27. Group 2

27.1 Similarities and trends in the properties of the Group 2 metals, magnesium to barium, and

Paper 4

Question Paper

1 **(a)** **(i)** Describe the trend in the solubility of the hydroxides of magnesium, calcium and strontium.

Explain your answer.

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most soluble least soluble

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[4]

(ii) Suggest the variation in pH of saturated solutions of the hydroxides of magnesium, calcium and strontium.

Explain your answer.

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..... [1]

2 **(a)** When a sample of hydrated lithium ethanedioate, $Li_2C_2O_4 \cdot H_2O$, is gently heated, two gaseous products are formed and a white solid residue remains.

The residue is added to $HNO_3(aq)$. A gas is produced that turns limewater milky.

Complete the equation for the decomposition of $Li_2C_2O_4 \cdot H_2O$.

$Li_2C_2O_4 \cdot H_2O \rightarrow$ ..... + ... + ...

[1]

(b) The trend in the decomposition temperatures of the Group 2 ethanedioates is similar to that of the Group 2 nitrates.

Suggest which of CaC_2O_4 and BaC_2O_4 will decompose at the **lower** temperature. Explain your answer.

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..... [2]

3 **(a)** Describe the trend in the solubility of the sulfates of magnesium, calcium and strontium.

Explain your answer.

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most soluble least soluble

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[4]

4 **(a)** **(i)** Lithium nitrate, $LiNO_3$, decomposes on heating in a similar way to Group 2 nitrates to give the metal oxide, a brown gas and oxygen.

Write an equation for the decomposition of $LiNO_3$.

..... [1]

(ii) The other Group 1 nitrates, MNO_3, decompose on heating to form the metal nitrite, MNO_2, and oxygen.

The thermal stability of these nitrates increases down the group.

Suggest why the thermal stability of MNO_3 increases down the group.

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..... [2]

5 **(a)** Group 2 nitrates decompose when heated.

Describe how the thermal stability of Group 2 nitrates changes with increasing proton number.

Explain your answer.

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..... [3]

(b) Copper(II) nitrate decomposes in a similar manner to Group 2 nitrates.

Write an equation for the decomposition of $Cu(NO_3)_2$.

..... [1]

6 **(a)** Group 2 carbonates decompose when heated to form the metal oxide and carbon dioxide.

(i) Suggest a mechanism for the decomposition of the carbonate ion by adding **two** curly arrows in Fig. 1.1.

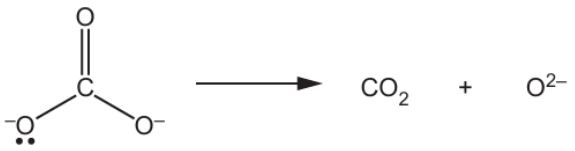

Fig. 1.1

[1]

(ii) Describe the variation in the thermal stability of Group 2 carbonates. Explain your answer.

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..... [3]

7 **(b)** Calcium nitrate, $Ca(NO_3)_2$, is a white crystalline solid. When heated, it starts to decompose at approximately 500°C.

(i) Write an equation for the decomposition of $Ca(NO_3)_2$.

..... [1]

(ii) Suggest temperatures at which $Mg(NO_3)_2$ and $Ba(NO_3)_2$ start to decompose.

Explain your answer.

temperature at which $Mg(NO_3)_2$ starts to decompose ..... °C

temperature at which $Ba(NO_3)_2$ starts to decompose .....°C

explanation .....

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[3]

8 Some of the ionic compounds of Group 2 elements undergo thermal decomposition.

Thermal decomposition of solid anhydrous magnesium ethanedioate, MgC_2O_4, occurs above 650 °C. The products are magnesium oxide and a mixture of two different gases, one of which gives a white precipitate with saturated calcium hydroxide solution.

(a) Complete the equation for the thermal decomposition of MgC_2O_4.

$$MgC_2O_4 \rightarrow$$ [1]

(b) Suggest which of MgC_2O_4 or CaC_2O_4 undergoes thermal decomposition at a **lower** temperature. Explain your answer.

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..... [2]

9 **(a)** The solubility of the Group 2 sulfates decreases down the group.

Explain this trend.

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..... [3]

10 **(a)** The solubility of the Group 2 hydroxides increases down the group.

Explain this trend.

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..... [3]

11 Copper is a transition element. It forms a wide variety of compounds.

(e) Copper(II) nitrate, $Cu(NO_3)_2$, and barium nitrate, $Ba(NO_3)_2$, both decompose when heated.

Copper(II) nitrate decomposes at a lower temperature than barium nitrate.

Suggest a reason for this difference. Explain your answer.

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..... [2]

12 **(a)** State and explain the trend observed in the thermal stability of the Group 2 nitrates.

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..... [3]

(b) **(i)** Lead(II) nitrate, $Pb(NO_3)_2$, decomposes on heating in a similar manner to the Group 2 nitrates.

Write an equation for the decomposition of lead(II) nitrate.

..... [1]

(ii) Suggest how the ease of decomposition of $Pb(NO_3)_2$ would compare to that of $Ba(NO_3)_2$. Explain your answer. You may find it useful to refer to the *Data Booklet*.

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..... [1]

13 Separate samples of 0.02 mol of calcium carbonate and 0.02 mol of barium carbonate are heated until completely decomposed to the metal oxide and carbon dioxide.

(a) State which of these two Group 2 carbonates requires the **higher** temperature before it begins to decompose. Explain your answer.

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..... [2]

(b) After decomposition is complete, the 0.02 mol sample of calcium oxide is taken and added to 2.00 dm^3 of water. A solution is formed with no solid present. Dilute sulfuric acid is then added dropwise until a precipitate is seen.

The same procedure is repeated with the 0.02 mol sample of barium oxide, using the same concentration solution of dilute sulfuric acid.

Identify the sample to which **most** sulfuric acid must be added to cause a precipitate to appear.

Explain your answer. You should refer to the solubilities of the precipitates and relevant energy terms in your answer.

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..... [3]

14 Separate samples of 0.01 mol of magnesium nitrate and 0.01 mol of strontium nitrate are heated until completely decomposed to the metal oxide, nitrogen dioxide and oxygen.

(a) State which of these two Group 2 nitrates requires the **higher** temperature before it begins to decompose. Explain your answer.

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..... [2]

(b) After decomposition is complete the 0.01 mol sample of magnesium oxide is taken and increasing amounts of water are added to it, with stirring, until no solid remains.

This procedure is repeated with the 0.01 mol sample of strontium oxide.

Identify the sample to which most water must be added to cause all the solid to dissolve. Explain your answer by reference to the solubilities of the products formed when water is added to the oxides. You should refer to relevant energy terms in your answer.

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..... [3]

15 **(a)** **(i)** Describe and explain the trend in the solubility of the Group 2 hydroxides down the group.

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..... [4]

Group 2 hydroxides decompose on heating to give the corresponding metal oxide and water vapour.

(ii) Suggest which of $Mg(OH)_2$ and $Sr(OH)_2$ will decompose at a **lower** temperature.

Explain your answer.

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..... [2]

16 **(a)** Describe and explain how the solubility of the Group 2 sulfates varies down the group.

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..... [4]

(b) The trend in the decomposition temperatures of Group 2 peroxides, MO_2, is similar to that of Group 2 carbonates.

Suggest which of barium peroxide, BaO_2, and calcium peroxide, CaO_2, will decompose at the **lower** temperature. Explain your answer.

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..... [2]

(c) Magnesium iodate(V), $Mg(IO_3)_2$, decomposes when heated to form magnesium oxide, oxygen and iodine.

Construct an equation for this reaction.

..... [1]

17 **(b)** **(i)** Write an equation for the reaction between BaO and H_2O.
Include state symbols.

..... [1]

(ii) State and explain how the solubilities of the hydroxides of the Group 2 elements vary down the group.

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..... [4]

18 **(b)** The sulfates of the Group 2 elements vary in solubility down Group 2.

(i) Give the names of **two** solutions that could be mixed to form barium sulfate.

..... [1]

(ii) State and explain how the solubilities of the sulfates of the Group 2 elements vary down Group 2.

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..... [4]

19 **(b)** Describe and explain how the thermal stability of Group 2 nitrates changes with increasing atomic number.

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..... [3]

(c) The variation in the thermal stability of Group 2 amides is similar to that of Group 2 nitrates.

(i) Suggest whether calcium amide, $Ca(NH_2)_2$, will decompose more or less readily than barium amide, $Ba(NH_2)_2$. Explain your answer.

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..... [1]

(ii) $Ba(NH_2)_2$ decomposes when heated to form barium nitride, Ba_3N_2, and ammonia as the only products.

Write an equation for this reaction.

..... [1]

20 **(a)** By reference to the formation of σ and π bonds, describe and explain the shape of a benzene molecule, C_6H_6.

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..... [3]

21 **(a)** Describe fully what would be seen when magnesium and strontium are heated separately in oxygen.

magnesium .....

strontium .....
[2]

(b) **(i)** Write an equation for each of the following processes. Include state symbols.

calcium is burned in air

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calcium carbonate is heated strongly

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[2]

(ii) Calcium hydroxide is formed when water is added to calcium oxide. Calcium hydroxide and calcium carbonate are both used in agriculture.

Describe the main benefit of adding calcium hydroxide or calcium carbonate to soil.

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(iii) Explain why the Group 2 hydroxides become more soluble down the group.

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..... [3]

(c) Describe the observations, if any, that you would make when:

- a few drops of NaOH(aq) are added to $BaCl_2$(aq)

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- a few drops of H_2SO_4(aq) are added to $BaCl_2$(aq).

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[2]

(d) Describe and explain how the thermal stability of the Group 2 carbonates varies down the group.

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..... [3]

22 **(a)** Describe what you would see when calcium and barium are heated separately with oxygen.

calcium .....

barium .....

[2]

(b) The decomposition temperatures of the Group 2 carbonates vary down the group.

State and explain the variation in the decomposition temperatures.

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..... [3]

(c) Magnesium carbonate was heated in an open test-tube. It was difficult to see whether a thermal decomposition reaction took place.

Explain why.

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