O Level Combined Chemistry Structured

The Mole Concept and Stoichiometry Test 2.0

Q1

Copper can be obtained by heating copper(II) oxide in a stream of hydrogen gas as shown in Fig. 4.1.

The burner is turned off when reaction is completed but the hydrogen is kept flowing until the tube is cold.

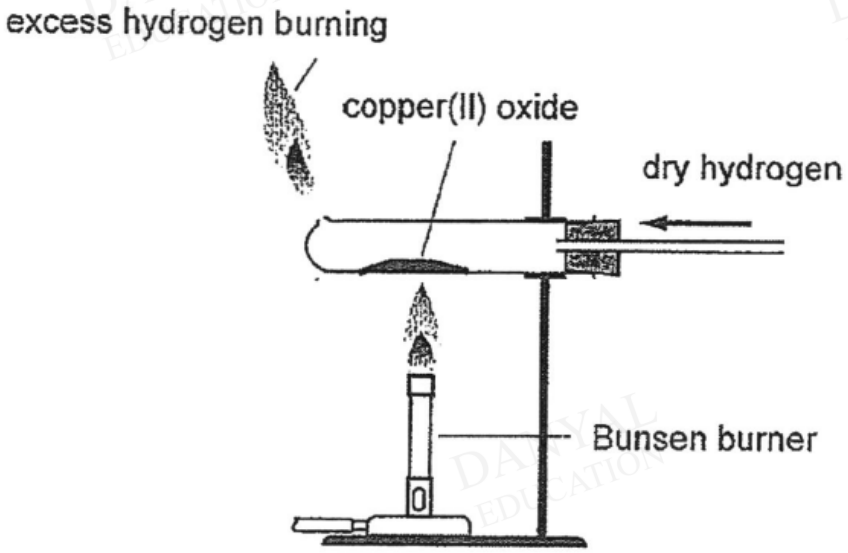

Fig. 4.1

The reaction is represented by the following equation.

$$CuO + H_2 \rightarrow Cu + H_2O$$

(a) Suggest why hydrogen is kept flowing until the tube is cold after the reaction is completed.

..... [1]

(b) Explain, in terms of oxidation state, whether copper(II) oxide has been oxidised or reduced.

.....

..... [1]

(c) Calculate the mass of copper formed when 8 g of copper(II) oxide is used.

[2]

(d) Calculate the volume of unreacted hydrogen gas if 10 dm^3 of hydrogen gas was used.

[3]

(e) Can copper be obtained by heating copper(II) oxide with carbon?

Explain your answer.

.....

..... [1]

Q2

Compound K has a relative molecular mass of 124. A 200 cm^3 of another sample contains 248 g of K.

(a) Calculate the concentration of K in g/dm^3.

concentration = ... g/dm^3 [1]

(b) Calculate the concentration of K in mol/dm^3.

concentration = ... mol/dm^3 [1]

(c) Reacting K with dilute hydrochloric acid produced a colourless gas that formed a white precipitate in limewater. A **blue** solution was formed.

(i) Given that the relative molecular mass of K is 124, deduce the identity of K. Show your working.

K is .....[2]

(ii) Using the identity of K found in (c)(i), write a balanced chemical equation for the reaction of K with dilute hydrochloric acid. State symbols are not required.

.....[1]

(iii) Calculate the maximum volume of gas produced when 100 cm^3 of 0.5 mol/dm^3 of K was reacted with excess dilute hydrochloric acid.
[The volume of one mole of any gas is 24 dm^3 at room temperature and pressure.]

volume = ... dm^3 [2]

Q3

A disproportionation reaction is one where the **same** element is oxidised and reduced simultaneously.

Chlorine undergoes a disproportionation reaction as shown:

$$3\ Cl_2 + 6\ NaOH \rightarrow NaClO_3 + 5\ NaCl + 3\ H_2O$$

This reaction is used in the large-scale production of bleach, $NaClO_3$.

If 120 tonnes of bleach was produced in this reaction, calculate the volume of chlorine gas that was used.

[Relative atomic masses: A_r: Na: 23; Cl: 35.5]
[1 tonne = 10^6 g]

volume = ... dm^3 [2]

Q4

A sample of 94 g copper(II) nitrate decomposes upon heating according to the equation:

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

(a) Calculate the volume of oxygen gas produced at room temperature and pressure. [3]

Q5

Bleach contains sodium hypochlorite (NaOC*l*) which is manufactured by reacting sodium hydroxide with chlorine.

$$2NaOH\ (aq) + Cl_2\ (g) \longrightarrow NaOCl\ (aq) + NaCl\ (aq) + H_2O\ (l)$$

In an experiment, 3.6 dm^3 of chlorine gas was allowed to react with 250 cm^3 of 1 mol/dm^3 sodium hydroxide.

(a) Calculate the number of moles of chlorine and sodium hydroxide used in the reaction.

[2]

(b) Using your answer in (a), identify the reactant that is

(i) in excess: .....

(ii) limiting. ..... [1]

(c) Calculate the mass of sodium hypochlorite produced.

[2]

Answers

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Q1

(a)	To ensure copper formed is not oxidised to form copper(II) oxide again.	[1]
(b)	Copper(II) oxide has been reduced as the oxidation state of copper has decreased from +2 (in CuO) to 0 (in Cu). [1]	[1]
(c)	No. of moles of CuO used = 8 ÷ (64 + 16) = 0.1 mol From the equation, 1 mol of CuO → 1 mol of Cu 0.1 mol of CuO → 0.1 mol of Cu [1] Mass of Cu formed = 0.1 x 64 = 6.4 g [1]	[2]
(d)	From the equation, 1 mol of CuO → 1 mol of H_2 0.1 mol of CuO → 0.1 mol of H_2 [1] Volume of H_2 used = 0.1 x 24 = 2.4 dm^3 [1] Volume of H_2 unreacted = 10 – 2.4 = 7.6 dm^3 [1]	[3]
(e)	Yes, as carbon is more reactive than copper and displace copper from copper(II) oxide.	[1]

Q2

(a)

Concentration of K = 248/ 0.2 = **1240 g/dm^3** [1]

(b)

Concentration of K = (248 / 124) / 0.2 = **10 mol/dm^3** [1]

(c) (i)

K is a metal carbonate since carbon dioxide is formed when reacting with dilute acid.

K is a copper(II) salt since blue solution formed.

Mass of metal left = 124 – 12 – (3 x 16)

= 124 – 60

= **64** [1]

Hence, K is copper(II) carbonate (**$CuCO_3$**) [1]

(c) (ii)

$CuCO_3 + 2\,HCl \rightarrow CuCl_2 + CO_2 + H_2O$ [1]

Allow for ecf based on formula of K given in 5(c)(i)

(c) (iii)

No. of mol of K = 0.1 x 0.5 = 0.05 mol [1]

By mole ratio, 1 K : 1 CO_2

No. of mol of CO_2 = 0.05 mol

Vol of CO_2 = 24 x 0.05 = **1.2 dm^3** [1]

Allow for ecf based on equation stated in 5(c)(ii)

Q3

No. of mol of $NaClO_3$ = (120 x 10^6) / (23 + 35.5 + 48)

= 1.13 x 10^6 mol (3sf) [1]

By mole ratio,

3 Cl_2 : 1 $NaClO_3$

No. of mol of Cl_2 = (1.13 x 10^6) x 3

= 3.38 x 10^6 mol (3sf)

Vol. of Cl_2 = 3.38 x 10^6 x 24.0

= **8.11 x 10^7 dm^3** [1]

Q4

(a) No. of moles of $Cu(NO_3)_2$ = 94 / 188 = 0.5 mol [1]
No. of moles of O_2 = 0.5 / 2 = 0.25 mol [1]
Volume of O_2 = 0.25 x 24 = 6.00 dm^3 [1]

Q5

(a)	No of moles of chlorine = Vol/24dm^3 = 0.15mol No of moles of NaOH = Concentration X Volume = 1mol/dm^3 X 0.25dm^3 = 0.25 mol [1]		[1] [1]
(b)	(i)	in excess Chlorine	Both must be correct to be awarded [1]. No ½ m
	(ii)	limiting Sodium Hydroxide	
(c)	No of moles of sodium hypochlorite : 0.125mol Mass of sodium hypochlorite = Mole X Mr = 0.125 X [23 + 16 + 35.5] = 9.31g		[1] [1]