10. Group 2

10.1 Properties and reactions of Group 2 metals and compounds

Paper 2

Question Paper

1 **(c)** **Z** is a salt that contains a Period 4 element from Group 2. When **Z** is heated brown gas forms.

Identify the formula of **Z** and use it to write an equation for the reaction.

..... [2]

2 Barium hydroxide, $Ba(OH)_2$, is a strong base used in inorganic and organic reactions.

Fig. 2.1 shows a reaction scheme involving $Ba(OH)_2$.

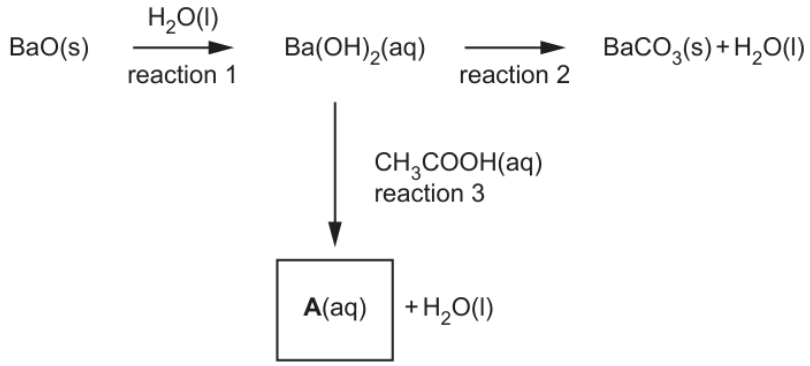

Fig. 2.1

(a) **(i)** State the variation in solubilities of group 2 hydroxides.

..... [1]

(ii) State what is observed in reaction 1.

..... [1]

(iii) Suggest a reactant for reaction 2.

..... [1]

(iv) Identify **A**.

..... [1]

(v) $Ba(OH)_2$ is made by the reaction of Ba with water.

Write an equation for this reaction.

..... [1]

(b) The mineral barytocalcite contains both $BaCO_3$ and $CaCO_3$. Both compounds decompose on heating.

(i) State which compound decomposes first when barytocalcite is heated.

Explain your answer.

.....

..... [1]

(ii) Construct an equation for the complete thermal decomposition of barytocalcite.

The formula of barytocalcite is $BaCa(CO_3)_2$.

$BaCa(CO_3)_2$ ..... [1]

3 NO and NO_2 react at 25 °C to give N_2O_3 as shown in the equation.

$$NO(g) + NO_2(g) \rightleftharpoons N_2O_3(g) \qquad \Delta H = -7.2\,kJ\,mol^{-1}$$

The reaction is reversible and reaches equilibrium in a closed system.

(f) A student titrates nitric acid with a base to form a solution containing aqueous magnesium nitrate.

(i) Identify a base that the student could use.

..... [1]

(ii) The student evaporates the water to obtain magnesium nitrate solid. When this solid is heated it decomposes.

Write an equation for the decomposition of magnesium nitrate.

..... [1]

(iii) State how the thermal stability of Group 2 nitrates changes down the group.

..... [1]

4 Calcium, magnesium and radium are Group 2 elements. Radium follows the same trends as the other members of Group 2.

(b) (i) Write the equation for the thermal decomposition of calcium nitrate.

..... [1]

(ii) Suggest which of the Group 2 nitrates, calcium, magnesium or radium, requires the highest temperature to decompose. Explain your answer.

.....

.....

..... [1]

(c) Predict what you would observe when aqueous radium chloride is added to aqueous sodium sulfate.
Do **not** refer to temperature changes in your answer.

.....

..... [1]

5 Radium, Ra, is an element found in Group 2 of the Periodic Table. It is a crystalline solid at room temperature and conducts electricity.

Radium chloride, $RaCl_2$, has a melting point of 900 °C and is soluble in water.

(c) Solid Ra and Ca show similar reactions with H_2O, but the reactions occur at different rates.

Separate samples, each containing a single piece of solid Ra or Ca, are added to equal volumes of cold water.

Each sample contains equal numbers of moles of solid and the H_2O is in excess.

(i) Construct an equation for the reaction of Ra with H_2O.

..... [1]

(ii) Identify which element, Ra or Ca, reacts with H_2O at a faster rate. Suggest how the observations of each reaction would differ.

.....

..... [1]

(iii) Suggest why these reactions occur at different rates.

.....

.....

..... [2]

(iv) One of the solutions is cloudy when the reaction has finished.

At the end of each reaction, universal indicator is added to each reaction mixture.

Suggest pH values of the solutions made in both reactions. Explain your answer.

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.....

..... [2]

6 Magnesium shows reactions typical of a Group 2 metal.

(b) Fig. 2.1 shows some reactions of magnesium and its compounds.

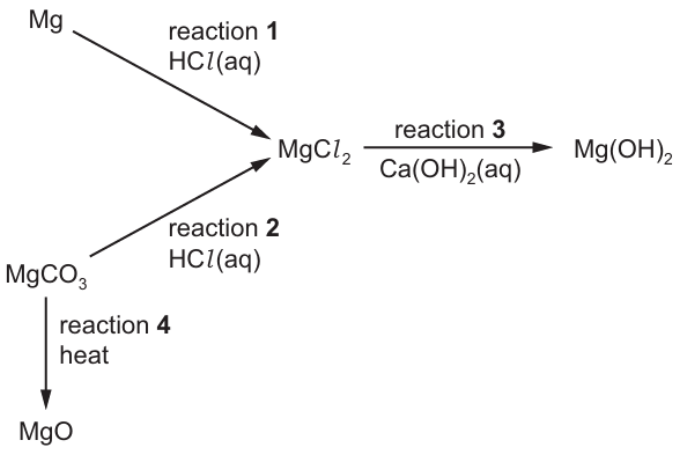


Fig. 2.1

(i) Identify the other products of reactions **1** and **2**.

reaction **1** .....

reaction **2** .....

[2]

(ii) Reaction **3** is used to form a precipitate of $Mg(OH)_2$ from $MgCl_2(aq)$.

State why $Ca(OH)_2(aq)$ would **not** form a precipitate of $Ba(OH)_2$ from $BaCl_2(aq)$.

.....

..... [1]

(iii) State the type of reaction that occurs in reaction **4**.

..... [1]

7 Ethanedioic acid, HO_2CCO_2H, has a relative molecular mass of 90.0.

(b) Solid ethanedioic acid reacts with aqueous calcium ions to make a precipitate of calcium ethanedioate, CaC_2O_4.

CaC_2O_4 breaks down when heated to form calcium oxide, carbon dioxide and carbon monoxide.

(i) Construct an equation to represent the reaction of CaC_2O_4 when heated. Include state symbols.

..... [2]

(ii) Identify the type of reaction which occurs when CaC_2O_4 is heated.

..... [1]

(iii) Identify another compound containing calcium ions which will also produce carbon dioxide and calcium oxide when it is heated.

..... [1]

8 A Group 2 metal combines with bromine to form a crystalline solid, **M**Br_2.

Excess aqueous $AgNO_3$ is added to a solution of **M**Br_2 and a precipitate forms. The mixture is filtered. The precipitate is dried and the mass of the precipitate is recorded.

(f) Separate 1.0 g samples of three different magnesium salts are tested in order to identify the anion present in each sample.

(i) Explain how the action of heat is used to identify which sample is:

- $MgCO_3$
- $Mg(NO_3)_2$
- MgO.

.....

.....

.....

.....

..... [3]

(ii) Complete the electron configuration of the magnesium cation present in these salts.

$1s^2$ ..... [1]

(g) A sample of $MgCO_3(s)$ is distinguished from a sample of $Mg(OH)_2(s)$ by adding a small amount of each solid to $HCl(aq)$.

State **one** similarity and **one** difference in these two reactions.

similarity .....

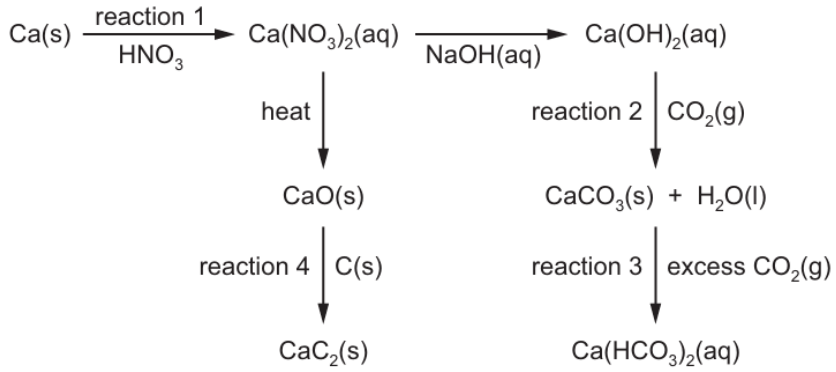
.....

difference .....

.....

[2]

9 The reaction scheme shows some reactions of calcium.



(a) (i) Reaction 1 produces $Ca(NO_3)_2$ and one other product.

Identify the other product.

..... [1]

(ii) Construct an equation for the thermal decomposition of $Ca(NO_3)_2(s)$.

..... [1]

(iii) State the trend in the thermal stability of the Group 2 nitrates down the group.

..... [1]

(iv) In reaction 3, excess CO_2 is bubbled through water containing $CaCO_3$. A solution of $Ca(HCO_3)_2(aq)$ forms.

Construct an equation for reaction 3.

..... [1]

(b) Describe how $Ca(OH)_2$ is used in agriculture.

.....

..... [1]

10 Calcium nitrate, $Ca(NO_3)_2$, reacts with ammonia, carbon dioxide and water to form a mixture of ammonium nitrate and calcium carbonate.

$$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$$

The product mixture can then be added to soil.

(b) State **two** reasons why this mixture of products is added to some soils.

1 .....

2 .....

[2]

11 Phosphorus, sulfur and chlorine can all react with oxygen to form oxides.

(c) Emissions of SO_2 from coal-fired power stations can be reduced by mixing the coal with powdered limestone.

Limestone is heated to form CaO in reaction 1. This then reacts with SO_2 and O_2 to form $CaSO_4$ in reaction 2.

reaction 1: $CaCO_3(s) \rightarrow CaO(s) + CO_2(s)$

reaction 2: $CaO(s) + SO_2(g) + \frac{1}{2}O_2(g) \rightarrow CaSO_4(s)$

(i) State the type of reaction occurring in reaction 1.

..... [1]

12 **(a)** Group 2 elements share common chemical properties.

(ii) 0.001 mol of strontium reacts with an excess of cold water. When the reaction is complete a colourless solution is seen.

Construct the equation for the reaction of strontium with cold water. Include state symbols.

..... [2]

(iii) 0.005 mol of calcium and 0.005 mol of strontium are added separately to two beakers. Each beaker contains 100 cm^3 of cold water.
At the end of each reaction a white solid and a colourless solution are seen in both beakers.

Predict which element, calcium or strontium, produces the more alkaline solution. Explain your answer.

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.....

..... [2]

(iv) Describe one observation when magnesium carbonate is added to excess dilute sulfuric acid.

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..... [1]