Paper 4

Questions are applicable for extended candidates only

1 This question is about acids, bases and alkalis.

(g) Dilute nitric acid, $HNO_3(aq)$, reacts with aqueous calcium hydroxide, $Ca(OH)_2(aq)$, as shown.

$$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$$

$20.0\,cm^3$ of $0.0150\,mol/dm^3$ $Ca(OH)_2(aq)$ reacts with $25.0\,cm^3$ of $HNO_3(aq)$.

Calculate the concentration of $HNO_3(aq)$ in g/dm^3.

Use the following steps.

- Calculate the number of moles of $Ca(OH)_2(aq)$ used.

..... mol

- Determine the number of moles of $HNO_3(aq)$ which react with the $Ca(OH)_2(aq)$.

..... mol

- Calculate the concentration of $HNO_3(aq)$ in mol/dm^3.

..... mol/dm^3

- Calculate the concentration of $HNO_3(aq)$ in g/dm^3.

..... g/dm^3

[5]

2 Copper is element 29 in the Periodic Table.

(e) Copper(II) oxide is formed when copper(II) nitrate, $Cu(NO_3)_2$, is heated.

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

(i) State the class of oxide to which copper(II) oxide belongs.

..... [1]

(ii) State the meaning of the Roman numeral (II) in the name copper(II) oxide.

..... [1]

(iii) 0.0200 moles of $Cu(NO_3)_2$ is heated.

Calculate the mass of 0.0200 moles of $Cu(NO_3)_2$.

mass = ... g [2]

(iv) Calculate the **total** volume of gas, in dm^3 at r.t.p., produced when 0.0200 moles of $Cu(NO_3)_2$ is heated.

volume = ... dm^3 [2]

(v) Powdered aluminium reduces copper(II) oxide.

Write the symbol equation for this reaction.

..... [2]

3 Oxygen is produced by the decomposition of aqueous hydrogen peroxide. Manganese(IV) oxide, MnO_2, is a catalyst for this reaction.

(d) The equation for the decomposition of aqueous hydrogen peroxide, $H_2O_2(aq)$, is shown.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

$50.0\,cm^3$ of a $0.200\,mol/dm^3$ solution of $H_2O_2(aq)$ is used.

Calculate the mass of O_2 that forms.
Use the following steps.

- Calculate the number of moles of H_2O_2 used.

..... mol

- Determine the number of moles of O_2 produced.

..... mol

- Calculate the mass of O_2 produced.

..... g
[3]

4 This question is about sodium and compounds of sodium.

(c) A student determines the concentration of a solution of dilute sulfuric acid, H_2SO_4, by titration with aqueous sodium hydroxide, NaOH.

step 1 25.0 cm^3 of 0.200 mol/dm^3 NaOH is transferred into a conical flask.

step 2 Three drops of methyl orange indicator are added to the conical flask.

step 3 A burette is filled with H_2SO_4.

step 4 The acid in the burette is added to the conical flask until the indicator changes colour. The volume of acid is recorded. This process is known as titration.

step 5 The titration is repeated several times until a suitable number of results is obtained.

(iv) 20.0 cm^3 of H_2SO_4 reacts with 25.0 cm^3 of 0.200 mol/dm^3 NaOH.

The equation for the reaction is shown.

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the concentration of H_2SO_4 using the following steps.

- Calculate the number of moles in 25.0 cm^3 of 0.200 mol/dm^3 NaOH.

..... mol

- Determine the number of moles of H_2SO_4 that react with the NaOH.

..... mol

- Calculate the concentration of H_2SO_4.

..... mol/dm^3
[3]

5 Potassium is a Group I element.

(c) When potassium is added to water, it reacts vigorously and a coloured flame is seen. The equation for the reaction is shown.

$$2K(s) + 2H_2O(l) \rightarrow 2KOH(aq) + H_2(g)$$

(iv) Calculate the volume, in cm^3, of hydrogen gas formed when 2.34 g of potassium is added to excess water at room temperature and pressure.

Use the following steps.

- Calculate the number of moles of potassium added.

= ..... mol

- Determine the number of moles of hydrogen gas formed.

= ..... mol

- Calculate the volume of hydrogen gas formed.

volume = ... cm^3

[3]

6 (e) Calcium nitrate crystals are hydrated and have the formula $Ca(NO_3)_2 \bullet xH_2O$ where x is a whole number of molecules of water.

The student heats the crystals to remove the molecules of water.

$$Ca(NO_3)_2 \bullet xH_2O(s) \rightarrow Ca(NO_3)_2(s) + xH_2O(g)$$

(ii) The student heats a sample of $Ca(NO_3)_2 \bullet xH_2O$ and forms 2.46 g of $Ca(NO_3)_2$ and 0.0600 moles of H_2O.

Determine the value of x. Use the following steps.

- Calculate the M_r of $Ca(NO_3)_2$.

M_r = ...

- Determine the number of moles of $Ca(NO_3)_2$ formed.

moles of $Ca(NO_3)_2$ formed = ...

- Determine the value of x in $Ca(NO_3)_2 \bullet xH_2O$.

x = ...

[3]