture by double indicator methods (Ghanaians only).
- (vi) Stoichiometry of reactions.

#### **Redox titrations**

Titration of the following systems to solve analytical problems:

- (i) Acidic  $\text{MnO}_4^-$  with  $\text{Fe}^{2+}$ ;
- (ii) Acidic  $\text{MnO}_4^-$  with  $\text{C}_2\text{O}_4^{2-}$ ;
- (iii)  $\text{I}_2$  in KI versus  $\text{S}_2\text{O}_3^{2-}$ .

### **(d) QUALITATIVE ANALYSIS**

No formal scheme of analysis is required.

- (i) Characteristic tests of the following cations with dilute  $\text{NaOH}_{(\text{aq})}$  and  $\text{NH}_3_{(\text{aq})}$ ;

$\text{NH}_4^+$ ;  $\text{Ca}^{2+}$ ;  $\text{Pb}^{2+}$ ;  $\text{Cu}^{2+}$ ;  $\text{Fe}^{2+}$ ;  $\text{Fe}^{3+}$ ;  $\text{Al}^{3+}$ ; and  $\text{Zn}^{2+}$ .

- (ii) Confirmatory tests for the above cations.

- (iii) Characteristic reaction of dilute HCl on solids or aqueous solutions and conc.  $\text{H}_2\text{SO}_4$  on solid samples of the following:  
 $\text{Cl}^-$  ;  $\text{SO}_3^{2-}$  ;  $\text{CO}_3^{2-}$  ;  $\text{NO}_3^-$  and  $\text{SO}_4^{2-}$ .
- (iv) Confirmatory tests for the above anions
- (v) Comparative study of the halogens; displacement reactions.
- (vi) Characteristic tests for the following gases:  $\text{H}_2$ ;  $\text{NH}_3$ ;  $\text{CO}_2$ ;  $\text{HCl}$  and  $\text{SO}_2$ .
- (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).