CHEMISTRY

GENERAL OBJECTIVES

The aim of the Unified Tertiary Matriculation Examination (UTME) syllabus in Chemistry is to prepare the candidates for the Board's examination. It is designed to test their achievement of the course objectives, which are to:

(i) apply the basic principles governing scientific methods in new situations;
(ii) interpret scientific data;
(iii) deduce the relationships between chemistry and other sciences;
(iv) apply the knowledge of chemistry to industry and everyday life.

DETAILED SYLLABUS

TOPICS/CONTENTS/NOTES	OBJECTIVES
1. Separation of mixtures and purification of chemical substances	Candidates should be able to:
(a) Pure and impure substances	i) distinguish between pure and impure substances;
(b) Boiling and melting points.	ii) use boiling and melting points as criteria for purity of chemical substances;
(c) Elements, compounds and mixtures	(iii) distinguish between elements, compounds and mixture;
(d) Chemical and physical changes.	(iv) differentiate between chemical and physical changes;
(e) Separation processes: evaporation, simple and fractional distillation, sublimation, filtration, crystallization, paper and column chromatography, simple and fractional crystallization.	(v) identify the properties of the components of a mixture; (vi) specify the principle involved in each separation method.
2. Chemical combination Stoichiometry, laws of definite and multiple proportions, law of conservation of matter, Gay Lussac's law of combining volumes, Avogadro's law; chemical symbols, formulae, equations and their uses, relative atomic mass based on $^{12}C=12$, the mole concept and Avogadro's number.	Candidates should be able to: (i) perform simple calculations involving formulae, equations/chemical composition and the mole concept; (ii) deduce the chemical laws from given expressions/statements; (iii) interpret data based on these laws; (iv) interpret graphical representations related to these laws.
3. Kinetic theory of matter and Gas Laws	Candidates should be able to:
(a) An outline of the kinetic theory of matter, melting, vapourization and reverse processes; melting and boiling explained in terms of molecular motion and Brownian movement.	(i) apply the theory to distinguish between solids, liquids and gases; (ii) deduce reasons for change of state; (iii) draw inferences based on molecular motion;

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(b) The laws of Boyle, Charles, Graham and Dalton (law of partial pressure); combined gas law, molar volume and atomicity of gases.	(iv) deduce chemical laws form given expressions/ statements; (v) interpret graphical representations related to these laws; (vi) perform simple calculations based on these laws and the relationship between the vapour density of gases and the relative molecular mass.
4. Atomic structure and bonding	Candidates should be able to:
(a) (i)The concept of atoms, molecules and ions, the works of Dalton, Millikan, Rutherford, Mosely, Thompson and Bohr. Simple hydrogen spectrum, Ionization of gases illustrating the electron as fundamental particle of matter.	(i) distinguish between atom, molecules and ions; (ii) assess the contributions of these scientists to the development of the atomic structure; (iii) deduce the number of protons, neutrons and electrons from atomic and mass numbers of an atom;
(ii) Atomic structure, electron configuration, atomic number, mass number and isotopes; specific examples should be drawn from elements of atomic number 1 to 20. Shapes of s and p orbitals.	(iv) apply the rules guiding the arrangement of electrons in an atom; (v) relate isotopy to mass number; (vi) perform simple calculations on relative atomic mass (vii) determine the number of electrons in s and p atomic orbitals.
(b) The periodic table and periodicity of elements, presentation of the periodic table with a view to recognizing families of elements e.g. alkali metals, halogens, the noble gases and transition metals. The variation of the following properties should be noticed: ionization energy, ionic radii, electron affinity and electronegativity.	(viii) relate atomic number to the position of an element on the periodic table; (ix) relate properties of groups of elements on the periodic table; (x) identify reasons for variation in properties across the period.
(c) Chemical bonding. Electrovalency and covalency, the electron configuration of elements and their tendency to attain the noble gas structure. Hydrogen bonding and metallic bonding as special types of electrovalency and covalency respectively; coordinate bond as a type of covalent bond as illustrated by complexes like $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $[Cu(NH_3)_4]^{2+}$ and $[Ag(NH_3)_2]^{+}$; van der Waals' forces should be mentioned as a special type of bonding forces.	(xi) differentiate between the different types of bonding. (xii) deduce bond types based on electron configurations; (xiii) relate the nature of bonding to properties of compounds; (xiv) apply it in everyday chemistry;
(d) Shapes of simple molecules: linear ((H_2, 0_2, $C1_2$,HCI and CO_2), non-linear (H_2O) and tetrahedral; (CH_4)	(xv) differentiate between the various shapes of molecules

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(b) Nuclear Chemistry: (i) Radioactivity (elementary treatment only) (ii) Nuclear reactions. Simple equations, uses and applications of natural and artificial radioactivity.	xvi) distinguish between ordinary chemical reaction and nuclear reaction; (xvii) differentiate between natural and artificial radioactivity; (xviii) compare the properties of the different types of nuclear radiations; (xix) compute simple calculations on the half-life of a radioactive material; (xx) balance simple nuclear equation; (xxi) identify the various applications of radioactivity.
5. Air The usual gaseous constituents – nitrogen, oxygen, water vapour, carbon (IV) oxide and the noble gases (argon and neon), proportion of oxygen in the air e.g. by burning phosphorus or by using alkaline pyrogallol, air as a mixture and some uses of the noble gas.	Candidates should be able to: (i) deduce reason (s) for the existence of air as a mixture; (ii) identify the principle involved in the separation of air components; (iii) deduce reasons for the variation in the composition of air in the environment; (iv) specify the uses of some of the constituents of air.
6. Water Composition by volume: Water as a solvent, atmospheric gases dissolved in water and their biological significance. Water as a product of the combustion of hydrogen. Hard and soft water: Temporary and permanent hardness and methods of softening hard water. Purification of town water supplies. Water of crystallization, efflorescence, deliquescence and hygroscopy. Examples of the substances exhibiting these properties and their uses.	Candidates should be able to: (i) identify the various uses of water; (ii) distinguish between the properties of hard and soft water; (iii) determine the causes of hardness; (iv) identify methods of removal of hardness; (v) describe the processes involved in the purification of water for town supply; (vi) distinguish between these phenomena; (vii) identify the various compounds that exhibit these phenomena.
7. Solubility (a) Unsaturated, saturated and supersaturated solutions. Solubility curves and simple deductions from them, (solubility defined in terms of mole per dm^3) and simple calculations.	Candidates should be able to: (i) distinguish between the different types of solutions; (ii) interpret solubility curves; (iii) calculate the amount of solute that can dissolve in a given amount of solvent at a given temperature; (iv) deduce that solubility is temperature-dependent;

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(b) Solvents for fats, oil and paints and the use of such solvents for the removal of stains.	(v) classify solvents based on their uses;
(c) Suspensions and colloids: Harmattan haze and paints as examples of suspensions and fog, milk, aerosol spray and rubber solution as examples of colloids.	(vi) differentiate between a true solution, suspension and colloids; (vii) compare the properties of a true solution and a 'false' solution. (viii) provide typical examples of suspensions and colloids.
8. Environmental Pollution (a) Sources and effects of pollutants.	Candidates should be able to: (i) identify the different types of pollution and pollutants;
(b) Air pollution: Examples of air pollutants such as H_2S, CO, SO_2, oxides of nitrogen, fluorocarbons and dust.	(ii) classify pollutants as biodegradable and non-biodegradable; (iii) assess the effects of pollution on the environment;
(c) Water pollution Sewage and oil pollution should be known.	(iv) recommend measures for control of environment pollution.
(d) Soil pollution: Oil spillage, Biodegradable and non-biodegradable pollutants.	
9. Acids, bases and salts	Candidates should be able to:
(a) General characteristics and properties of acids, bases and salts. Acids/base indicators, basicity of acids, normal, acidic, basic and double salts. An acid defined as a substance whose aqueous solution furnishes H_3O^+ions or as a proton donor. Ethanoic, citric and tartaric acids as examples of naturally occurring organic acids, alums as examples of double salts, preparation of salts by neutralization, precipitation and action of acids on metals. Oxides and trioxocarbonate (IV) salts	(i) distinguish between the properties of acids and bases; (ii) identify the different types of acids and bases; (iii) differentiate between acidity and alkalinity using acid/base indicators; (iv) identify the various methods of preparation of salts; (v) classify different types of salts;
(b) Qualitative comparison of the conductances of molar solutions of strong and weak acids and bases, relationship between conductance, amount of ions present and their relative mobilities.	vi) relate degree of dissociation to strength of acids and bases; (vii) relate degree of dissociation to conductance;

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(c) pH and pOH scale. pH defined as $-\log[H_3O^+]$ (d) Acid/base titrations. (e) Hydrolysis of salts: Simple examples such as NH_4C1, $AICI_3$, Na_2CO_3, CH_3COONa to be mentioned	(viii) perform simple calculations on pH; (ix) identify the appropriate acid-base indicator; (x) interpret graphical representation of titration curves; (xi) perform simple calculations based on the mole concept; (xii) balance equations for the hydrolysis of salts; (xiii) deduce the properties (acidic, basic, neutral) of the resultant solution.
10. Oxidation and reduction (a) Oxidation in terms of the addition of oxygen or removal of hydrogen. (b) Reduction as removal of oxygen or addition of hydrogen. (c) Oxidation and reduction in terms of electron transfer. (d) Use of oxidation numbers. Oxidation and reduction treated as change in oxidation. number and use of oxidation numbers in balancing simple equations. IUPAC nomenclature of inorganic compounds. (e) Tests for oxidizing and reducing agents.	Candidates should be able to: (i) identify the various forms of expressing oxidation and reduction; (ii) classify chemical reactions in terms of oxidation or reduction; (iii) balance redox reaction equations; (iv) deduce the oxidation number of chemical species; (v) compute the number of electron transfer in redox reactions; (vi) identify the name of redox species using IUPAC nomenclature. (vii) distinguish between oxidizing and reducing agents in redox reactions.
11. Electrolysis (a) Electrolytes and non-electrolytes. Faraday's laws of electrolysis. (b) Electrolysis of dilute H_2SO_4, aqueous $CuSO_4$, $CuC1_2$ solution, dilute and concentrated NaC1 solutions and fused NaC1 and factors affecting discharge of ions at the electrodes.	Candidates should be able to: (i) identify between electrolytes and non-electrolytes; (ii) perform calculations based on faraday as a mole of electrons. (iii) identify suitable electrodes for different electrolytes. (iv) specify the chemical reactions at the electrodes; (v) determine the products at the electrodes; (vi) identify the factors that affect the product of electrolysis;

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(c) Uses of electrolysis: Purification of metals e.g. copper and production of elements and compounds e.g. A1, Na, O_2, Cl_2 and NaOH.	(vii) specify the different areas of application of electrolysis;
(d) Electrochemical cells: Redox series (K, Na, Ca, Mg, AI, Zn, Fe, PbII, H, Cu, Hg, Au,) half-cell reactions and electrode potentials. Simple calculations only.	(viii) identify the various electrochemical cells; (ix) calculate electrode potentials using half-cell reaction equations;
(e) Corrosion as an electrolytic process, cathodic protection of metals, painting, electroplating and coating with grease or oil as ways of preventing iron from corrosion.	(x) determine the different areas of applications of electrolytic processes; (XI) apply the methods to protect metals.
12. Energy changes	
(a) Energy changes(ΔH) accompanying physical and chemical changes: dissolution of substances in or reaction with water e.g. Na, NaOH, K, NH_4, Cl. Endothermic ($+\Delta H$) and exothermic ($-\Delta H$) reactions. (b) Entropy as an order-disorder phenomenon: simple illustrations like mixing of gases and dissolution of salts. (c) Spontaneity of reactions: $\Delta G^{\theta} = 0$ as a criterion for equilibrium, ΔG greater or less than zero as a criterion for non-spontaneity or spontaneity.	Candidates should be able to: (i) determine the types of heat changes (ΔH) in physical and chemical processes; (ii) interpret graphical representations of heat changes; (iii) relate the physical state of a substance to the degree of orderliness; (iv) determine the conditions for spontaneity of a reaction ; (v) relate (ΔH), ΔS^{θ} and ΔG^{θ} as the driving forces for chemical reactions; (vi) solve simple problems based on the relationships $\Delta G^{\theta} = \Delta H^{\theta} - T\Delta S^{\theta}$)
13. Rates of Chemical Reaction	
(a) Elementary treatment of the following factors which can change the rate of a chemical reaction: (i) Temperature e.g. the reaction between HCI and $Na_2S_2O_3$ or Mg and HCI	Candidates should be able to: (i) identify the factors that affect the rates of a chemical reaction; (ii) determine the effects of these factors on the rate of reactions; (iii) recommend ways of moderating these effects;

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(ii) Concentration e.g. the reaction between HCl and $Na_2S_2O_3$, HCl and marble and the iodine clock reaction, for gaseous systems, pressure may be used as concentration term. (iii) Surface area e.g. the reaction between marble and HCI with marble in (i) powdered form (ii) lumps of the same mass. (iv) Catalyst e.g. the decomposition of H_2O_2 or $KClO_3$ in the presence or absence of MnO_2	iv) examine the effect of concentration on the rate of a chemical reaction; (v) describe how the rate of a chemical reaction is affected by surface area; (vi) determine the types of catalysts suitable for different reactions.
(b) Concentration/time curves. (c) Activation energy Qualitative treatment of Arrhenius' law and the collision theory, effect of light on some reactions. e.g. halogenation of alkanes	(vii) interpret reaction rate curves; (viii) solve simple problems on the rate of reactions; (x) relate the rate of reaction to the kinetic theory of matter. (xi) examine the significance of activation energy to chemical reactions. (xi) deduce the value of activation energy (Ea) from reaction rate curves.
14. Chemical equilibra Reversible reactions and factors governing the equilibrium position. Dynamic equilibrium. Le Chatelier's principle and equilibrium constant. Simple examples to include action of steam on iron and N_2O_4Type equation here. $2NO_2$. No calculation will be required.	Candidates should be able to: (i) identify the factors that affects the position of equilibrium of a chemical reaction; (ii) predict the effects of each factor on the position of equilibrium.
15. Non-metals and their compounds (a) Hydrogen: commercial production from water gas and cracking of petroleum fractions, laboratory preparation, properties, uses and test for hydrogen. (b) Halogens: Chlorine as a representative element of the halogen. Laboratory preparation, industrial preparation by electrolysis, properties and uses, e.g. water sterilization, bleaching, manufacture of HC1, plastics and insecticides.	Candidates should be able to: (i) predict reagents for the laboratory and industrial preparation of these gases and their compounds. (ii) identify the properties of the gases and their compounds. (iii) compare the properties of these gases and their compounds. (iv) specify the uses of each gas and its compounds; (v) determine the specific test for each gas and its compounds. (vi) determine specific tests for Cl, SO_4^{2-}, S_2, NH_4^{4+}, NO_3^-, CO_3^{2-}.

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Hydrochloric acid preparation and properties. Chlorides and test for chlorides.	
(c) Oxygen and Sulphur (i) Oxygen: Laboratory preparation, properties and uses. Commercial production from liquid air. Oxides: Acidic,basic, amphoteric and neutral, trioxygen (ozone) as an allotrope and the importance of ozone in the atmosphere.	(vii) identify the allotrope oxygen; (viii) determine the significance of ozone to our environment.
(ii) Sulphur: Uses and allotropes: preparation of allotropes is not expected . Preparation, properties and uses of sulphur (IV) oxide, the reaction of SO_2 with alkalis. Trioxosulphate (IV) acid and its salts, the effect of acids on salts of trioxosulphate (IV), Tetraoxosulphate (VI) acid: Commercial preparation (contact process only), properties as a dilute acid, an oxidizing and a dehydrating agent and uses. Test for SO_4^{2-}.	(ix) identify the allotropes of sulphur and their uses; (x) specify the commercial preparation of the acid, its properties and uses;
Hydrogen sulphide: Preparation and Properties as a weak acid, reducing agent and precipitating agent. Test for S^{2-}	(xi) predicts reagents for the laboratory Preparation for the gas;
(d) Nitrogen: (i) Laboratory preparation (ii) Production from liquid air (iii) Ammonia: Laboratory and industrial preparations (Haber Process only), properties and uses, ammonium salts and their uses, oxidation of ammonia to nitrogen (IV) oxide and trioxonitrate (V) acid. Test NH_4^+	(xii) specify the laboratory and industrial preparation for the gas; (xiii) use Haber process for the industrial preparation of ammonia;
(iv) Trioxonitrate (V) acid: Laboratory preparation from ammonia; properties and uses. Trioxonitrate (V) salt-action of heat and uses. Test for NO_3^-	(xiv) identify reagents for the laboratory preparation of the acid, its properties and uses;
(v) Oxides of nitrogen: Properties.	

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The nitrogen cycle. (e) Carbon: (i) Allotropes: Uses and properties (ii) Carbon (IV) oxide- Laboratory preparation, properties and uses. Action of heat on trioxocarbonate (IV) salts and test for CO_3^{2-} (iii) Carbon (II) oxide: Laboratory preparation, properties including its effect on blood; sources of carbon (II) oxide to include charcoal, fire and exhaust fumes. (iv) Coal: Different types, products obtained form destructive distillation of wood and coal. (v) Coke: Gasification and uses. Manufacture of synthetic gas and uses.	(xv) examine the relevance of nitrogen cycle to the environment. (xvi) identify allotropes of carbon; (xvii) predict reagents for the laboratory preparation of CO_2; (xviii) specify the properties of the gas and its uses; (xiv) determine the test for CO_2; (xx) determine the reagents for the laboratory preparation of the gas; (xxi) examine its effect on human; (xxii) identify the different forms of coal: (xxiiii) determine their uses; (xxiv) specify the uses of coke and synthetic gas.
16. Metals and their compounds (a) Alkali metals e.g. sodium (i) Sodium hydroxide:- Production by electrolysis of brine, its action on aluminium, zinc and lead ions. Uses including precipitation of metallic hydroxides. (ii) Sodium trioxocarbonate (IV) and sodium hydrogen trioxocarbonate (IV): Production by Solvay process, properties and uses, e.g. Na_2CO_3 in the manufacture of glass. (iii) Sodium chloride: its occurrence in sea water and uses, the economic importance of sea water and the recovery of sodium chloride. (b) Alkaline-earth metals, e.g. calcium; calcium oxide, calcium hydroxide and calcium trioxocarbonate (IV); Properties and uses. Preparation of calcium oxide from sea shells, the chemical composition of cement and the setting of mortar. Test for Ca^{2+}.	Candidates should be able to: (i) determine the method for extraction suitable for each metal; (ii) relate the methods of extraction to the properties for the metals; (iii) compare the chemical reactivities of the metals; (iv) specify the uses of the metals; (v) determine specific test for metallic ions; (vi) determine the process for the production of the compounds of these metals; (vii) compare the chemical reactivities of the compounds. (viii) specify the uses of these compounds; (ix) determine the processes for the preparation of the compounds of the metal;

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(c) Aluminium Purification of bauxite, electrolytic extraction, properties and uses of aluminium and its compounds. Test for $A1^{3+}$	(x) describe the method of purification of bauxite
(d) Tin Extraction form its ores. Properties and uses.	
(e) Metals of the first transition series. Characteristic properties: (i) electron configuration (ii) oxidation states (iii) complex ion formation (iv) formationof coloured ions	(xi) relate the method of extraction to it properties; (xii) specify the uses of tin; (xiii) identify the general properties of the first transition metals; (xiv) deduce reasons for the specific properties of the transition metals; (xv) determine the IUPAC names of simple transition metal complexes.
(f) Iron Extraction form sulphide and oxide ores, properties and uses, different forms of iron and their properties and advantages of steel over iron. Test for Fe^{2+} and Fe^{3+}	(xvi) determine the suitable method of extraction for the metal; (xvii) specify the properties and uses of the metal;
(g) Copper Extraction from sulphide and oxide ores, properties and uses of copper salts, preparation and uses of c o p p er (I I) tetraoxosulphate (VI). Test for Cu^{2+}	(xviii) identify the appropriate method of extraction for the metal and its compounds; (xix) relate the properties of the metal and its compound to their uses.
(h) Alloy Steel, stainless steel, brass, bronze, type-metal, duralumin and soft solder (constituents and uses only).	(xx) specify the constituents and uses of the various alloys mentioned. (xxi) compare the properties and uses of alloys to pure metals.
17. Organic Compounds An introduction to the tetravalency of carbon, the general formula, IUPAC nomenclature and the determination of empirical formula of each class of the organic compounds mentioned below.	Candidates should be able to: (i) derive the name of organic compounds form their general formulae; (ii) relate the name of a compound to its structure; (iii) relate the tetravalency of carbon to its ability to form chains of compound (catenation); (iv) classify compounds according to their functional groups;
(a) Aliphatic hydrocarbons	
(i) Alkanes Homologous series in relation to physical properties, substitution reaction and a few examples and uses of halogenated products. Isomerism: structural only (examples on isomerism should	(v) derive empirical formula and molecular formula, from given data; (vi) relate structure/functional groups to specific properties; (vii) derive various isomeric form from a given formula;

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not go beyond six carbon atoms). Petroleum: composition, fractional distillation and major products; cracking and reforming, Petrochemicals – starting materials of organic syntheses, quality of petrol and meaning of octane number.	(viii) distinguish between the different types of isomerism; (ix) classify the various types of hydrocarbon; (x) distinguish each class of hydrocarbon by their properties; (xi) specify the uses of various hydrocarbons; (xii) identify crude oil as a complex mixture of hydrocarbon; (xiii) relate the fractions of hydrocarbon to their properties and uses; (xiv) relate transformation processes to quality improvement of the fractions;
(ii) Alkenes Isomerism: structural and geometric isomerism, additional and polymerization reactions, polythene and synthetic rubber as examples of products of polymerization and its use in vulcanization.	xv) distinguish between various polymerization processes;
(iii) Alkynes Ethyne – production from action of water on carbides, simple reactions and properties of ethyne.	(xvi) distinguish between aliphatic and aromatic hydrocarbons;
(b) Aromatic hydrocarbons e.g. benzene - Structure, properties and uses.	(xvii) relate the properties of benzene to its structure
(c) Alkanols Primary, secondary, tertiary – production of ethanol by fermentation and from petroleum by-products. Local examples of fermentation and distillation, e.g. gin from palm wine and other local sources and glycerol as a polyhydric alkanol. Reactions of OH group – oxidation as a distinguishing test between primary, secondary and tertiary alkanols.	(xviii) compare the various classes of alkanols; (xix) determine the processes involved in ethanol production; (xx) examine the importance of ethanol as an alternative energy provider;
(d) Alkanals and alkanones. Chemical test to distinguish between Alkanals and alkanones.	(xxi) differentiate between alkanals and alkanones;
(e) Alkanoic acids. Chemical reactions; neutralization and esterification, ethanedioic (oxalic) acid as an example of a dicarboxylic acid and benzene carboxylic acid as an example of an aromatic acid.	(xxii) compare the various classes of alkanoic acid; (xxiii) identify natural sources of alkanoates;

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(f) Alkanoates Formation from alkanoic acids and Alkanols – fats and oils as alkanoates. Saponification: Production of soap and margarine from alkanoates and distinction between detergents and soaps. (g) Amines (Alkanamines) Primary, Secondary, tertiary (h) Carbohydrates Classification – mono-, di- and polysaccharides, composition, chemical tests for simple sugars and reaction with concentrated tetraoxosulphate (VI) acid. Hydrolysis of complex sugars e.g. cellulose form cotton and starch from cassava, the uses of sugar and starch in the production of alcoholic beverages, pharmaceuticals and textiles. (i) Giant molecules e.g. proteins, enzymes, natural rubbers and polymers.	(xxiv) specify the uses of alkanoates; (xxv) distinguish between detergent and soap; (xxvi) compare the various classes of alkanamine; (xxvii) identify the natural sources of carbohydrates and giant molecules; (xxviii) compare the various classes of carbohydrates; (xxix) infer the product of hydrolysis of carbohydrates; (xxx) determine the uses of carbohydrates; (xxxi) relate giant molecules to their uses.

RECOMMENDED TEXTS

Ababio, O.Y. (2005). *New School Chemistry for Senior Secondary Schools, (Third Edition), Onitsha*: Africana FIRST Publishers Limited

Bajah, S.T. Teibo, B.O., Onwu, G and Obikwere, A. (1999). *Senior Secondary Chemistry, Book 1, Lagos:* Longman

Bajah, S.T., Teibo, B.O., Onwu, G and Obikwere, A. (2000). *Senior Secondary Chemistry, Books 2 and 3, Lagos:* Longman

Ohia, G.N.C., Adewoyin, F.A. and Akpan, B.B. (1997). *Exam Focus Chemistry for WASSCE & JME: Ibadan:* University Press Plc

STAN (1987). *Chemistry for Senior Secondary Schools, Ibadan:* Heinemann

Sylvester: O.O. (2004). *A Comprehensive Practical Chemistry for Senior Secondary Schools, Ibadan:* Evans

Uche, I.O., Adenuga, I.J. and Iwuagwu, S.L. (2003). *Countdown to WASSCE/SSCE, NECO, JME Chemistry, Ibadan:* Evans