

Cambridge AS & A Level

CHEMISTRY

Paper 2

Topical Past Paper Questions
+ Answer Scheme

2015 - 2021



Chapter 10

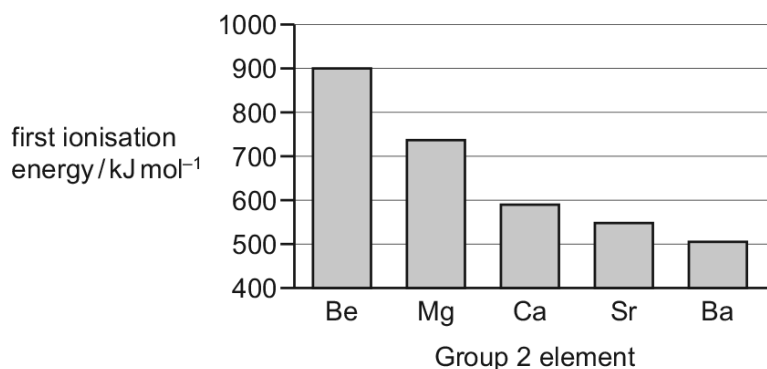
Group 2



10.1 Similarities and trends in the properties of the Group 2 metals

51. 9701_w20_qp_21 Q: 1

The graph shows the first ionisation energies of some of the elements in Group 2.



(a) Write an equation for the first ionisation energy of Mg.

Include state symbols.

..... [1]

(b) Explain the observed trend in first ionisation energies down Group 2.

.....

 [3]

(c) The second ionisation energy of Be is 1757 kJ mol⁻¹.

Explain why the second ionisation energy of Be is higher than the first ionisation energy of Be.

.....

 [2]

[Total: 6]

52. 9701_w20_qp_22 Q: 2

The Period 3 elements, Na to S, all react with oxygen to form oxides.

(a) State the trend in acid/base behaviour of the oxides of the Period 3 elements, from Na to S.

.....
 [1]

(b) State and explain the trend, from Na to S, in the maximum oxidation number of the Period 3 elements in their oxides.

.....

 [2]

(c) Sodium oxide and phosphorus(V) oxide both react with water.

Name the product of each reaction.

reaction	product
sodium oxide with water	
phosphorus(V) oxide with water	

[2]

(d) Explain why phosphorus(V) oxide has a low melting point of approximately 300°C but magnesium oxide has a high melting point of approximately 2850°C.

.....

 [3]

(e) Aluminium oxide, Al_2O_3 , reacts separately with both acids and alkalis.

(i) Write an equation for the reaction of aluminium oxide with excess aqueous hydrochloric acid.

..... [1]

(ii) Write an equation for the reaction of aluminium oxide with excess aqueous sodium hydroxide.

..... [1]

(f) Describe the lattice structure of silicon(IV) oxide.

Your answer should include reference to the arrangement of the silicon and oxygen atoms and the bonds between them.

.....
.....
.....
..... [2]

(g) Sodium oxide and silicon(IV) oxide react to form sodium silicate(IV), Na_2SiO_3 .

Sodium oxide is obtained from the thermal decomposition of sodium carbonate.

Write equations for the following reactions:

(i) sodium oxide with silicon(IV) oxide

..... [1]

(ii) the thermal decomposition of sodium carbonate, forming sodium oxide and carbon dioxide.

..... [1]

[Total: 14]



53. 9701_s19_qp_21 Q: 1

(a) Group 2 elements share common chemical properties.

- (i) Calcium reacts in cold water more quickly than magnesium because more energy is required to remove the outer electrons in magnesium. This occurs even though calcium atoms have a greater nuclear charge.

Explain why more energy is required to remove the outer electrons in magnesium than in calcium.

.....
.....
..... [2]

- (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 cm³ 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.

.....
.....
..... [2]

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

.....
..... [1]

(b) Element **X** is a metal. **X** reacts with oxygen to form a black solid oxide. The oxidation state of **X** in this oxide is +2. The carbonate of **X**, XCO_3 , is a green solid. It decomposes on heating to form the oxide and a colourless gas.

(i) From the information given, state two similarities and one difference that metal **X** and its compounds have with Group 2 metals and their compounds.

similarity 1

.....

similarity 2

.....

difference 1

.....

[3]

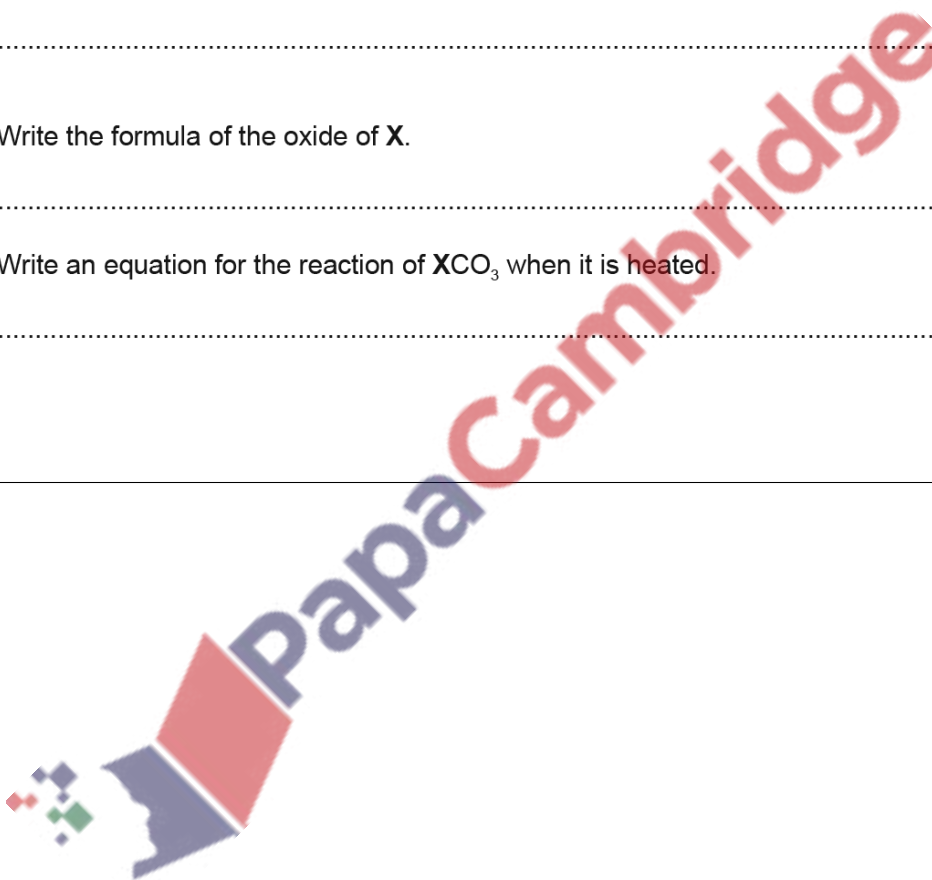
(ii) Write the formula of the oxide of **X**.

..... [1]

(iii) Write an equation for the reaction of XCO_3 when it is heated.

..... [1]

[Total: 12]



54. 9701_s19_qp_23 Q: 3

(a) Magnesium reacts with oxygen to form magnesium oxide.

State **two** observations that would be made when magnesium is heated strongly and placed in a gas jar of pure oxygen.

.....
..... [1]

(b) Acid indigestion is caused by an excess of hydrochloric acid in the stomach. Magnesium oxide is commonly found in indigestion tablets.

(i) Give the equation to show how magnesium oxide relieves acid indigestion.

..... [1]

(ii) Name the type of reaction that occurs in (b)(i).

..... [1]

(c) Magnesium oxide is described as a ceramic material. It has a high melting point.

State and explain why ceramic materials such as magnesium oxide have high melting points.

.....
.....
..... [2]

(d) Magnesium oxide can be made from magnesium carbonate in a one-step reaction using heat.

(i) Write an equation for this reaction. Include state symbols.

..... [1]

(ii) Name the type of reaction occurring during this process.

..... [1]

[Total: 7]

55. 9701_s18_qp_22 Q: 1

Sodium and magnesium are the first two elements in the third period.

(a) Sodium and magnesium both react with cold water to produce the same type of product in solution. With sodium the solution is clear but with magnesium it appears cloudy.

(i) Write an equation for the reaction of magnesium with cold water.

..... [1]

(ii) Suggest why the solution is cloudy after the reaction of magnesium with cold water.

.....
..... [1]

(b) Group 2 elements, including magnesium, react with oxygen and with dilute acids. There are trends in both the physical and chemical properties of the elements and their compounds down the group. Reactivity generally increases from Mg to Ba.

(i) Explain why there is a general increase in reactivity from Mg to Ba.

.....
.....
..... [2]

(ii) Give **two** observations for the reaction of magnesium with oxygen. Write an equation for this reaction. Include state symbols.

.....
.....
equation [3]

(iii) Write an equation for the reaction of magnesium with sulfuric acid.

..... [1]

(iv) Suggest why there is a general decrease in the melting points of the elements down Group 2.

.....
.....
.....
..... [3]

[Total: 11]

56. 9701_m16_qp_22 Q: 1

This question is about Period 3 elements and their compounds.

(a) Give an explanation for each of the following statements.

(i) The atomic radius decreases across Period 3 (Na to Ar).

.....
.....
.....
..... [2]

(ii) The first ionisation energy of sulfur is lower than that of phosphorus.

.....
.....
.....
..... [2]

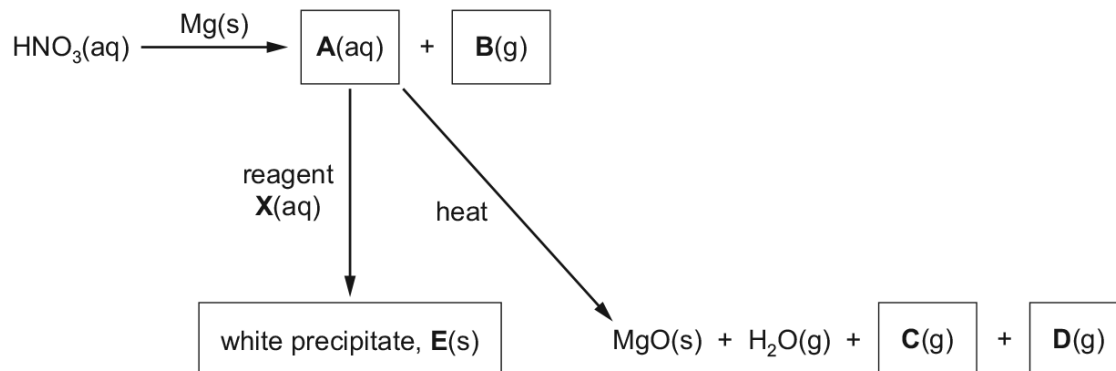
(iii) Sodium is a better electrical conductor than phosphorus.

.....
.....
.....
..... [2]

(iv) Magnesium is a better electrical conductor than sodium.

.....
..... [1]

(b) The flow chart below shows a series of reactions.



(i) Give the **formula** of each of the compounds **A** to **D**.

A

B

C

D

[4]

(ii) **E** reacts with dilute aqueous acid to produce a gas that turns limewater cloudy.

Suggest the identity of reagent **X**.

..... [1]

[Total: 12]



57. 9701_s16_qp_21 Q: 3

The elements in Group 2, and their compounds, show many similarities and trends in their properties.

(a) Magnesium, calcium, strontium and barium all react with cold water.

(i) Describe what you would see when some calcium is added to cold water.

.....

 [3]

(ii) Write an equation for the reaction taking place in (i).

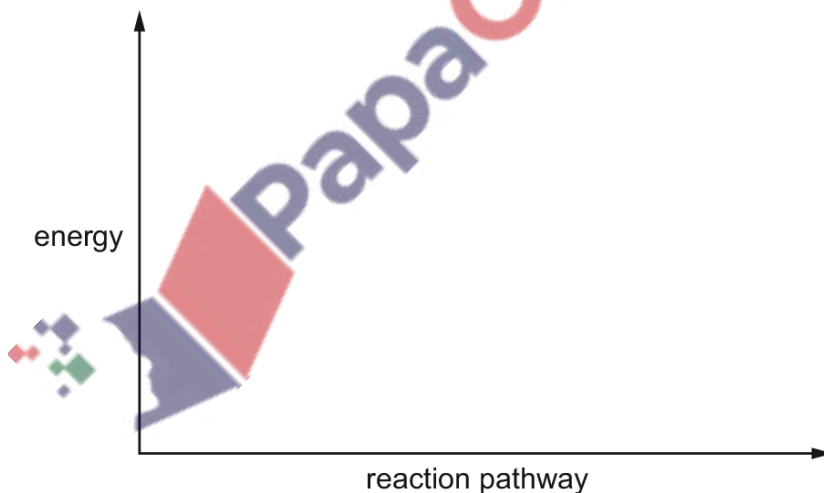
..... [1]

(iii) Describe how the reaction of barium with cold water would differ from the reaction of calcium in (i) in terms of what you would see.

.....
 [1]

(b) Magnesium oxide can be formed by the reaction of magnesium and oxygen in the air.

(i) Draw a **fully labelled** reaction pathway diagram for the reaction between magnesium and oxygen.



[2]

(ii) Explain why there is no visible reaction when a piece of magnesium ribbon is exposed to the air.

.....

 [2]

- (iii) Magnesium oxide is used to manufacture heat-resistant bricks for furnace linings in the steel-making industry.

State and explain the property of magnesium oxide that makes it suitable for this use.

.....
.....
.....
..... [2]

- (iv) Suggest a reason why magnesium oxide cannot be used as a lining for any furnaces containing acidic materials.

.....
..... [1]

- (c) The nitrates and carbonates of the Group 2 elements, from magnesium to barium, decompose when heated.

- (i) State the trend in the temperature of thermal decomposition of these Group 2 nitrates and carbonates.

.....
..... [1]

- (ii) Give the equation for the thermal decomposition of magnesium carbonate.

..... [1]

- (iii) Give the equation for the thermal decomposition of calcium nitrate.

..... [1]

[Total: 15]

10.2 Some uses of Group 2 compounds

58. 9701_s20_qp_23 Q: 1

(a) A sample of barium is heated in oxygen.

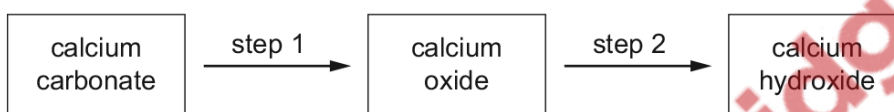
(i) Describe **two** observations for this reaction.

.....
..... [2]

(ii) Write an equation for this reaction. Include state symbols.

..... [1]

(b) Calcium carbonate can be converted into calcium hydroxide in a two-step process.



(i) Describe how the two-step process is carried out to convert calcium carbonate into calcium hydroxide. Include relevant equations.

.....
.....
..... [3]

(ii) Name the type of reaction occurring when calcium carbonate is converted into calcium oxide.

..... [1]

(iii) State **one** common use for both calcium carbonate and calcium hydroxide.

..... [1]

- (c) Gallium is a silver-grey solid. Aluminium and gallium share many similar chemical properties.
- (i) Construct an equation for the reaction of gallium when heated in oxygen to form gallium oxide, Ga_2O_3 .
 [1]
- (ii) Deduce the oxidation number of gallium in Ga_2O_3 .
 [1]
- (iii) Complete the table by predicting the formula of each gallium-containing product formed when gallium oxide reacts separately with hot aqueous hydrochloric acid and with hot concentrated sodium hydroxide.

reagents and conditions	formula of gallium-containing product
gallium oxide + hot $\text{HCl}(\text{aq})$	
gallium oxide + hot concentrated $\text{NaOH}(\text{aq})$	

[2]

[Total: 12]

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(c) The carbonates and nitrates of the elements in Group 2 can all be decomposed by heating.

(i) Write an equation for the thermal decomposition of magnesium nitrate.

..... [1]

(ii) The thermal decomposition of calcium carbonate forms a solid product that is industrially important. This solid product reacts with water to form a compound commonly known as slaked lime.

Write equations for the thermal decomposition of calcium carbonate and the reaction of the solid product to form slaked lime.

thermal decomposition

formation of slaked lime

[2]

(d) Calcium carbonate and calcium hydroxide both have an important use in agriculture.

(i) Describe this use and explain what makes these two compounds suitable for it.

.....

.....

..... [2]

(ii) Write an ionic equation to illustrate this use of calcium carbonate.

..... [1]

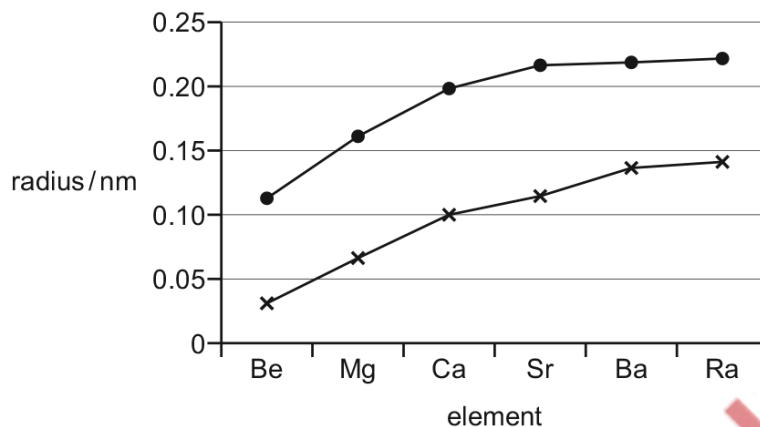
[Total: 16]



60. 9701_w16_qp_21 Q: 3

The elements in Group 2 and their compounds show various trends in their physical and chemical properties.

(a) The graph below shows the radius values of the atoms and 2+ ions of the elements in Group 2.



(i) Explain why both lines show a steady increase in the values of the radii down the group.

.....

 [2]

(ii) State and explain which line represents the atomic radii and which represents the ionic radii.

.....

 [2]

(b) L is a salt of a Group 2 element M.

When L is heated strongly a brown gas is observed and a white solid remains.

The white solid dissolves in water to form a colourless solution of the metal hydroxide $M(OH)_2$.

Addition of dilute sulfuric acid to this colourless solution produces a dense white precipitate.

(i) Identify the anion in salt L.

..... [1]

- (ii) Identify the element **M** and write an ionic equation for the formation of the white precipitate with sulfuric acid.

M =

equation [1]

- (iii) Give the formula of salt **L** and use it to write an equation for the thermal decomposition of salt **L**.

formula of salt **L**

equation [2]

- (c) Calcium carbonate and calcium hydroxide can both be used in agriculture to neutralise acidic soils.

- (i) Write ionic equations for the neutralisation of acid by each of calcium hydroxide and calcium carbonate.

calcium hydroxide

calcium carbonate [2]

- (ii) Suggest and explain why calcium carbonate is a better choice than calcium hydroxide for this purpose in areas of high rainfall.

.....
.....
..... [2]

- (d) Magnesium reacts with both cold water and steam.

Give the formula of the magnesium-containing product of each of these reactions.

with cold water

with steam [2]

[Total: 14]

61. 9701_S15_qp_23 Q: 2

The elements in Group II, and their compounds, show a variety of trends in their properties.

(a) Magnesium, calcium and barium all react with cold water to form hydroxides.

(i) Describe and explain the trend in reactivity of these three elements with cold water.

.....
.....
.....
.....
..... [3]

(ii) Give the equation for the reaction of magnesium with cold water.

..... [1]

(iii) Suggest why the water eventually turns cloudy during the reaction of magnesium with cold water.

.....
..... [1]

(iv) Suggest the equation for the reaction of hot magnesium with steam.

..... [1]

(b) The oxides of magnesium, calcium and barium all react with dilute nitric acid to form nitrates.

(i) Give the equation for the reaction of magnesium oxide with nitric acid.

..... [1]

(ii) State the trend in thermal stability of the nitrates of Group II.

.....
..... [1]

(iii) Give the equation for the thermal decomposition of magnesium nitrate.

..... [1]

- (iv) Apart from lithium nitrate, the nitrates of the Group I elements decompose in a different way to those of the Group II elements.

The equation for the thermal decomposition of potassium nitrate is



By identifying any changes in oxidation number, explain which element is reduced and which is oxidised in this decomposition.

.....

.....

.....

..... [3]

- (c) A refractory material is one that does not decompose or melt at very high temperatures. Over 50% of magnesium oxide production is for use as a refractory material.

Explain why magnesium oxide has a very high melting point.

.....

.....

..... [2]

- (d) The word 'lime' is usually used to refer to a range of calcium-containing compounds that have a range of uses.

- (i) Write equations to show how calcium carbonate can be converted into calcium hydroxide by a two-step process.

.....

..... [2]

A garden pond, with a total volume of 8000dm^3 , has been contaminated in such a way that its pH has fallen to 4. This means that the concentration of hydrogen ions, H^+ , in the water is $1 \times 10^{-4}\text{mol dm}^{-3}$.

- (ii) Write an ionic equation for the neutralisation reaction that occurs between hydrogen ions and carbonate ions, CO_3^{2-} .

..... [1]

- (iii) Use your equation to calculate the mass of powdered calcium carbonate that would need to be added to the pond to neutralise the acidity.

mass = g [2]

[Total: 19]