1. 0620/42/M/J/19/No.5

Copper(II) sulfate crystals, $CuSO_4.5H_2O$, are hydrated.

Copper(II) sulfate crystals are made by reacting copper(II) carbonate with dilute sulfuric acid.

The equation for the overall process is shown.

$$CuCO_3 + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O + CO_2$$

step 1 Powdered solid copper(II) carbonate is added to 50.0 cm^3 of 0.05 mol / dm^3 sulfuric acid until the copper(II) carbonate is in excess.

step 2 The excess of copper(II) carbonate is separated from the aqueous copper(II) sulfate.

step 3 The aqueous copper(II) sulfate is heated until the solution is saturated.

step 4 The solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(a) Calculate the maximum mass of the copper(II) sulfate crystals, $CuSO_4.5H_2O$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm^3 of 0.05 mol / dm^3 H_2SO_4.

..... mol

- Determine the number of moles of $CuSO_4.5H_2O$ that can form.

..... mol

- The M_r of $CuSO_4.5H_2O$ is 250.

  Calculate the maximum mass of $CuSO_4.5H_2O$ that can form.

..... g
[3]

(b) **Steps 1–5** were done correctly but the mass of crystals obtained was less than the maximum mass.

Explain why.

..... [1]

(c) State **two** observations that would indicate that the copper(II) carbonate is in excess in **step 1**.

1 .....

2 .....

[2]

(d) When the reaction in **step 1** is done using lumps of copper(II) carbonate instead of powder, the rate of reaction decreases. All other conditions are kept the same.

Give a reason for this. Explain your answer in terms of particles.

.....

.....

..... [2]

(e) Name a different substance, other than copper(II) carbonate, that could be added to dilute sulfuric acid to produce copper(II) sulfate in **step 1**.

..... [1]

(f) Name the process used to separate the aqueous copper(II) sulfate from the excess of copper(II) carbonate in **step 2**.

..... [1]

(g) The solution of aqueous copper(II) sulfate was heated until it was saturated in **step 3**.

(i) Suggest what is meant by the term *saturated solution*.

.....

.....

..... [2]

(ii) What evidence would show that the solution was saturated in **step 3**?

..... [1]

(iii) Why should the aqueous copper(II) sulfate **not** be heated to dryness in **step 3**?

..... [1]

[Total: 14]

2. 0620/43/M/J/19/No.3

(a) (i) Sodium is in Group I of the Periodic Table.

Describe **two** physical properties of sodium which are different from the physical properties of transition elements such as copper.

1 .....

.....

2 .....

.....

[2]

(ii) Sodium reacts rapidly with water.

Give **one** observation made when sodium is added to water.

..... [1]

(b) Some car airbags contain sodium azide.
When a car airbag is used the sodium azide, NaN_3, decomposes.
The products are nitrogen and sodium.

The equation for the decomposition of sodium azide is shown.

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

Calculate the mass, in g, of sodium azide needed to produce 144 dm^3 of nitrogen using the following steps.

- Calculate the number of moles in 144 dm^3 of N_2 measured at room temperature and pressure.

moles of N_2 = ... mol

- Determine the number of moles of NaN_3 needed to produce this number of moles of N_2.

moles of NaN_3 = ... mol

- Calculate the relative formula mass, M_r, of NaN_3.

M_r = ...

- Calculate the mass of NaN_3 needed to produce 144 dm^3 of N_2.

..... g
[4]

(c) Some airbags contain silicon(IV) oxide.
When the airbag is used sodium oxide is formed.

Oxides can be classified as acidic, amphoteric, basic or neutral.

Classify each of these oxides:

sodium oxide .....

silicon(IV) oxide. .....

[2]

(d) Lead(II) azide is insoluble in water. Solid lead(II) azide can be made in a precipitation reaction between aqueous lead(II) nitrate and aqueous sodium azide.
Lead(II) azide has the formula $Pb(N_3)_2$.

(i) Deduce the formula of the azide ion.

..... [1]

(ii) Complete the chemical equation for the reaction between aqueous lead(II) nitrate and aqueous sodium azide to form solid lead(II) azide and aqueous sodium nitrate. Include state symbols.

$Pb(NO_3)_2(aq)$ + ... $NaN_3(aq) \rightarrow Pb(N_3)_2$(.....) + ...(.....)

[2]

(iii) Describe how you could obtain a sample of lead(II) azide that is **not** contaminated with any soluble salts from the reaction mixture.

.....

.....

.....

..... [2]

(e) An organic compound made from sodium azide has the composition by mass: 49.5% carbon, 7.2% hydrogen and 43.3% nitrogen.

Calculate the empirical formula of the organic compound.

[3]

[Total: 17]

3. 0620/42/F/M/19/No.5

Titanium is extracted from an ore called rutile. Rutile is an impure form of titanium(IV) oxide, TiO_2.

(a) Rutile is mixed with coke and heated in a furnace through which chlorine gas is passed. The product is gaseous titanium(IV) chloride, $TiCl_4$.

$$TiO_2(s) + 2C(s) + 2Cl_2(g) \rightarrow TiCl_4(g) + 2CO(g)$$

The gaseous titanium(IV) chloride produced is condensed into the liquid state. The titanium(IV) chloride is then separated from liquid impurities.

(i) Suggest the name of the process by which liquid titanium(IV) chloride could be separated from the liquid impurities.

..... [1]

(ii) Carbon monoxide, CO(g), is also produced in the reaction.

Why should carbon monoxide **not** be released into the atmosphere?

..... [1]

(b) Calculate the volume of chlorine gas, $Cl_2(g)$, at room temperature and pressure, that reacts completely with 400 g of $TiO_2(s)$ using the following steps.

$$TiO_2(s) + 2Cl_2(g) + 2C(s) \rightarrow TiCl_4(g) + 2CO(g)$$

- Calculate the relative formula mass, M_r, of TiO_2.

M_r of TiO_2 = ...

- Calculate the number of moles in 400 g of TiO_2.

..... mol

- Determine the number of moles of Cl_2 that react with 400 g of TiO_2.

moles of Cl_2 = ... mol

- Calculate the volume of Cl_2 that reacts with 400 g of TiO_2.

volume of Cl_2 = ... dm^3

[4]

(c) Titanium(IV) chloride, $TiCl_4$, is heated with an excess of magnesium, in an atmosphere of argon.

(i) Balance the chemical equation for the reaction.

$$TiCl_4 + \text{.....} Mg \rightarrow Ti + \text{.....} MgCl_2$$

[1]

(ii) Titanium(IV) chloride can be reacted with sodium instead of magnesium.

The reaction between titanium(IV) chloride and sodium is similar to the reaction between titanium(IV) chloride and magnesium.

Write a chemical equation for the reaction between titanium(IV) chloride and sodium.

..... [1]

(iii) Suggest why the reaction between titanium(IV) chloride and magnesium is done in an atmosphere of argon and **not** in air.

.....

..... [1]

(d) After titanium(IV) chloride is heated with magnesium, the unreacted magnesium is removed by adding an excess of dilute hydrochloric acid to the mixture.

The dilute hydrochloric acid also dissolves the magnesium chloride.
The dilute hydrochloric acid does **not** react with the titanium or dissolve it.

(i) Give **two** observations and write a chemical equation for the reaction that occurs when dilute hydrochloric acid reacts with magnesium.

1 .....

2 .....

chemical equation .....

[3]

(ii) Name the process that is used to separate the titanium from the mixture after all the magnesium has been removed.

..... [1]

(iii) Titanium does not react with the dilute hydrochloric acid or dissolve in it.

Suggest why titanium does **not** react with dilute hydrochloric acid.

..... [1]

(e) Magnesium cannot be produced by electrolysis of aqueous magnesium chloride using inert electrodes.

(i) Name the product formed at the negative electrode (cathode) during the electrolysis of aqueous magnesium chloride.

..... [1]

(ii) Suggest how magnesium can be produced from magnesium chloride by electrolysis.

..... [1]

[Total: 16]