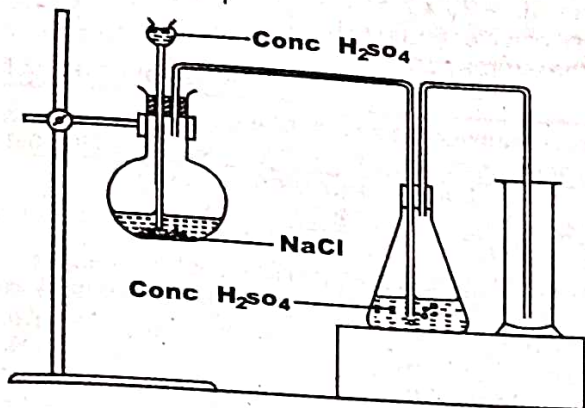


# JUNE 2007 WASSCE CHEMISTRY 2 THEORY QUESTIONS

Answer three questions from this section.

- 1 (a) Define the following terms. (i) saturated solution; (ii) solubility. [4 Marks] (b) In an experiment to determine the solubility of a given salt Y, the following data were provided: Mass of dry empty dish = 7.16 g, Mass of dish + saturated solution of salt Y = 17.85 g. Mass of dish + salt Y = 9.30 g; Temperature of solution = 20°C; Molar mass of salt Y = 100; Density of solution Y = 100 g cm<sup>-3</sup>. Calculate the solubility of salt Y in (i) g dm<sup>-3</sup> of solution, (ii) mol dm<sup>-3</sup> of solution. [6 marks] (c) State the type of bond broken on melting each of the following substances: (i) NaCl, (ii) CO<sub>2</sub>, (iii) SiO<sub>2</sub>, (iv) Al. [4 marks] (d) Explain the following observations: (i) the chemical reactivity of alkali metals increases down the group; (ii) Mg has a higher melting point than Na; (iii) K is a better reducing agent than Na. [6 marks] (e) (i) What are isotopes? (ii) Lithium exists as <sup>6</sup>Li and <sup>7</sup>Li in the ratio 2:25. Calculate the relative atomic mass of the lithium. [5 marks]
- 2 (a) Define the following in terms of electron transfer: (i) oxidation; (ii) reduction. [2 marks] (b) (i) Determine the oxidation state of phosphorus in each of the following structures: I. POCl<sub>3</sub>; II. PH<sub>3</sub>. (ii) State with reasons whether the following compounds will form acidic, neutral or basic aqueous solutions: I. NaNO<sub>3</sub>; II. NH<sub>4</sub>Cl; III. Na<sub>2</sub>CO<sub>3</sub>. [10 marks]
- (c) Consider the set-up



- (i) What is the gas produced in the experiment illustrated by the set-up above? (ii) Name the method of collection of the gas. (iii) Give a reason for your answer in 2(c)(ii) above. (iv) State the function of the concentrated H<sub>2</sub>SO<sub>4</sub> in the conical flask. (v) Give one; I. physical property, II. chemical property of the gas. (vi) State one chemical test to identify the gas. [8 marks] (d) A 4.3g hydrated sodium tetraoxosulphate(VI) (Na<sub>2</sub>SO<sub>4</sub> · xH<sub>2</sub>O) was heated to remove the water of crystallization. The remaining anhydrous salt had a mass of 2.12g. Calculate the value of x in the hydrated salt. [H = 1; O = 16; Na = 23; S = 32] [5 marks]

3. (a) (i) What is a homologous series? (ii) Give two homologous series present in petroleum. (iii) Give one example of a compound belonging to each of the homologous series in 3(a)(ii). (iv) Name two fractions obtained from the fractional distillation of petroleum. (v) Why is there a

gradual change in the physical properties of petroleum fractions? [10 marks] (b) Write a two-step balanced chemical equations for the reaction of (i) ethanol with excess concentrated tetraoxosulphate (VI) acid at high temperature; (ii) excess ethanol with concentrated tetraoxosulphate (VI) acid at lower temperature. [6 marks] (c) An organic compound of relative molecular mass 46, on analysis was found to contain 52.0% carbon, 13.3% hydrogen and 34.7% oxygen (i) Determine its I. empirical formula. II. molecular formula. (ii) Draw two possible structures of the compound and name one of them. [O = 16; C = 12; H = 1] (9 marks)

4. (a) Write an equation in each case to represent the (i) β-decay of <sup>24</sup>Na to give Mg. (ii) reaction of sodium with cold water. [4 marks] (b) (i) State two differences between reaction 4(a)(i) and (ii). (ii) State two applications of the type of reaction represented in 4(a)(i). [4 marks] (c) Consider the reaction represented by the equation: Mg<sub>(s)</sub> + 2HCl<sub>(aq)</sub> → MgCl<sub>2(aq)</sub> + H<sub>2(g)</sub> (i) Name the type of reaction involved. (ii) Give two ways by which the reaction could be made faster. (iii) What volume of hydrogen gas would be produced from 6.0g of the magnesium? [H = 1; 1 mole of a gas occupy 22.4 dm<sup>3</sup> at s.t.p] [6 marks] (d) What is (i) an electrolyte. (ii) electrolysis? (e) (i) Give one metal that is extracted using electrolytic process (ii) Name the ore of the metal. (iii) What is the substance discharged at each electrode when dilute NaCl is electrolysed using graphite electrodes? (iv) Why would aqueous NaCl conduct electricity but solid NaCl would not? (v) Give one industrial use of NaCl. [7 marks]

## SECTION II

Answer one question only from this section

- 5(a) (i) What is the name of the process used for the industrial preparation of tetraoxosulphate (VI) acid? (ii) State the catalyst used in 5(a)(i). (iii) Show by means of balanced chemical equations only, the industrial preparation of tetraoxosulphate (VI) acid from sulphur (IV) oxide. (b) (i) Distinguish between dehydration and drying. (ii) Explain why concentrated tetraoxosulphate (VI) acid cannot be used to dry ammonia. (iii) What is the drying agent for ammonia? [7 marks] (c) (i) Give one example of I a chloride which is soluble in hot water, II. a trioxocarbonate (IV) which does not decompose on heating. III. an amphoteric oxide. (ii) List three methods for the preparation of salts. (iii) State one method for the recovery of a salt from its solution. [7 marks] (d) (i) State Gay Lussac's law of combining volumes. (ii) Consider the reaction represented by the following equation: C<sub>2</sub>H<sub>4(g)</sub> + 3O<sub>2(g)</sub> → 2H<sub>2</sub>O<sub>(g)</sub> + 2CO<sub>2(g)</sub> What is the volume of oxygen required for the complete combustion of 12.5cm<sup>3</sup> of ethene? [5 marks]
- 6(a) (i) Draw and label an energy profile diagram of an endothermic reaction. Indicate on your diagram the I. activation energy, II. heat change, ΔH. (ii) Explain how the rate of reaction is affected by I. addition of a catalyst, II. increase in temperature. [8 marks] (b) (i) Write an equation for the thermal decomposition of calcium trioxocarbonate (IV). (ii) Determine the volume of carbon (IV) oxide measured at s.t.p. that would be produced by the thermal decomposition of 10g calcium trioxocarbonate (IV) [Ca = 40; O = 16; C = 12] [5 marks] (c) (i) Give one use of each of the following forms of carbon: I. coal; II. wood charcoal; III. carbon (IV) oxide. (ii) Write a balanced chemical equation to show what happens when each of the following compounds is heated strongly: I. NaNO<sub>3(s)</sub>; II. MgCO<sub>3(s)</sub> [5 marks] (d) Consider the following compounds CaO, CaCO<sub>3</sub>, Ca(OH)<sub>2</sub>, NaOH. Which of them is (i) used in the manufacture of cement; (ii) used to detect the presence of carbon (IV) oxide; (iii) used to liberate carbon (IV) oxide when dilute acid is added; (iv) hygroscopic; (v) deliquescent? [5 marks]

# ANSWERS TO JUNE 2007 WASSCE CHEMISTRY 2 THEORY

**1(a)(i) A saturated solution** is one that will dissolve no more of the solute at a particular temperature in the presence of excess solute. A saturated solution is a solution that will not dissolve any more of the solute at a particular temperature in the presence of excess solute. A saturated solution is a solution in which the solute is in dynamic equilibrium with the solution at a particular temperature.

**(ii) Solubility** is the maximum amount of solute (number of moles/mass) that dissolves in 1 dm<sup>3</sup> of solvent at a particular temperature or

(b) mass of saturated solution = 17.85 - 7.16 = 10.69 or x say mass of dry salt = 9.30 - 7.16 = 2.14 or y say. Volume of solution = mass of solution since density = 10gdm<sup>3</sup> = 10.69cm<sup>3</sup>

**(i) Solubility in g/dm<sup>3</sup>** 10.69cm<sup>3</sup> of solution Y contains 2.14g of salt Y; 1 cm<sup>3</sup> of solution Y contains

$$\frac{2.14}{10.69} \text{ gcm}^{-3}$$

$$1000\text{cm}^3 = \frac{2.14 \times 1000}{10.69} = 200.19\text{gdm}^{-3}$$

**(ii) Solubility in moldm<sup>-3</sup>** =  $\frac{\text{Solubility in g dm}^{-3}}{\text{molar mass of salt Y}}$

$$= \frac{200.19}{100} = 2.00 \text{ mol dm}^{-3} \text{ or } 200.187\text{gdm}^{-3}$$

(c) (i) NaCl<sub>(s)</sub> - Ionic bond (ii) CO<sub>2(s)</sub> - Van der waal forces

(iii) SiO<sub>2(s)</sub> - Covalent bond (iv) Al<sub>(s)</sub> - Metallic bond.

(d) (i) Reactivity is due to loss of electrons/ease of electron loss hence ionization energy decreases down the group.

(ii) Mg has more valence electrons contributing to the stronger binding energy compared to Na

(iii) Potassium loses electron more readily than sodium / K. has lower ionization energy than Na; Ease of loss of electrons by an atom is a measure of its reducing ability.

(e) (i) **Isotopes** are atoms of the same element with the same atomic number but different mass number.

**(ii) Relative atomic mass of lithium**

$$\text{Li} = \frac{2 \times 6}{27} + \frac{25 \times 7}{27} = 6.925 \text{ or } 6.93$$

**2(a)(i) oxidation:** process of electron loss reduction: process of electron gain

(i) I. POCl<sub>3</sub>; P + (-2) + 3 (-1) = 0; P -2 - 3 = 0; P = + 5

II. PH<sub>3</sub>; P + 3 (-1) = 0; P - 3 = 0; P = +3

(ii) NaNO<sub>3</sub> - Neutral. It is a salt of a strong acid and a strong base/ions do not undergo hydrolysis.

II. NH<sub>4</sub>Cl - Acidic. It is a salt of a strong acid and a weak base/NH<sub>4</sub><sup>+</sup> or cation undergoes hydrolysis

III. Na<sub>2</sub>CO<sub>3</sub> - Basic. It is a salt of weak acid and a strong base/CO<sub>3</sub><sup>2-</sup> or anion undergoes hydrolysis

(c)(i) hydrogen chloride gas / HCl<sub>(g)</sub> (ii) downward delivery/upward displacement of air (iii) the gas is denser than air (iv) drying/purification of the gas

**Physical properties**

- denser than air
- very soluble in water
- fumes in moist air
- colourless gas

**Chemical properties**

- turns moist blue litmus red.
  - does not support combustion
  - gives cloud of white fumes in contact with NH<sub>3</sub> vapour.
- (vi) Pass the gas into Ag NO<sub>3(aq)</sub> a white precipitate of AgCl is formed (which is soluble in NH<sub>3(aq)</sub> but insoluble in

HNO<sub>3(aq)</sub> or Bring the gas into contact with ammonia, white fumes is given off.

(d) Mass of water 4.30g - 2.12g = 2.18g

Mass of Na<sub>2</sub>SO<sub>4</sub> 23 x 2 x 32 + 16 x 4 = 142

Molar mass of H<sub>2</sub>O 2 + 16 = 18

2.12g of anhydrous salt contain = 2.18g of water

142g of anhydrous salt contain =  $\frac{2.18 \times 142}{18} = 146.018$   
2.12

$$x(\text{H}_2\text{O}) = 146; 18x = 146; x = \frac{146}{18} = 8$$

OR

Mass of water = 4.30-2.12g = 2.18g

Mass of Na<sub>2</sub>SO<sub>4</sub> = 23 x 2 + 32 + 16 x 4 = 142

Molar mass of water (H<sub>2</sub>O) = 18

Applying the expression

XH <sub>2</sub> O	Mass of water lost
Molar mass of anhydrous salt	Mass of anhydrous salt
x = $\frac{\text{Molar mass of anhydrous salt} \times \text{mass of water lost}}{\text{Mass of anhydrous salt} \times \text{H}_2\text{O}}$	

$$X = \frac{142 \times 2.18}{2.12 \times 18} = \frac{309.50}{39.16} = 8$$

3. (a) (i) A homologous series is a family of organic compounds which follows a regular structural pattern in which each successive member differs in its molecular formula by a -CH<sub>2</sub> group.

(ii) Alkanes, Alkenes, Alkyne

**(iii) Alkanes                      Alkenes                      Alkynes**

- |           |         |         |
|-----------|---------|---------|
| - methane | methene | methyne |
| - ethane  | ethene  | ethyne  |
| - propane | propene | propyne |
| - butane  | butene  | butyne  |
| - pentane | pentene | pentyne |
| - hexane  | hexene  | hexyne  |
| - heptane | heptene | heptyne |
| - octane  | octene  | octyne  |
| - Nonane  | Nonene  | Nonyne  |
| - Decane  | Decene  | Decyne  |

(iv) - Petroleum gas

- Petrol/Gasoline

- Kerosene

- Diesel oil/Gas oil

- Lubricating oil

- Paraffin wax

- Bitumen

(v) The gradual change is due to increase in the number of carbon content of the fractions.

(b)(i)  $\text{C}_2\text{H}_5\text{OH}_{(aq)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow \text{C}_2\text{H}_5\text{HSO}_{4(aq)} + \text{H}_2\text{O}_{(l)}$

$\text{C}_2\text{H}_5\text{HSO}_{4(aq)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow \text{C}_2\text{H}_5\text{SO}_4 + \text{H}_2\text{SO}_4$

(ii)  $\text{C}_2\text{H}_5\text{OH}_{(aq)} + \text{H}_2\text{SO}_{4(aq)} \rightarrow \text{C}_2\text{H}_5\text{HSO}_{4(aq)} + \text{H}_2\text{O}_{(l)}$

$\text{C}_2\text{H}_5\text{HSO}_{4(aq)} + \text{C}_2\text{H}_5\text{OH}_{(aq)} \rightarrow \text{C}_2\text{H}_5\text{OC}_2\text{H}_5 + \text{H}_2\text{SO}_{4(aq)}$

	Carbon	Hydrogen	Oxygen
% composition	52.0	13.3	34.7
Atomic mass	12	1	16
Mole ratio	$\frac{52}{12}$	$\frac{13.3}{1}$	$\frac{34.7}{16}$
	4.33	13.3	2.17
Divide by the =	$\frac{4.33}{2.17}$	$\frac{13.3}{2.17}$	$\frac{2.17}{2.17}$
smallest value	2	6	1

The empirical formula = C<sub>2</sub>H<sub>6</sub>O

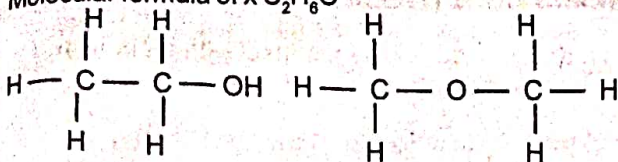
(ii) Molecular formula of X

(C<sub>2</sub>H<sub>6</sub>O)<sub>n</sub> = 46

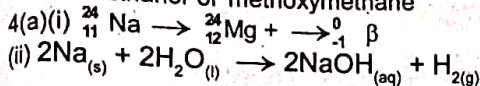
(12 x 2 + 6 x 1 + 16)<sub>n</sub> = 46

46n = 46; n = 1

Molecular formula of  $x \text{C}_2\text{H}_6\text{O}$



Ethanol or methoxymethane



(b)(i) Reaction(i)	Reaction(ii)
1 Takes place in the nucleus/ 2 Nuclear reaction 3 Large amount of heat is released 4 Involves protons, neutrons and electrons 5 New nuclides are formed	Take place in the valence Shell/chemical reaction Small amount of heat is released Involves valence electrons  New compounds are formed.
6 Not affected by external factors e.g. temp, pressure, catalyst	Usually affected by external factors

(ii)-sterilizing Instruments / generate energy

- treatment of cancer
- carbon dating
- pest control etc

(c) (i) Displacement/Redox reaction (ii) - Use Mg powder

- Use HCl of higher concentration
- Increase temperature of the reaction mixture

(iii)  $24\text{g Mg} = 22.4\text{dm}^3$  (of  $\text{H}_2$  gas)

$$\therefore 6\text{g Mg} = \frac{6\text{g} \times 22.4\text{dm}^3}{24\text{g}} = 5.6\text{dm}^3$$

(d)(i) **An electrolyte** is a compound which when molten or in aqueous solution will conduct electricity (and be decomposed by it).

(ii) **Electrolysis** is the decomposition of an electrolyte by the passage of an electric current.

(e)(i) Aluminium (ii) Bauxite

(iii) Cathode - Hydrogen Anode - Oxygen

(iv) In the liquid state the  $\text{Na}^+$  and  $\text{Cl}^-$  ions are mobile

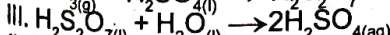
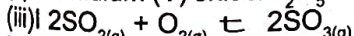
In the solid state the ions are in fixed positions and cannot conduct electricity.

(v) **Industrial uses of NaCl**

- (1) In the manufacture of  $\text{Cl}_{2(g)}$
- (2) Salting out in soap manufacture
- (3) Production of NaOH
- (4) Solvay process/production of  $\text{Na}_2\text{CO}_3$

5(a)(i) Contact process

(ii) Vanadium (V) oxide/ $\text{V}_2\text{O}_5$



(b)(i) **Dehydration** is the removal of the element of water from a compound with change in the chemical composition of the compound while drying is the removal of associated water from a substance without affecting its chemical composition.

(ii) Concentrated  $\text{H}_2\text{SO}_4$  reacts with ammonia to form ammonium tetraoxosulphate (VI) (iii) Calcium oxide (CaO) silica gel.

(c) (i) I. Lead chloride ( $\text{PbCl}_2$ )

II.  $\text{K}_2\text{CO}_3/\text{Na}_2\text{CO}_3$

III.  $\text{ZnO}/\text{Al}_2\text{O}_3/\text{SnO}/\text{PbO}_2$

(ii) I - Reaction of an acid with a base/neutralization

- Reaction of an acid with a metal
- Reaction of an acid with trioxocarbonate (IV)
- Double decomposition
- Precipitation

- Direct combination of its constituent element

- A metal with halogens.

(iii) - Evaporation

- Crystallization

(d) (i) **Gay Lussac's Law of combining volumes:** when gases react, they do so in volumes which are in simple ratio to one another and to the volumes of the products, if gaseous provided that temperature and pressure remain constant.

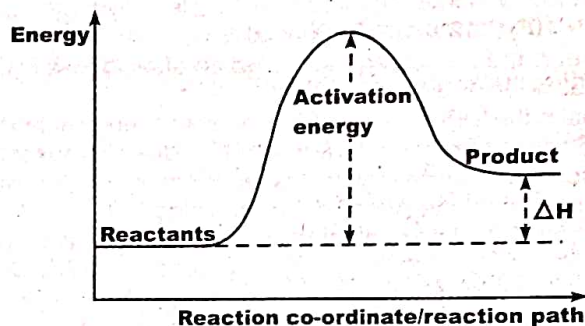
(ii)  $\text{C}_2\text{H}_{4(g)} + 3\text{O}_{2(g)} \rightarrow 2\text{H}_2\text{O} + 2\text{CO}_{2(g)}$   
1 volume of ethane = 3 volumes of oxygen (mole ratio of ethane to oxygen). OR

1  $\text{cm}^3$  of ethene requires  $3\text{cm}^3$  of oxygen.

$\therefore 12.5\text{cm}^3$  of ethene will require  $3 \times 12.5\text{cm}^3$  oxygen.

=  $37.5\text{cm}^3$

6(a)



(ii) I. Catalyst increases the rate of the reaction by providing alternative pathway with lower activation energy.

II. The rate of reaction increases with increase in temperature because there will be more effective collisions.



(ii) Molar mass of  $\text{CaCO}_3 = 40 + 12 + 16 \times 3 = 100$

$$10\text{g of CaCO} = \frac{10\text{g}}{100\text{g mol}^{-1}} = 0.1 \text{ mole}$$

1 mole of  $\text{CaCO}_3 = 1 \text{ mole of CO}_2$  or

0.1 mole of  $\text{CaCO}_3 = 0.1 \text{ mole of CO}_2$  but 1 mole =  $22.4\text{dm}^3$

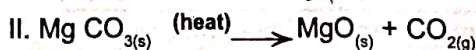
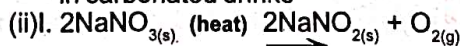
0.1 mole =  $2.24 \text{ dm}^3$

(c)(i) I. Coal - as fuel

II. Wood charcoal - for absorbing poisonous gases/as domestic fuel

III. Carbon (iv) oxide - in fire extinguishers

- manufacture of washing soda by solvay process.
- in carbonated drinks



(d)(i)  $\text{CaCO}_3$  - cement

(ii)  $\text{Ca(OH)}_2$  - detection of  $\text{CO}_2$

(iii)  $\text{CaCO}_3$  - liberates  $\text{CO}_2$  with addition of acids

(iv) CaO - hygroscopic

(v) NaOH - deliquescent

**JUNE 2007 WASSCE CHEMISTRY 2 OBJECTIVE TEST**

1. When sodium atom forms the ion  $\text{Na}^+$ , A. it gains one