10. Group 2

10.1 Properties and reactions of Group 2 metals and compounds

Paper 1

Question Paper

1 X is a Group 2 element in either Period 3 or Period 5. $X(OH)_2$ is less soluble in water than $Ca(OH)_2$.

When $X(NO_3)_2$ is heated, it decomposes.

Which row is correct?

	identity of X	equation describing decomposition of $X(NO_3)_2$
A	Mg	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
B	Mg	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$
C	Sr	$X(NO_3)_2 \rightarrow X + 2NO_2 + O_2$
D	Sr	$2X(NO_3)_2 \rightarrow 2XO + 4NO_2 + O_2$

2 Which statement comparing magnesium and barium, or their compounds, is correct?

A Magnesium reacts with dilute hydrochloric acid more rapidly than barium does.

B One mole of magnesium carbonate gives off a greater amount of gas when it reacts with an excess of dilute hydrochloric acid than one mole of barium carbonate does.

C The solubility of magnesium sulfate in water is greater than the solubility of barium sulfate in water.

D Magnesium carbonate undergoes thermal decomposition **less** readily than barium carbonate does.

3 V and W are two compounds. Each one contains a different Group 2 element.

A sample of each solid is added to water, shaken, and the pH of the resulting solution is measured.

compound	V	W
pH	13.6	9.4

Which row could identify V and W?

	V	W
A	$BaSO_4$	$MgSO_4$
B	$MgSO_4$	$BaSO_4$
C	$Ba(OH)_2$	$Mg(OH)_2$
D	$Mg(OH)_2$	$Ba(OH)_2$

4 All solubility data in this question is given at the same temperature.

The table gives some data for compounds of calcium and for compounds of X, an unidentified element in Group 2.

element	decomposition temperature of carbonate / °C	solubility of sulfate / mol per 100 g of water	solubility of hydroxide / mol per 100 g of water
Ca	840	4.66×10^{-3}	1.53×10^{-3}
X	1150		

What is the missing data for element X?

	solubility of sulfate / mol per 100 g of water	solubility of hydroxide / mol per 100 g of water
A	7.11×10^{-5}	2.00×10^{-5}
B	7.11×10^{-5}	3.37×10^{-3}
C	1.83×10^{-1}	2.00×10^{-5}
D	1.83×10^{-1}	3.37×10^{-3}

5 What is the total volume of gas produced, measured at room conditions, when 0.010 mol of anhydrous magnesium nitrate is completely decomposed by heating?

A 240 cm^3 **B** 480 cm^3 **C** 600 cm^3 **D** 720 cm^3

6 A mixture of calcium carbonate, calcium nitrate, strontium carbonate and strontium nitrate is thermally decomposed. The decomposition reaction of each substance goes to completion. Each substance is anhydrous.

How many different products are formed?

A 4 **B** 5 **C** 7 **D** 8

7 W is a solid that reacts with water to produce an alkaline solution.

The addition of two drops of dilute H_2SO_4 to this alkaline solution produces a white precipitate.

What could be the identity of solid W?

A magnesium hydroxide

B magnesium oxide

C barium oxide

D phosphorus oxide

8 Sodium is added to water to form solution Y. The pH of solution Y is measured.

When powdered substance X is added to solution Y, the pH falls.

Which **two** compounds could each be substance X?

A $MgCl_2$ and $Al(OH)_3$

B $MgCl_2$ and K_2O

C $NaCl$ and $Al(OH)_3$

D $NaCl$ and K_2O

9 Which row correctly describes the separate reactions of calcium and strontium with water?

	substance reduced	substance oxidised	more vigorous reaction
A	calcium or strontium	water	calcium + water
B	calcium or strontium	water	strontium + water
C	water	calcium or strontium	calcium + water
D	water	calcium or strontium	strontium + water

10 L and M are both compounds of Group 2 elements.

L and M are both soluble in water.

When solutions of L and M are mixed, a white precipitate is formed.

What could be L and M?

A barium chloride and magnesium sulfate

B barium sulfate and magnesium chloride

C barium nitrate and magnesium chloride

D barium carbonate and magnesium nitrate

11 A 5.00 g sample of an anhydrous Group 2 metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

A magnesium

B calcium

C strontium

D barium

12 What happens when a piece of magnesium ribbon is placed in cold water?

A A vigorous effervescence occurs.

B Bubbles of gas form slowly on the magnesium.

C The magnesium floats on the surface of the water and reacts quickly.

D The magnesium glows and a white solid is produced.

13 The table gives some data for compounds of two elements from Group 2 of the Periodic Table.

element	decomposition temperature of carbonate / °C	solubility of sulfate in mol / 100 g of water	solubility of hydroxide in mol / 100 g of water
calcium	840	4.66×10^{-3}	1.53×10^{-3}
Z	?	?	2.00×10^{-5}

What is the missing data for element Z?

	decomposition temperature of carbonate / °C	solubility of sulfate in mol / 100 g of water
A	350	1.83×10^{-1}
B	350	7.11×10^{-5}
C	1100	1.83×10^{-1}
D	1100	7.11×10^{-5}

14 Q is a mixture of two compounds of Group 2 elements.

Q undergoes thermal decomposition to produce a white solid and only two gaseous products. One of the gaseous products relights a glowing splint.

What could be the components of mixture Q?

A $MgCl_2$ and $CaCO_3$

B $MgCO_3$ and $Ca(NO_3)_2$

C $Mg(NO_3)_2$ and $Ca(NO_3)_2$

D MgO and CaO

15 Which statement explains why calcium has a higher melting point than barium?

A Calcium cations are smaller than barium cations and have a stronger attraction to the delocalised electrons.

B The structure of calcium is partly giant molecular.

C There are more delocalised electrons in calcium than in barium as it has a lower ionisation energy.

D There is greater repulsion between barium atoms as they have more complete electron shells than calcium atoms.

16 For which compound is there the greatest percentage loss of mass on strong heating?

A anhydrous calcium carbonate

B anhydrous calcium nitrate

C anhydrous magnesium carbonate

D anhydrous magnesium nitrate

17 The table compares calcium with barium and calcium carbonate with barium carbonate.

Which row is correct?

	reactivity of the element with water	thermal stability of the metal carbonate
A	barium is more reactive	barium carbonate is more stable
B	barium is more reactive	calcium carbonate is more stable
C	calcium is more reactive	barium carbonate is more stable
D	calcium is more reactive	calcium carbonate is more stable

18 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg^{2+} and the other contains Ba^{2+}. Tests are carried out on separate 5 cm^3 samples of P and Q.

test 1: add 1 cm^3 of 0.1 mol dm^{-3} $Na_2SO_4(aq)$

test 2: add 1 cm^3 of 0.1 mol dm^{-3} NaOH(aq)

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba^{2+}	more precipitate with Ba^{2+}
B	more precipitate with Ba^{2+}	more precipitate with Mg^{2+}
C	more precipitate with Mg^{2+}	more precipitate with Ba^{2+}
D	more precipitate with Mg^{2+}	more precipitate with Mg^{2+}

19 The oxides BaO, CaO, MgO and SrO all produce alkaline solutions when added to water.

Which oxide produces the saturated solution with the highest pH?

A BaO **B** CaO **C** MgO **D** SrO

20 Which row is correct?

	the temperature needed to decompose Group 2 metal nitrates	the solubility of Group 2 sulfates
A	decreases down the group	decreases down the group
B	decreases down the group	increases down the group
C	increases down the group	increases down the group
D	increases down the group	decreases down the group

21 The nitrates of beryllium, calcium, magnesium and strontium all decompose in the same way when heated. When 2.00 g of one of these anhydrous nitrates is decomposed, 1.32 g of gas is produced.

What is the nitrate?

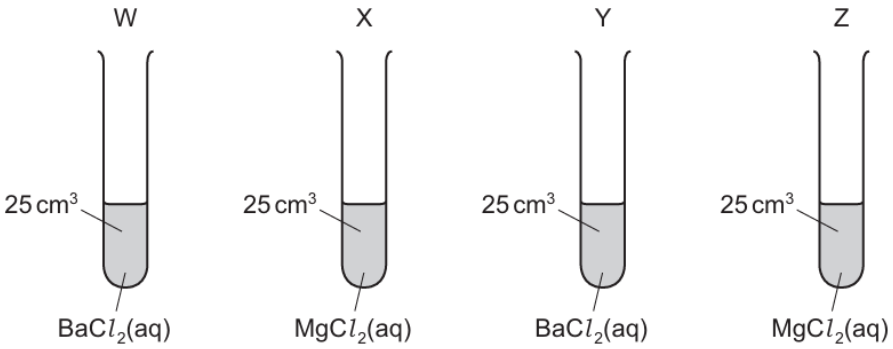
A beryllium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

22 In the diagram, each test-tube W, X, Y and Z contains 25 cm^3 of a 0.1 mol dm^{-3} solution of a salt.



To test-tubes W and X, 25 cm^3 of 0.1 mol dm^{-3} NaOH(aq) is added.

To test-tubes Y and Z, 25 cm^3 of 0.1 mol dm^{-3} H_2SO_4(aq) is added.

In which of test-tubes W and X does the liquid have the higher pH and which of test-tubes Y and Z has the greater mass of precipitate?

	higher pH	greater mass of precipitate
A	W	Y
B	W	Z
C	X	Y
D	X	Z

23 In separate experiments, 5.0 g samples of each of four s-block metals are added to an excess of water. The gas evolved is collected and its volume measured under the same conditions of temperature and pressure for each sample.

Which metal produces the largest volume of gas?

A calcium

B potassium

C rubidium

D strontium

24 A mixture contains magnesium carbonate and barium carbonate only. A sample of the mixture is dissolved in nitric acid to produce a solution.

How could this solution be processed into a magnesium compound and a separate barium compound?

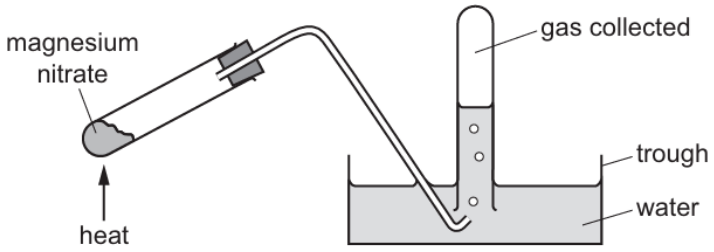
A Add HCl(aq), filter off the solid barium chloride.

B Add HCl(aq), filter off the solid magnesium chloride.

C Add H_2SO_4(aq), filter off the solid barium sulfate.

D Add H_2SO_4(aq), filter off the solid magnesium sulfate.

25 A sample of magnesium nitrate is heated in the apparatus shown.



The pH of the solution in the trough is measured.

The gas collected is tested with a glowing splint.

What are the results?

	pH of solution in trough	splint test
A	8	relights
B	2	relights
C	8	extinguished
D	2	extinguished

26 NH_3(aq) is added to separate samples of NaCl(aq), $MgCl_2$(aq), $BaCl_2$(aq) and $SiCl_4$(l). Under the conditions of this experiment, only two samples will produce a white precipitate when NH_3(aq) is added.

What are these two samples?

A $MgCl_2$(aq) and $BaCl_2$(aq)

B $MgCl_2$(aq) and $SiCl_4$(l)

C NaCl(aq) and $BaCl_2$(aq)

D NaCl(aq) and $SiCl_4$(l)

27 The table gives information about calcium carbonate and calcium hydroxide.

Which row is correct?

	calcium carbonate is more soluble in water than calcium hydroxide	calcium hydroxide can be manufactured using calcium carbonate as a starting material
A	no	no
B	no	yes
C	yes	no
D	yes	yes

28 Q is a Group 2 metal.

An excess of QCO_3(s) is added to H_2SO_4(aq) followed by filtration. A sample of QSO_4 is then obtained by evaporation of the filtrate.

What could be the identity of Q?

A barium, calcium or magnesium

B barium or calcium only

C calcium only

D calcium or magnesium only

29 In which list are all three compounds soluble in water?

A barium chloride, calcium carbonate, magnesium hydroxide

B barium hydroxide, calcium hydroxide, strontium carbonate

C barium chloride, barium hydroxide, magnesium sulfate

D barium sulfate, calcium sulfate, magnesium hydroxide

30 Anhydrous magnesium nitrate, $Mg(NO_3)_2$, decomposes when heated, giving a white solid and a mixture of two gases, X and Y.

Y is oxygen.

What is the ratio $\frac{\text{mass of X released}}{\text{mass of Y released}}$?

A $\frac{1}{0.174}$ **B** $\frac{1}{0.267}$ **C** $\frac{1}{0.348}$ **D** $\frac{1}{3.43}$

31 Which statement about the compounds of the Group 2 metals is correct?

A Barium carbonate is less thermally stable than strontium carbonate.

B Barium sulfate is less soluble than magnesium sulfate.

C Calcium hydroxide is less soluble than magnesium hydroxide.

D Calcium nitrate is more thermally stable than strontium nitrate.

32 A 0.005 mol sample of anhydrous calcium carbonate is completely thermally decomposed to give 100 cm^3 of gas.

In a separate experiment carried out under the same conditions, a 0.005 mol sample of anhydrous calcium nitrate is completely thermally decomposed. The volume of gaseous products is measured.

What total volume of gaseous products is produced from the calcium nitrate?

A 50 cm^3 **B** 100 cm^3 **C** 200 cm^3 **D** 250 cm^3

33 Q is a mixture of a Group 2 oxide and a Group 2 sulfate. Q contains equal amounts of the two compounds.

Q is shaken with water and the resulting mixture filtered; a solid residue is obtained. There is no reaction when the solid residue is shaken with HCl(aq). Shaking the filtrate with H_2SO_4(aq) produces a white precipitate.

What could be Q?

A BaO + $BaSO_4$

B BaO + $MgSO_4$

C MgO + $BaSO_4$

D MgO + $MgSO_4$

34 Which substance will **not** be a product of the thermal decomposition of hydrated magnesium nitrate?

A dinitrogen monoxide

B magnesium oxide

C oxygen

D steam

35 A farmer requires a solid compound to raise the pH of the soil in a field from 5.5 to above 6.0.

Which compound could the farmer use?

A $(NH_4)_2SO_4$ **B** NH_4NO_3 **C** $Ca(OH)_2$ **D** $Ca(NO_3)_2$

36 Z is an anhydrous compound of a Group 2 element. When it is heated, Z undergoes thermal decomposition to produce two different gases. Z has relatively low thermal stability compared to other Group 2 compounds containing the same anion as Z.

What is compound Z?

A barium carbonate

B barium nitrate

C magnesium carbonate

D magnesium nitrate

37 This question is about two elements in Group 2, Q and R.

Three of the statements shown are correct for metal Q.

The one remaining statement is correct for metal R.

Which statement applies to R?

A A saturated solution of the hydroxide of this metal has the higher pH value.

B This metal has a carbonate that is used in agriculture to reduce the acidity of soil.

C This metal has the greater atomic radius.

D This metal reacts more quickly with cold water.

38 A student mixes pairs of chemicals together in separate test-tubes.

- excess calcium (s) + water (l)
- barium chloride (aq) + strontium hydroxide (aq)
- calcium carbonate (s) + excess hydrochloric acid (aq)
- magnesium sulfate (aq) + barium nitrate (aq)

How many of the mixtures produce a white, solid product?

A 0 **B** 1 **C** 2 **D** 3

39 What are the trends in the stated properties as Group 2 is descended from magnesium to barium?

	decomposition temperature of the carbonate	first ionisation energy
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

40 Which row could refer to barium metal and barium hydroxide?

	colour seen when the metal is burnt in O_2	pH of a saturated solution of the hydroxide
A	green flame	8
B	green flame	13
C	white flame	8
D	white flame	13

41 An excess of MgO is shaken with water. The resulting mixture is filtered into test-tube P.

An excess of BaO is shaken with water. The resulting mixture is filtered into test-tube Q.

Which oxide reacts more readily with water and which filtrate has the **lower** pH?

	oxide reacts more readily with water	test-tube with filtrate of **lower** pH
A	BaO	P
B	BaO	Q
C	MgO	P
D	MgO	Q

42 0.25 g of anhydrous magnesium nitrate is heated strongly until it completely decomposes.

What is the total volume of gas produced, measured under room conditions?

A 40 cm^3 **B** 81 cm^3 **C** 101 cm^3 **D** 202 cm^3

43 Magnesium nitrate, $Mg(NO_3)_2$, decomposes when heated to give a white solid and a mixture of gases. One of the gases released is an oxide of nitrogen, X.

7.4 g of anhydrous magnesium nitrate is heated until no further reaction takes place.

What mass of X is produced?

A 1.5 g **B** 2.3 g **C** 3.0 g **D** 4.6 g

44 Which property shows an **increase** from magnesium to barium?

A the first ionisation energy of the elements

B the oxidising power of the metals

C the solubility of the hydroxides

D the solubility of the sulfates

45 A 5.00 g sample of an anhydrous Group 2 metal nitrate loses 3.29 g in mass when heated strongly.

Which metal is present?

A magnesium

B calcium

C strontium

D barium

46 Solutions P and Q each contain a different Group 2 ion at the same concentration. One contains Mg^{2+}, the other contains Ba^{2+}. Tests are carried out on separate 5 cm^3 samples of P and Q.

test 1: add 1 cm^3 of 0.1 mol dm^{-3} Na_2SO_4(aq)

test 2: add 1 cm^3 of 0.1 mol dm^{-3} NaOH(aq)

What are the results of these tests?

	results in test 1	results in test 2
A	more precipitate with Ba^{2+}	more precipitate with Ba^{2+}
B	more precipitate with Ba^{2+}	more precipitate with Mg^{2+}
C	more precipitate with Mg^{2+}	more precipitate with Ba^{2+}
D	more precipitate with Mg^{2+}	more precipitate with Mg^{2+}

47 Which statement about the compounds of Group 2 elements magnesium to barium is correct?

A Carbonates of Group 2 elements produce bubbles when added to dilute nitric acid.

B Nitrates of Group 2 elements produce nitrogen and oxygen on heating.

C Oxides of Group 2 elements produce bubbles when added to dilute hydrochloric acid.

D The oxides of Group 2 elements are amphoteric.

48 When equal volumes of saturated solutions of barium hydroxide and calcium hydroxide are mixed, a white precipitate, Y, forms. The mixture is filtered and carbon dioxide is bubbled through the filtrate, producing a second white precipitate, Z.

What are Y and Z?

	Y	Z
A	$Ba(OH)_2$	$Ca(OH)_2$
B	$Ba(OH)_2$	$CaCO_3$
C	$Ca(OH)_2$	$BaCO_3$
D	$Ca(OH)_2$	$Ba(OH)_2$

49 1.15 g of a metallic element needs 300 cm^3 of oxygen for complete reaction, under room conditions, to form an oxide which contains O^{2-} ions.

What could be the identity of this metallic element?

A calcium

B magnesium

C potassium

D sodium

50 Substance X reacts with water. A gas is given off and the pH of the solution increases. The solution is then reacted with sulfuric acid and a white precipitate forms.

What could be substance X?

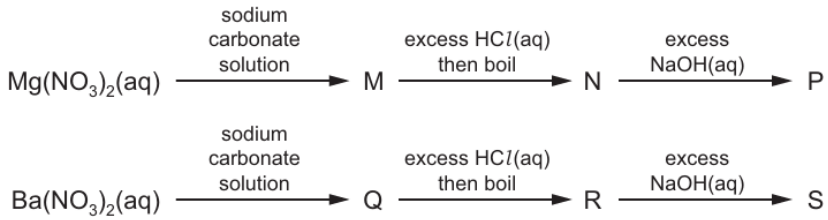
A barium

B barium oxide

C magnesium

D magnesium oxide

51 Solutions of 0.1 mol dm^{-3} $Mg(NO_3)_2$ and 0.1 mol dm^{-3} $Ba(NO_3)_2$ separately undergo a series of reactions using pure reagents.



M, N and P are magnesium compounds.

Q, R and S are barium compounds.

How many of M, N, P, Q, R and S are white precipitates?

A 2 **B** 3 **C** 4 **D** 5

52 How many of the solutions shown, when added to separate portions of magnesium sulfate solution, produce a white precipitate?

$HCl(aq)$ $NH_3(aq)$ $(NH_4)_2CO_3(aq)$ $Ba(NO_3)_2(aq)$

A 0 **B** 1 **C** 2 **D** 3

53 A white solid, Z, is soluble in water. A sample of Z is heated with a Bunsen burner until there is no further change. When the residue is shaken with water a solution is formed with no solid remaining.

What could Z be?

A $MgCO_3$ **B** $Mg(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

54 A sample of anhydrous calcium nitrate is placed in a test-tube and heated in a roaring Bunsen flame until it decomposes. The description of the gas in the test-tube is then noted. A glowing splint is then put into the test-tube and any changes are noted.

Which observations are correct?

	description of the gas in the test-tube	result of glowing splint test
A	brown	the splint goes out
B	brown	the splint relights
C	colourless	the splint goes out
D	colourless	the splint relights

55 Which statement explains the observation that magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride?

A The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+.

B NH_4Cl dissociates less fully than $NaCl$.

C The Na^+ and Mg^{2+} ions have the same number of electrons.

D The NH_4^+ ion can donate a proton.

56 A 4.00 g sample of an anhydrous Group 2 metal nitrate is heated strongly until there is no further change. A solid residue of mass 1.37 g is formed.

Which metal is present?

A barium

B calcium

C magnesium

D strontium

57 In which row are all statements comparing magnesium and barium correct?

	fourth ionisation energy		reaction with water	
	magnesium	barium	magnesium	barium
A	higher	lower	faster	slower
B	higher	lower	slower	faster
C	lower	higher	faster	slower
D	lower	higher	slower	faster

58 When 3.00 g of an anhydrous nitrate of a Group 2 metal is decomposed, 1.53 g of gas is produced.

What is the nitrate compound?

A beryllium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

59 Which row correctly describes one property of barium and one property of barium oxide?

	observation when barium metal is added to water	pH of solution obtained when a spatula measure of BaO is added to 100 cm^3 of water
A	a few gas bubbles form on the metal surface	8
B	a few gas bubbles form on the metal surface	13
C	rapid effervescence is seen	8
D	rapid effervescence is seen	13

60 In Group 2 of the Periodic Table, the properties of the elements and their compounds show regular change down the group.

Which property shows a **decrease** from magnesium to barium?

A the decomposition temperature of the carbonates

B the decomposition temperature of the nitrates

C the solubility of the hydroxides

D the solubility of the sulfates