1 Hydrated magnesium nitrate, $Mg(NO_3)_2.6H_2O$, is heated in a boiling tube and the following observations are made.

Stage 1 The white solid forms a clear, colourless solution.

Stage 2 Condensation forms around the mouth of the boiling tube and a white solid starts to form at the bottom of the tube.

Stage 3 As the heating continues, the colourless solution disappears leaving a white solid.

Stage 4 The white solid melts.

Stage 5 A brown gas forms.

Stage 6 A glowing splint reignites when it is placed in the boiling tube.

Stage 7 A white solid is left in the boiling tube.

(a) Explain what is happening in stages 1 and 2.

(3)

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(b) (i) Identify the products formed in stages 5, 6 and 7.

(3)

Stage 5 .....

Stage 6 .....

Stage 7 .....

(ii) Write the equation for the complete thermal decomposition of hydrated magnesium nitrate, $Mg(NO_3)_2.6H_2O$.

State symbols are not required.

(2)

(c) The chlorides of magnesium and calcium can be distinguished from each other by carrying out a flame test.

(i) Describe what you would see in each test.

(2)

Magnesium chloride .....

Calcium chloride .....

*(ii) Explain how flame colours arise in a flame test.

(3)

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(iii) Suggest why the observations of the flame tests for magnesium chloride and calcium chloride are different.

(2)

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(Total for Question = 15 marks)

2 (a) (i) An alkaline solution is produced when barium reacts with cold water. Write the equation for this reaction, including all state symbols.

(2)

(ii) The reaction in (a)(i) is a redox reaction. State the initial and final oxidation number of any element that changes its oxidation number.

(2)

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(b) Dilute hydrochloric acid is added to the solution produced in (a)(i). Write the equation for the reaction which occurs. State symbols are **not** required.

(1)

(c) Dilute sulfuric acid is added to another sample of the solution produced in (a)(i). How would the appearance of the resulting mixture differ from the mixture produced in (b)? Explain this difference.

(2)

Appearance .....

Explanation .....

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(d) (i) Two white powders are known to be barium carbonate and magnesium carbonate.

How could you distinguish between the two powders by heating them? [No practical details are required.]

Include the equation for the action of heat on one of these carbonates. State symbols are not required.

(2)

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Equation:

(ii) Suggest another test, other than heating or the use of an acid, which could be used to distinguish between magnesium carbonate and barium carbonate. State the results for both compounds.

(2)

Test .....

Result with magnesium carbonate .....

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Result with barium carbonate .....

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(Total for Question = 11 marks)

3 Metal nitrates decompose on heating. Potassium nitrate, KNO_3, decomposes to form potassium nitrite and oxygen, whereas calcium nitrate, $Ca(NO_3)_2$, decomposes to form calcium oxide, nitrogen dioxide and oxygen.

(a) Write equations for the decomposition of each of these metal nitrates. State symbols are **not** required.

(2)

(i) Potassium nitrate

(ii) Calcium nitrate

(b) State **two** things that you would **see** when anhydrous calcium nitrate is heated.

(2)

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*(c) Explain why potassium nitrate and calcium nitrate decompose to form different products.

(3)

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(Total for Question 7 marks)

4 Calcium oxide, known as quicklime, is produced by the thermal decomposition of calcium carbonate, found naturally in limestone.

(a) (i) Explain what is meant by the term **thermal decomposition**.

(2)

(ii) Write an equation for the thermal decomposition of calcium carbonate, including state symbols.

(1)

(iii) Other Group 2 carbonates can also undergo thermal decomposition. Describe and explain the trend in thermal stability of carbonates down Group 2.

(3)

(b) 0.121 g of an impure sample of quicklime was dissolved in 50.0 cm^3 of hydrochloric acid, concentration 0.100 mol dm^{-3}. The excess hydrochloric acid was titrated with sodium hydroxide solution, concentration 0.100 mol dm^{-3}, and 18.0 cm^3 was needed to just neutralize the acid. The indicator used was methyl orange.

The equations for the reactions involved are shown below.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

(i) What colour would the indicator be at the end-point?

(1)

(ii) Calculate the number of moles of hydrochloric acid that reacted with the sodium hydroxide solution.

(1)

(iii) Calculate the number of moles of hydrochloric acid originally added to the quicklime. Use this answer and your answer to (b)(ii) to calculate the number of moles of quicklime that reacted with the hydrochloric acid.

(2)

(iv) Calculate the percentage purity of the sample of quicklime. Give your answer to **three** significant figures.

(2)

(c) (i) Describe how to carry out a flame test on the impure sample of quicklime to confirm that it contains calcium ions.

(3)

(ii) If the flame test gave a green colour, in addition to the expected brick red flame, which Group 2 metal is also likely to be present?

(1)

(Total for Question = 16 marks)