Q1. Which one of the following compounds contains the smallest percentage, by mass, of oxygen?

A $CH_3OCH_2CH_3$

B $CH_3OCH_2NH_2$

C COS

D $C_4H_9Al(OH)_2$

(Total 1 mark)

Q2. The percentage of copper in a copper(II) salt can be determined by using a thiosulphate titration. 0.305 g of a copper(II) salt was dissolved in water and added to an excess of potassium iodide solution, liberating iodine according to the following equation:

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

The iodine liberated required 24.5 cm^3 of a 0.100 mol dm^{-3} solution of sodium thiosulphate:

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

The percentage of copper, by mass, in the copper(II) salt is

A 64.2

B 51.0

C 48.4

D 25.5

(Total 1 mark)

Q3. The chloride of an element **Z** reacts with water according to the following equation.

$$ZCl_4(l) + 2H_2O(l) \rightarrow ZO_2(s) + 4HCl(aq)$$

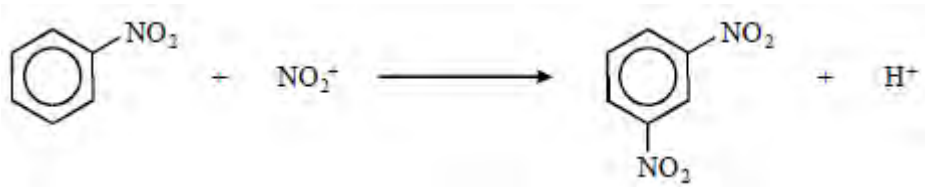
A 1.304 g sample of ZCl_4 was added to water. The solid ZO_2 was removed by filtration and the resulting solution was made up to 250 cm^3 in a volumetric flask. A 25.0 cm^3 portion of this solution was titrated against a 0.112 mol dm^{-3} solution of sodium hydroxide, of which 21.7 cm^3 were required to reach the end point.

Use this information to calculate the number of moles of HCl produced and hence the number of moles of ZCl_4 present in the sample. Calculate the relative molecular mass, M_r, of ZCl_4.

From your answer deduce the relative atomic mass, A_r, of element **Z** and hence its identity.

(Total 9 marks)

Q4. 1,3-dinitrobenzene can be prepared by heating nitrobenzene with a mixture of fuming nitric acid and concentrated sulphuric acid. The reaction can be represented by the following equation.



If the yield of the reaction is 55%, the mass of 1,3-dinitrobenzene produced from 12.30 g of nitrobenzene is

A 16.90 g

B 16.80 g

C 9.30 g

D 9.24 g

(Total 1 mark)

Q5. On heating, magnesium reacts vigorously with element **X** to produce compound **Y**. An aqueous solution of **Y**, when treated with aqueous silver nitrate, gives a white precipitate that is readily soluble in dilute aqueous ammonia. What is the minimum mass of **X** that is needed to react completely with 4.05 g of magnesium?

A 11.83 g

B 5.92 g

C 5.33 g

D 2.67 g

(Total 1 mark)

Q6. (a) Sodium carbonate forms a number of hydrates of general formula $Na_2CO_3.xH_2O$

A 3.01 g sample of one of these hydrates was dissolved in water and the solution made up to 250 cm^3.
In a titration, a 25.0 cm^3 portion of this solution required 24.3 cm^3 of 0.200 mol^{-1} dm^{-3} hydrochloric acid for complete reaction.

The equation for this reaction is shown below.

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$

(i) Calculate the number of moles of HCl in 24.3 cm^3 of 0.200 mol dm^{-3} hydrochloric acid.

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(ii) Deduce the number of moles of Na_2CO_3 in 25.0 cm^3 of the Na_2CO_3 solution.

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(iii) Hence deduce the number of moles of Na_2CO_3 in the original 250 cm^3 of solution.

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(iv) Calculate the M_r of the hydrated sodium carbonate.

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(5)

(b) In an experiment, the M_r of a different hydrated sodium carbonate was found to be 250.
Use this value to calculate the number of molecules of water of crystallisation, *x*, in this hydrated sodium carbonate, $Na_2CO_3.xH_2O$

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(3)

(c) A gas cylinder, of volume 5.00×10^{-3} m^3, contains 325 g of argon gas.

(i) Give the ideal gas equation.

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(ii) Use the ideal gas equation to calculate the pressure of the argon gas in the cylinder at a temperature of 298 K.
(The gas constant R = 8.31 J K^{-1} mol^{-1})

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(4)
(Total 12 marks)

Q7. (a) Calculate the concentration, in mol dm^{-3}, of the solution formed when 19.6 g of hydrogen chloride, HCl, are dissolved in water and the volume made up to 250 cm^3.

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(3)

(b) The carbonate of metal **M** has the formula M_2CO_3. The equation for the reaction of this carbonate with hydrochloric acid is given below.

$M_2CO_3 + 2HCl \rightarrow 2MCl + CO_2 + H_2O$

A sample of M_2CO_3, of mass 0.394 g, required the addition of 21.7 cm^3 of a 0.263 mol dm^{-3} solution of hydrochloric acid for complete reaction.

(i) Calculate the number of moles of hydrochloric acid used.

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(ii) Calculate the number of moles of M_2CO_3 in 0.394 g.

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(iii) Calculate the relative molecular mass of M_2CO_3

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(iv) Deduce the relative atomic mass of **M** and hence suggest its identity.

*Relative atomic mass of **M*** .....

.....

*Identity of **M*** .....

(6)
(Total 9 marks)

Q8. Butan-1-ol was converted into butyl propanoate by reaction with an excess of propanoic acid. In the reaction, 6.0 g of the alcohol gave 7.4 g of the ester. The percentage yield of ester was

A 57

B 70

C 75

D 81

(Total 1 mark)

Q9. (a) The equation for the reaction between magnesium carbonate and hydrochloric acid is given below.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

When 75.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid were added to 1.25 g of impure $MgCO_3$ some acid was left unreacted. This unreacted acid required 21.6 cm^3 of a 0.500 mol dm^{-3} solution of sodium hydroxide for complete reaction.

(i) Calculate the number of moles of HCl in 75.0 cm^3 of 0.500 mol dm^{-3} hydrochloric acid.

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(ii) Calculate the number of moles of NaOH used to neutralise the unreacted HCl.

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(iii) Show that the number of moles of HCl which reacted with the $MgCO_3$ in the sample was 0.0267

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(iv) Calculate the number of moles and the mass of $MgCO_3$ in the sample, and hence deduce the percentage by mass of $MgCO_3$ in the sample.

Moles of $MgCO_3$ .....

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Mass of $MgCO_3$ .....

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Percentage of $MgCO_3$ .....

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(8)

(b) A compound contains 36.5% of sodium and 25.5% of sulphur by mass, the rest being oxygen.

(i) Use this information to show that the empirical formula of the compound is Na_2SO_3

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(ii) When Na_2SO_3 is treated with an excess of hydrochloric acid, aqueous sodium chloride is formed and sulphur dioxide gas is evolved. Write an equation to represent this reaction.

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(4)

(Total 12 marks)