CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

10 GROUP 2

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Chapter 10

Group 2

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

537. 9701_m22_qp_12 Q: 21

Which row gives correct comparisons between the solubilities of calcium hydroxide and barium hydroxide and the thermal stabilities of calcium carbonate and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

---

538. 9701_m21_qp_12 Q: 14

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

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539. 9701_m21_qp_12 Q: 15

An anhydrous white salt, Z, is heated strongly for 30 minutes. A mixture of gases is given off. The solid remaining in the test-tube is then dissolved in a small volume of dilute hydrochloric acid. The addition of a few drops of dilute sulfuric acid to the test-tube causes a white precipitate to form.

Which substance could be Z?

A barium carbonate

B barium nitrate

C magnesium carbonate

D magnesium nitrate

---

540. 9701_s21_qp_11 Q: 14

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 + $MgSO_4$

---

541. 9701_s21_qp_11 Q: 15

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

---

542. 9701_s21_qp_12 Q: 14

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** $Ca(NO_3)_2$

---

543. 9701_s21_qp_12 Q: 15

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

---

544. 9701_s21_qp_13 Q: 17

Which statement is correct?

A Doctors can use the very insoluble $MgSO_4$ to investigate the digestive system.

B Farmers can lower the pH of soil by spreading $CaCO_3$ on it.

C Students can test a solution for SO_4^{2-} ions by using $Ba(NO_3)_2(aq)$ followed by $HNO_3(aq)$.

D The insoluble hydroxide, $Ba(OH)_2$, can be safely used to lower the acidity of the stomach.

---

545. 9701_s21_qp_13 Q: 18

A solid, X, was placed in an excess of the liquid Y.

A colourless gas was given off and a white precipitate was seen. The precipitate was not X.

What could be the identities of X and Y?

	X	Y
A	$BaCO_3$	H_2O
B	Ca	dilute H_2SO_4
C	Mg	dilute H_2SO_4
D	$SrCO_3$	dilute HCl

---

546. 9701_w21_qp_11 Q: 2

2.0 g of ammonium nitrate, NH_4NO_3, decomposes to give 0.90 g of water and a single gas.

What is the identity of the gas?

A NO **B** NO_2 **C** N_2O **D** N_2

---

547. 9701_w21_qp_11 Q: 14

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

---

548. 9701_w21_qp_12 Q: 13

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.

---

549. 9701_w21_qp_13 Q: 14

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

---

550. 9701_m20_qp_12 Q: 13

Compound Z is insoluble in water but soluble at low pH.

What could be compound Z?

A barium carbonate

B barium chloride

C barium hydroxide

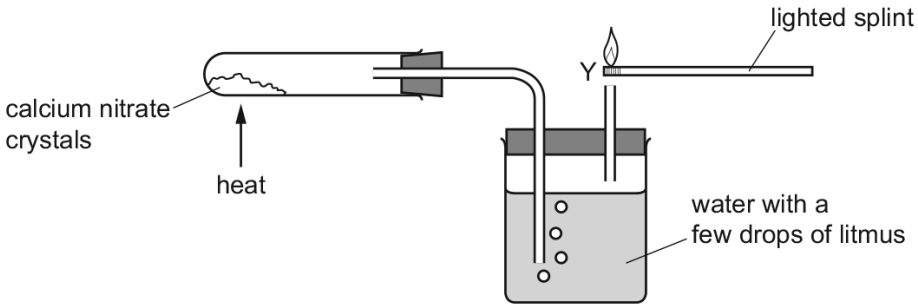
D barium sulfate

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551. 9701_m20_qp_12 Q: 17

A student investigates calcium nitrate crystals by heating them in the apparatus shown.

A colourless gas leaves the apparatus at Y. A flame is held to this gas.



Which observations would the student make?

	litmus solution	flame at Y
A	changes to blue	flame burns more brightly
B	changes to blue	flame goes out
C	changes to red	flame burns more brightly
D	changes to red	flame goes out

---

552. 9701_s20_qp_11 Q: 14

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

---

553. 9701_s20_qp_12 Q: 17

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

---

554. 9701_s20_qp_13 Q: 14

The statements apply to the elements in Group 2.

Which statement is correct?

A As atomic number increases, ionic radius increases.

B As atomic number increases, reducing ability decreases.

C As atomic number increases, first ionisation energy increases.

D As atomic radius increases, first ionisation energy increases.

---

555. 9701_s20_qp_13 Q: 18

Which property shows an **increase** from calcium to barium going down Group 2?

A the ease of decomposition of the carbonates

B the solubility of the hydroxides

C the solubility of the sulfates

D the volume of hydrogen given off when 1 g of the metal reacts with water

---

556. 9701_w20_qp_11 Q: 13

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.

---

557. 9701_w20_qp_11 Q: 15

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

---

558. 9701_w20_qp_11 Q: 18

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

---

559. 9701_w20_qp_12 Q: 13

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

---

560. 9701_w20_qp_12 Q: 16

Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement about the reactions of lithium or its compounds can be predicted from this statement?

A Lithium burns very slowly in oxygen.

B Lithium carbonate decomposes on heating in a blue Bunsen burner flame, forming lithium oxide and carbon dioxide.

C Lithium nitrate decomposes on heating, forming lithium nitrite, $LiNO_2$, and oxygen.

D Lithium reacts very violently with cold water, producing hydrogen.

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561. 9701_m19_qp_12 Q: 14

Metal T reacts with water to produce a colourless solution. A white precipitate is produced when this colourless solution is mixed with aqueous sulfuric acid.

What is metal T?

A barium

B magnesium

C potassium

D sodium

---

562. 9701_m19_qp_12 Q: 15

When calcium nitrate thermally decomposes, oxygen is one of the products.

Which volume of oxygen is produced under room conditions when 0.50 mol of calcium nitrate thermally decomposes?

A $6.0\,dm^3$ **B** $12.0\,dm^3$ **C** $18.0\,dm^3$ **D** $30.0\,dm^3$

---

563. 9701_m19_qp_12 Q: 16

L, M and N are Group 2 metals. L reacts more vigorously with dilute hydrochloric acid than N does. $M(OH)_2$ is more soluble than $N(OH)_2$.

What could be the identities of L, M and N?

	L	M	N
A	Ba	Ca	Sr
B	Ba	Sr	Ca
C	Ca	Ba	Sr
D	Sr	Ca	Ba

---

564. 9701_s19_qp_11 Q: 14

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

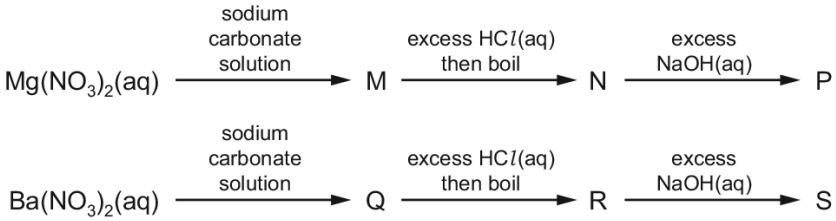
C magnesium

D magnesium oxide

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565. 9701_s19_qp_11 Q: 15

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

---

566. 9701_s19_qp_12 Q: 15

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

---

567. 9701_s19_qp_12 Q: 16

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.

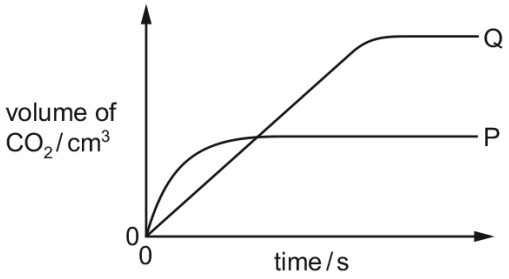
What could Z be?

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

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568. 9701_s19_qp_13 Q: 11

The volume of carbon dioxide collected by reacting 0.100 mol of magnesium carbonate with 50.0 cm^3 of 1.00 mol dm^{-3} sulfuric acid is measured against time. The volume produced is plotted against time and the line labelled P on the graph is obtained.



The experiment is repeated using 0.100 mol of the same magnesium carbonate, and a different sample of acid. All other conditions remain the same. Plotting these results gives the line labelled Q.

Which sample of acid could give the line labelled Q?

A 100 cm^3 of 0.500 mol dm^{-3} sulfuric acid

B 100 cm^3 of 1.00 mol dm^{-3} sulfuric acid

C 200 cm^3 of 0.500 mol dm^{-3} hydrochloric acid

D 200 cm^3 of 1.00 mol dm^{-3} hydrochloric acid

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569. 9701_s19_qp_13 Q: 14

Dilute hydrochloric acid is added to solid barium carbonate and solid magnesium carbonate in separate test-tubes.

Dilute sodium hydroxide is added to 0.1 mol dm^{-3} barium chloride and 0.1 mol dm^{-3} magnesium chloride in separate test-tubes.

Which row is correct?

	$BaCO_3$(s) + HCl(aq)	$BaCl_2$(aq) + NaOH(aq)	$MgCO_3$(s) + HCl(aq)	$MgCl_2$(aq) + NaOH(aq)
A	no change	white ppt	no change	no change
B	effervescence	no change	effervescence	no change
C	effervescence	no change	effervescence	white ppt
D	effervescence	white ppt	effervescence	white ppt

---

570. 9701_w19_qp_11 Q: 14

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

---

571. 9701_w19_qp_11 Q: 15

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+}

---

572. 9701_w19_qp_12 Q: 13

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.

---

573. 9701_w19_qp_12 Q: 14

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	$Ca(OH)_2$	$Ba(OH)_2$

---

574. 9701_m18_qp_12 Q: 20

Which types of stereoisomerism are shown by 2,4-dimethylhex-2-ene?

A both cis-trans isomerism and optical isomerism

B cis-trans isomerism only

C neither cis-trans isomerism nor optical isomerism

D optical isomerism only

---

575. 9701_m18_qp_12 Q: 21

An organic ion containing a carbon atom with a negative charge is called a carbanion.

An organic ion containing a carbon atom with a positive charge is called a carbocation.

The reaction between aqueous sodium hydroxide and 1-bromobutane proceeds by an S_N2 mechanism.

What is the first step in the mechanism?

A attack by a nucleophile on a carbon atom with a partial positive charge

B heterolytic bond fission followed by attack by an electrophile on a carbanion

C heterolytic bond fission followed by attack by a nucleophile on a carbocation

D homolytic bond fission followed by attack by a nucleophile on a carbocation

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576. 9701_s18_qp_11 Q: 18

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

---

577. 9701_s18_qp_11 Q: 19

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

---

578. 9701_s18_qp_12 Q: 16

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

---

579. 9701_s18_qp_13 Q: 14

An ore contains magnesium carbonate and barium carbonate. A sample of the ore is dissolved in nitric acid.

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.

---

580. 9701_s18_qp_13 Q: 15

When calcium and calcium hydride, CaH_2, react separately with water, they each produce a white solid and a colourless gas. The white solid is the same compound in each reaction.

Which statement is correct?

A Both Ca and CaH_2 produce H_2.

B Both Ca and CaH_2 produce O_2.

C Ca produces H_2 and CaH_2 produces O_2.

D Ca produces O_2 and CaH_2 produces H_2.

---

581. 9701_w18_qp_11 Q: 15

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

---

582. 9701_w18_qp_11 Q: 18

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.

---

583. 9701_w18_qp_12 Q: 14

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

---

584. 9701_w18_qp_12 Q: 15

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

---

585. 9701_m17_qp_12 Q: 14

Why does barium react more rapidly with cold water than magnesium does?

A Barium atoms are larger and form ions more easily than magnesium atoms.

B Barium floats on the surface of the water but magnesium sinks in the water.

C Barium hydroxide is less soluble than magnesium hydroxide.

D The sum of the 1st and 2nd ionisation energies of barium is more than that for magnesium.

---

586. 9701_s17_qp_11 Q: 14

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

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

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	barium oxide	X
B	barium oxide	Y
C	magnesium oxide	X
D	magnesium oxide	Y

---

587. 9701_s17_qp_11 Q: 15

Samples of magnesium carbonate, $MgCO_3$, are placed in crucibles R and S. The sample in crucible R is heated until there is no further loss in mass, and then allowed to cool. The sample in crucible S is left unheated.

Dilute hydrochloric acid is then added to both crucibles.

On adding the dilute hydrochloric acid, which observations are correct?

	R	S
A	gas produced	gas produced
B	gas produced	no gas produced
C	no gas produced	gas produced
D	no gas produced	no gas produced

---

588. 9701_s17_qp_12 Q: 3

In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate. Heat is evolved, an unreactive gas is produced, and all nitrogen atoms are reduced.

What is the equation for this reaction?

A $2Al + Ba(NO_3)_2 \rightarrow Al_2O_3 + BaO + 2NO$

B $4Al + 4Ba(NO_3)_2 \rightarrow 2Al_2O_3 + 4Ba(NO_2)_2 + O_2$

C $10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$

D $10Al + 18Ba(NO_3)_2 \rightarrow 10Al(NO_3)_3 + 18BaO + 3N_2$

---

589. 9701_s17_qp_12 Q: 14

Trends are seen in the physical and chemical properties of the elements of Group 2 and their compounds.

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

A the rate of the reaction between the element and dilute hydrochloric acid

B the solubility of the hydroxides

C the solubility of the sulfates

D the temperature of decomposition of the carbonates

---

590. 9701_s17_qp_12 Q: 15

Calcium oxide is added to water and the resulting mixture is filtered.

This filtrate is X.

When carbon dioxide is bubbled through filtrate X, a white precipitate is formed.

Which equation for this reaction of filtrate X with carbon dioxide is correct?

A $CaO + CO_2 \rightarrow CaCO_3$

B $Ca(OH)_2 + CO_2 \rightarrow CaO + H_2CO_3$

C $2CaO + H_2O + CO_2 \rightarrow CaCO_3 + Ca(OH)_2$

D $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

---

591. 9701_s17_qp_13 Q: 15

Which row correctly describes the 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

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592. 9701_w17_qp_11 Q: 15

The mineral dolomite is a mixture of magnesium carbonate and calcium carbonate.

An aqueous reagent, X, was added to a small sample of dolomite. Effervescence was seen and a white solid, Y, was formed.

What could be the correct identity of reagent X and solid Y?

	reagent X	solid Y
A	hydrochloric acid	calcium chloride
B	hydrochloric acid	magnesium chloride
C	sulfuric acid	calcium sulfate
D	sulfuric acid	magnesium sulfate

---

593. 9701_w17_qp_12 Q: 14

Radium is an element below barium in Group 2 of the Periodic Table.

Which equation shows what happens when solid radium nitrate, $Ra(NO_3)_2$, is heated strongly?

A $Ra(NO_3)_2(s) \rightarrow RaO(s) + N_2O(g) + 2O_2(g)$

B $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 2N_2(g) + 5O_2(g)$

C $2Ra(NO_3)_2(s) \rightarrow 2RaO(s) + 4NO_2(g) + O_2(g)$

D $4Ra(NO_3)_2(s) \rightarrow 2Ra_2O(s) + 8NO_2(g) + 3O_2(g)$

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594. 9701_w17_qp_12 Q: 19

X is a mixture of two compounds of Group 2 elements.

X 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 **X**?

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

---

595. 9701_s16_qp_11 Q: 14

X and Y are both Group 2 metals.

X and Y both form hydroxide compounds, but $X(OH)_2$ is more soluble in water than $Y(OH)_2$.

If a piece of metal Y is put into cold water a very slow reaction occurs, and only a very few, small hydrogen bubbles can be seen.

What could be the identities of X and Y?

	X	Y
A	barium	magnesium
B	barium	strontium
C	calcium	strontium
D	magnesium	calcium

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596. 9701_s16_qp_12 Q: 16

A solid, **T**, was placed in an excess of the liquid **U**.

A colourless gas was given off and a white precipitate was seen. The precipitate was not **T**.

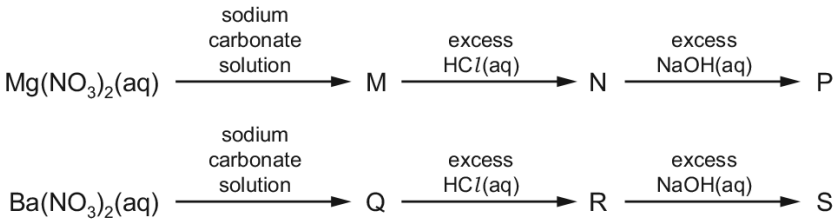
What could be the identities of **T** and **U**?

	T	**U**
A	$BaCO_3$	H_2O
B	Ca	dilute H_2SO_4
C	Mg	dilute H_2SO_4
D	$SrCO_3$	dilute HC*l*

---

597. 9701_s16_qp_13 Q: 14

Solutions of $Mg(NO_3)_2$ and $Ba(NO_3)_2$ separately undergo a series of reactions.



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

---

598. 9701_s16_qp_13 Q: 16

Steam is passed over heated magnesium to give compound J and hydrogen.

What is **not** a property of compound J?

A It has an M_r of 40.3.

B It is basic.

C It is a white solid.

D It is very soluble in water.

---

599. 9701_w16_qp_11 Q: 18

Which row of the table gives correct comparisons between the solubilities of calcium and barium hydroxide and the thermal stabilities of calcium and barium carbonate?

	solubility		thermal stability	
	calcium hydroxide	barium hydroxide	calcium carbonate	barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

---

600. 9701_w16_qp_12 Q: 17

When heated, magnesium nitrate decomposes.

Which equation for the thermal decomposition of magnesium nitrate is correct?

A $Mg(NO_3)_2 \rightarrow MgO + NO_2 + NO + O_2$

B $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO + 3O_2$

C $2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$

D $3Mg(NO_3)_2 \rightarrow Mg_2N_3 + MgO + 3NO + 7O_2$

---

601. 9701_s15_qp_11 Q: 13

The three minerals below are obtained from mines around the world. Each one behaves as a mixture of two carbonate compounds. They can be used as fire retardants because they decompose in the heat, producing CO_2. This gas smothers the fire.

barytocite	$BaCa(CO_3)_2$
dolomite	$CaMg(CO_3)_2$
huntite	$Mg_3Ca(CO_3)_4$

What is the order of effectiveness as fire retardant, from best to worst?

	best → worst		
A	dolomite	barytocite	huntite
B	dolomite	huntite	barytocite
C	huntite	barytocite	dolomite
D	huntite	dolomite	barytocite

---

602. 9701_s15_qp_11 Q: 19

Use of the Data Booklet is relevant to this question.

Which mass of solid residue will be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70 g **B** 1.00 g **C** 1.40 g **D** 2.25 g

---

603. 9701_s15_qp_12 Q: 12

Use of the Data Booklet is relevant to this question.

When 3.00 g of an anhydrous nitrate of a Group II 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

---

604. 9701_s15_qp_12 Q: 13

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.

---

605. 9701_s15_qp_12 Q: 14

Compound **X** releases carbon dioxide gas and forms a white solid, **Y**, when it is heated. Neither **X** nor **Y** are soluble in water. Compound **Y** is used as a refractory kiln lining.

What is compound **X**?

A $CaCO_3$ **B** CaO **C** $MgCO_3$ **D** MgO

---

606. 9701_s15_qp_13 Q: 18

Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement about the reactions of lithium or its compounds can be predicted from this statement?

A Lithium burns very slowly in oxygen.

B Lithium carbonate decomposes on heating in a blue Bunsen burner flame, forming lithium oxide and carbon dioxide.

C Lithium nitrate decomposes on heating, forming lithium nitrite, $LiNO_2$, and oxygen.

D Lithium reacts very violently with cold water, liberating hydrogen.

---

607. 9701_w15_qp_11 Q: 12

X is a Group II metal. The carbonate of **X** decomposes when heated in a Bunsen flame to give carbon dioxide and a white solid residue as the only products. This white solid residue is sparingly soluble in water. Even when large amounts of the solid residue are added to water the pH of the saturated solution is less than that of limewater.

What could be the identity of **X**?

A magnesium

B calcium

C strontium

D barium

---

608. 9701_w15_qp_11 Q: 13

Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

A barium carbonate

B barium chloride

C barium hydroxide

D barium sulfate

---

609. 9701_w15_qp_12 Q: 12

Which property decreases on descending Group II?

A radius of the cation, M^{2+}

B reactivity of the element with water

C shielding of outermost electrons

D the ease of thermal decomposition of the carbonates, MCO_3

Chapter 10

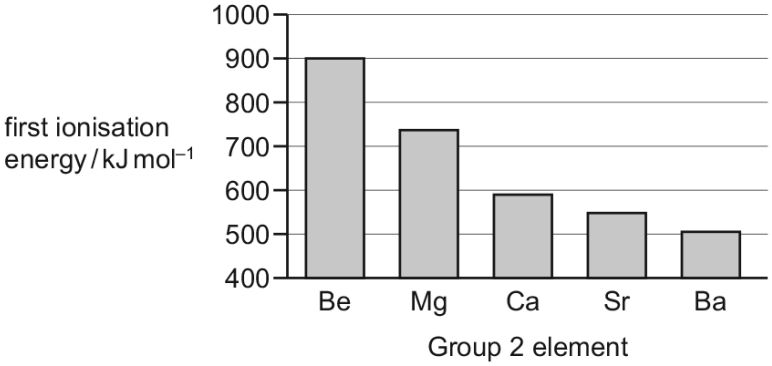
Group 2

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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 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.

.....

.....

..... [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**, **X**CO_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 **X**CO_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.

.....

.....

.....

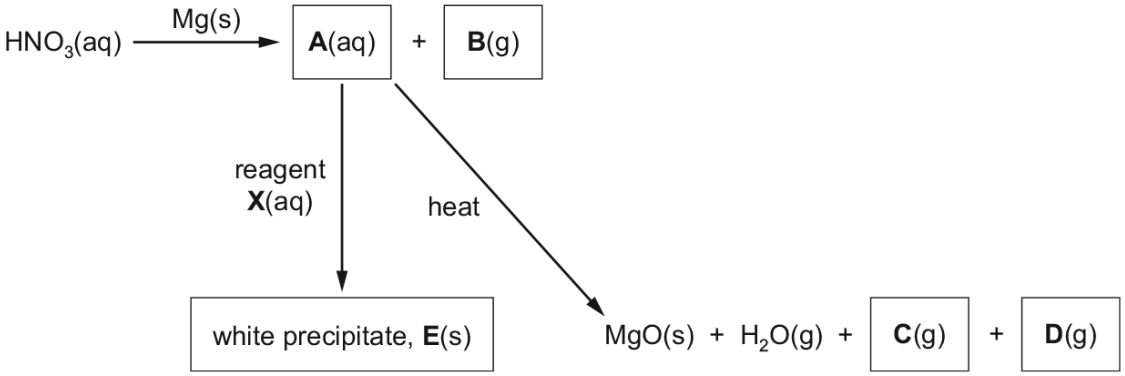
..... [2]

(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]

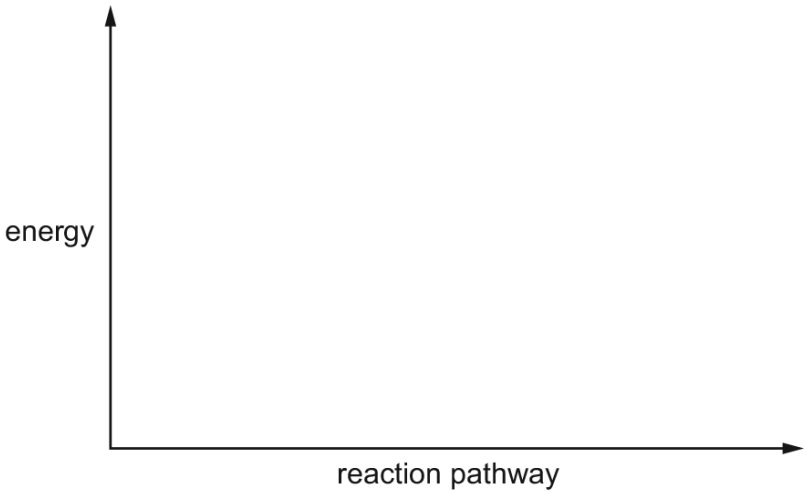
(iii) Describe how the reaction of barium with cold water would differ from the reaction of calcium in **(i)** in terms of what you would **see**.

.....

..... [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.

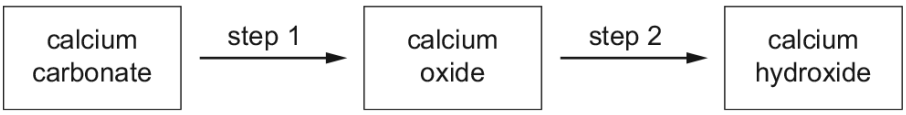
.....

..... [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 HC*l*(aq)	
gallium oxide + hot concentrated NaOH(aq)	

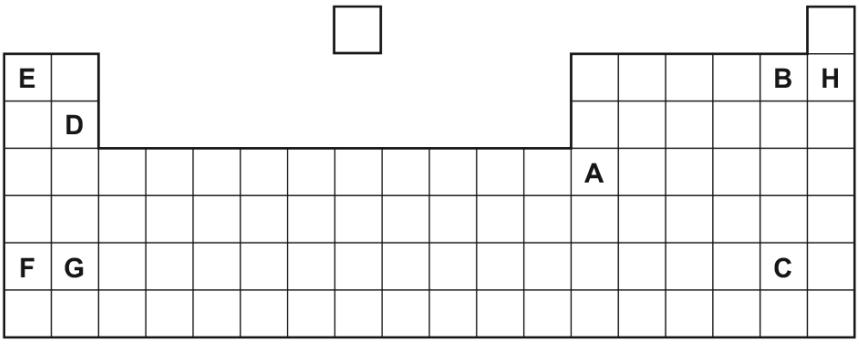
[2]

[Total: 12]

59. 9701_s17_qp_21 Q: 3

The properties of elements and their compounds show similarities, differences and trends depending on the positions of the elements in the Periodic Table.

(a) The positions of some elements are indicated. The letters used are **not** the symbols of the elements.



From the elements labelled, give the letter for;

(i) the element that forms an amphoteric oxide, ... [1]

(ii) the element with the highest first ionisation energy, ... [1]

(iii) the element that forms a soluble hydroxide and an insoluble sulfate, ... [1]

(iv) the most volatile element in a group that contains elements in all three states of matter at room temperature and pressure,

..... [1]

(v) the element that forms the largest cation. ..... [1]

(b) The elements in Group 2 all react with oxygen and with water.

(i) State and explain the conditions needed for magnesium to react with oxygen.

.....

..... [2]

(ii) State what would be seen during the reaction in **(b)(i)**.

.....

..... [1]

(iii) Write an equation for the reaction of magnesium with cold water.
Include state symbols.

..... [2]

(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.

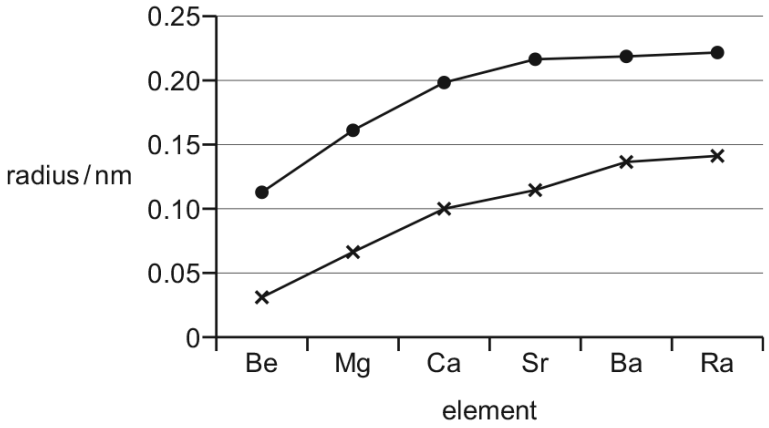
..... [1]

[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

$$2KNO_3 \rightarrow 2KNO_2 + O_2$$

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 8000 dm^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 1×10^{-4} 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]

1.
Which equation represents the reaction that occurs when calcium nitrate is heated strongly?

A $Ca(NO_3)_2 \rightarrow Ca(NO_2)_2 + O_2$

B $Ca(NO_3)_2 \rightarrow CaO + N_2O + 2O_2$

C $Ca(NO_3)_2 \rightarrow CaO_2 + 2NO_2$

D $2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$

[2002 M/J (15)]

2.
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 ions Na^+ and Mg^{2+} are isoelectronic (have the same number of electrons).

D The ion NH_4^+ acts as an acid.

[2002 M/J (17)]

3.
Which properties would be expected for the Group II element, strontium, or its compounds?

1 When heated in oxygen, strontium does not burn.

2 On being heated, strontium carbonate decomposes to give strontium oxide.

3 When strontium oxide is added to water, the solution is alkaline.

[2002 M/J (36)]

4.
River water in a chalky agricultural area may contain Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^-, and NO_3^- ions. In a waterworks, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated following the addition of calcium hydroxide?

A $CaCl_2$

B $CaCO_3$

C $MgCO_3$

D $Mg(NO_3)_2$

[2002 O/N (16)]

5.
Which of the following magnesium compounds lose mass when heated by a bunsen flame?

1 magnesium carbonate

2 magnesium nitrate

3 magnesium oxide

[2002 O/N (34)]

6.
What are the products of the thermal decomposition of magnesium nitrate?

A magnesium nitride and oxygen

B magnesium oxide and nitrogen

C magnesium oxide, nitrogen and oxygen

D magnesium oxide, nitrogen dioxide and oxygen

[2003 M/J (15)]

7.
The metals of Group II react readily with oxygen to form compounds of general formula *MO*.

When each of these oxides is added to water, which forms the most alkaline solution?

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

[2003 O/N (14)]

8.
A farmer spreads lime on land which has already been treated with a nitrogenous fertiliser.

Which reactions will occur over a period of time?

1 $Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$

2 $Ca(OH)_2 + 2H^+(aq) \longrightarrow Ca^{2+}(aq) + 2H_2O$

3 $Ca(OH)_2 + 2NH_4^+(aq) \longrightarrow Ca^{2+}(aq) + 2NH_3 + 2H_2O$

[2003 O/N (35)]

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9.

Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement concerning the reactions of lithium and its compounds is correct?

A Lithium carbonate decomposes on heating at a relatively low temperature, forming lithium oxide and carbon dioxide.

B Lithium nitrate decomposes on heating, forming lithium nitrite and oxygen.

C Lithium only burns slowly in oxygen.

D Lithium reacts violently with cold water, liberating hydrogen.

[2004 M/J (16)]

10.

Which reactions involving calcium and its compounds would produce **two** gaseous products?

1 heating solid anhydrous calcium nitrate

2 heating solid anhydrous calcium carbonate

3 adding calcium metal to water

[2004 O/N (35)]

11.

Use of the Data Booklet is relevant to this question.

Which is true for calcium or its compounds compared with the corresponding statements for magnesium?

A Calcium has a smaller atomic radius.

B Calcium oxide reacts less vigorously with water.

C Calcium reacts more vigorously with water.

D The sum of the first two ionisation energies of calcium is greater.

[2005 M/J (14)]

12.

Limestone, $CaCO_3$, has been used as a building material for thousands of years, and was used on the Pyramids in Egypt. In the past hundred years many limestone buildings have begun to suffer damage.

What is the cause of this damage?

A hydrocarbon emissions from motor vehicles

B increased temperature due to global warming

C increased ultraviolet radiation as the ozone layer is destroyed

D sulphur dioxide from fossil fuels forming 'acid rain'

[2005 M/J (17)]

13.

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

A aragonite, $CaCO_3$

B artinite, $MgCO_3.Mg(OH)_2.3H_2O$

C barytocalcite, $BaCO_3.CaCO_3$

D dolomite, $CaCO_3.MgCO_3$

[2005 O/N (16)]

14.

What properties enable magnesium oxide to be used as a refractory lining in a furnace?

1 It has a high melting point.

2 It has a low thermal conductivity.

3 It does not react with basic slags.

[2005 O/N (35)]

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15.
Hydroxyapatite, a basic calcium phosphate, $Ca(OH)_2.3Ca_3(PO_4)_2$, is the mineral found in bone.

In older people, calcium ions can be lost from the hydroxyapatite, weakening the bone structure. In such cases, strontium salts are administered to strengthen the bone. The strontium ions replace the lost calcium ions in the hydroxyapatite.

Which statements are correct?

1 Strontium ions are nearly the same size as calcium ions and so may easily replace them in the hydroxyapatite.

2 Strontium hydroxide is less soluble than calcium hydroxide and so will precipitate better in the bone structure.

3 There is ionic, covalent and metallic bonding in hydroxyapatite which gives it strength.

[2006 M/J (35)]

16.
Magnesium oxide may be used for the lining of an electric furnace for making crockery.

Which properties of magnesium oxide help to explain this use?

	strong forces between particles	ionic bonding	electrical conductor
A	yes	yes	no
B	yes	no	yes
C	no	yes	no
D	no	no	yes

[2006 O/N (7)]

17.
Steam is passed over heated magnesium to give compound **X** and hydrogen.

What is **not** a property of compound **X**?

A It has a high melting point.

B It is a basic oxide.

C It is a white solid.

D It is very soluble in water.

[2006 O/N (13)]

18.
A 5.00 g sample of an anhydrous Group II metal nitrate loses 3.29 g in mass on strong heating.

Which metal is present?

A magnesium

B calcium

C strontium

D barium

[2006 O/N (14)]

19.
Which magnesium compounds lose mass when heated by a Bunsen flame?

1 magnesium carbonate

2 magnesium nitrate

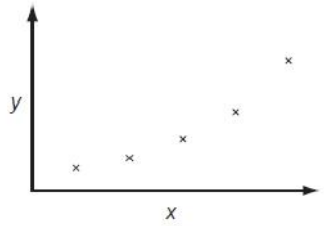
3 magnesium oxide

[2006 O/N (34)]

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20.
Use of the Data Booklet is relevant to this question.

The sketch graph shows the variation of one physical or chemical property with another for the Group II elements.



What are the correct labels for the axes?

	x-axis	*y*-axis
A	atomic number	mass number
B	atomic number	melting point
C	first ionisation energy	atomic number
D	first ionisation energy	atomic radius

[2007 O/N (14)]

21.
The chemical properties of an element at the top of a group in the Periodic Table are often different from those of the rest of the elements in the group.

Of the following properties of beryllium and its compounds, which property is typical of the elements below it in Group II?

A Be does not react with hot water.

B $BeCl_2$ is covalent.

C $Be(NO_3)_2$ produces BeO on thermal decomposition.

D BeO dissolves in alkalis.

[2007 O/N (15)]

22.
When a firework is lit a fuel and an oxidising agent react.

In such a firework, magnesium is the fuel and barium nitrate is the oxidising agent.

Which solid products are produced when the firework is lit?

1 BaO

2 MgO

3 $Mg(NO_3)_2$

[2007 O/N (35)]

23.
The electronic structure of the outer shell of the element radium is $7s^2$.

Which statements will be correct for radium within its group?

1 The element will decompose water, liberating hydrogen.

2 The element will show an oxidation number of +2 in all its compounds.

3 Radium has the highest first ionisation energy.

[2008 M/J (35)]

24.
Due to their similar ionic radii, the reactions of lithium and magnesium and their corresponding compounds are very similar.

Which statement concerning the reactions of lithium and its compounds is correct?

A Lithium carbonate decomposes on heating at a relatively low temperature, forming lithium oxide and carbon dioxide.

B Lithium nitrate decomposes on heating, forming lithium nitrite and oxygen.

C Lithium burns only slowly in oxygen.

D Lithium reacts violently with cold water, liberating hydrogen.

[2008 O/N (16)]

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25.

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 are isoelectronic (have the same number of electrons).

D The NH_4^+ ion acts as an acid.

[2008 O/N (19)]

26.

Which statements concerning the Group II elements magnesium, calcium and barium are correct?

1 Their reactivity increases with increasing relative atomic mass.

2 The oxidation number exhibited in their stable compounds is +2.

3 On strong heating, their nitrates give off oxygen only.

[2008 O/N (34)]

27.

In some fireworks there is a reaction between powdered aluminium and powdered barium nitrate in which heat is evolved and an unreactive gas is produced.

What is the equation for this reaction?

A $2Al + Ba(NO_3)_2 \rightarrow Al_2O_3 + BaO + 2NO$

B $4Al + 4Ba(NO_3)_2 \rightarrow 2Al_2O_3 + 4Ba(NO_2)_2 + O_2$

C $10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$

D $10Al + 18Ba(NO_3)_2 \rightarrow 10Al(NO_3)_3 + 18BaO + 3N_2$

[2009 M/J (11)]

28.

River water in a chalky agricultural area may contain Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^- and NO_3^- ions. In a waterworks, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated following the addition of calcium hydroxide?

A $CaCl_2$

B $CaCO_3$

C $Ca(NO_3)_2$

D $Mg(NO_3)_2$

[2009 M/J (13)]

29.

The rock *dolomite* is a double carbonate of magnesium and calcium, $CaCO_3.MgCO_3$.

When heated strongly, a product called *calcined dolomite* is formed which is used to line some furnaces for the production of metals.

Why is *calcined dolomite* used for this purpose?

1 It is a refractory material.

2 It will absorb acidic impurities in metallurgical processes.

3 It will reduce metallic oxides to metals.

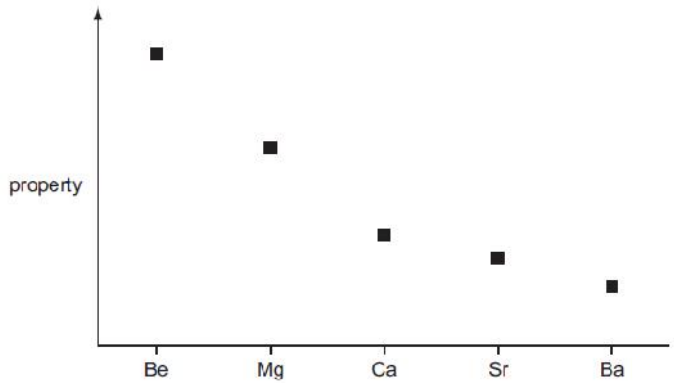
[2009 M/J (35)]

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30.

Use of the Data Booklet is relevant to this question.

The graph represents the variation of a property of the Group II elements.



What is this property?

A ionic radius

B ionisation energy

C neutron / proton ratio

D rate of reaction with water

[2009 O/N-11 (3)]

31.

Which property of Group II elements (beryllium to barium) decreases with increasing atomic number?

A reactivity with water

B second ionisation energy

C solubility of hydroxides

D stability of the carbonates

[2010 M/J-11 (17)]

32.

When magnesium nitrate, $Mg(NO_3)_2.7H_2O$, is heated, which three gases are given off?

A dinitrogen oxide, oxygen, water vapour

B hydrogen, nitrogen, oxygen

C hydrogen, nitrogen dioxide, oxygen

D nitrogen dioxide, oxygen, water vapour

[2010 O/N-11 (14)]

33.

Which property of beryllium and its compounds is typical of the elements below it in Group II?

A Be does not react with hot water.

B $BeCl_2$ is covalent.

C $Be(NO_3)_2$ produces BeO on thermal decomposition.

D BeO dissolves in alkalis.

[2010 O/N-11 (19)]

34.

Samples of calcium and barium are separately added to beakers of cold water containing a few drops of litmus solution.

Which observations will be made with **only** the calcium and **not** with the barium?

1 A white suspension appears in the water.

2 The solution turns blue.

3 A gas is evolved.

[2010 O/N-11 (34)]

35.

Use of the Data Booklet is relevant to this question.

Which mass of solid residue can be obtained from the thermal decomposition of 4.10 g of anhydrous calcium nitrate?

A 0.70g **B** 1.00g **C** 1.40g **D** 2.25g

[2010 O/N-12 (14)]

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36.
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 are isoelectronic (have the same number of electrons).

D The NH_4^+ ion can donate a proton.

[2010 O/N-12 (15)]

37.
Steam is passed over heated magnesium to give compound X and hydrogen.

What is **not** a property of compound X?

A It has an M_r of 40.3.

B It is basic.

C It is a white solid.

D It is very soluble in water.

[2011 M/J-11 (14)]

38.
Use of the Data Booklet is relevant to this question.

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

Which metal is present?

A magnesium

B calcium

C strontium

D barium

[2011 O/N-11 (15)]

39.
Lime mortar is made from quicklime, water and sand. Over a period of time, lime mortar changes into a much harder form. Both fresh and old lime mortar react with aqueous hydrochloric acid but only the old lime mortar effervesces during the reaction.

Which equation describes the change from fresh to old lime mortar?

A $CaO + CO_2 \rightarrow CaCO_3$

B $CaO + H_2O \rightarrow Ca(OH)_2$

C $Ca(OH)_2 \rightarrow CaO + H_2O$

D $Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

[2011 O/N-12 (18)]

40.
Use of the Data Booklet is relevant to this question.

Which properties would be expected for radium, $_{88}Ra$, or its compounds?

1 Radium carbonate would not decompose at the temperature of a Bunsen flame.

2 Radium hydroxide is very insoluble.

3 Radium does not react with cold water.

[2011 O/N-12 (34)]

41.
When a firework is lit, a fuel and an oxidising agent react together.

In one such firework, magnesium is the fuel and barium nitrate is the oxidising agent.

Which solids are produced when the firework is lit?

1 BaO

2 MgO

3 $Mg(NO_3)_2$

[2011 O/N-12 (35)]

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42.

Use of the Data Booklet is relevant to this question.

When a mineral was heated in a Bunsen flame to constant mass, a colourless gas that turned lime water milky was evolved. The remaining solid was cooled and then added to aqueous hydrochloric acid. Vigorous effervescence was seen.

What was the mineral?

A aragonite, $CaCO_3$

B artinite, $MgCO_3.Mg(OH)_2.3H_2O$

C barytocalcite, $BaCO_3.CaCO_3$

D dolomite, $CaCO_3.MgCO_3$

[2012 M/J-11 (13)]

43.

Use of the Data Booklet is relevant to this question.

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The metal oxides and nitrogen are the only products.

Which volume of nitrogen, measured under room conditions, is produced when 0.783 g of anhydrous barium nitrate reacts with an excess of aluminium?

A 46.8 cm^3 **B** 72.0 cm^3 **C** 93.6 cm^3 **D** 144 cm^3

[2012 M/J-11 (14)]

44.

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(aq) **B** CaO(aq) **C** MgO(aq) **D** SrO(aq)

[2012 M/J-11 (15)]

45.

What can be seen 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.

[2012 M/J-12 (17)]

46.

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

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

[2012 O/N-11 (14)]

47.

Use of the Data Booklet is relevant to this question.

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

[2012 O/N-11 (15)]

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48.

Use of the Data Booklet is relevant to this question.

When 3.00 g of an anhydrous nitrate of a Group II 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

[2012 O/N-13 (14)]

49.

Rat poison needs to be insoluble in rain water but soluble at the low pH of stomach contents.

What is a suitable barium compound to use for rat poison?

A barium carbonate

B barium chloride

C barium hydroxide

D barium sulfate

[2012 O/N-13 (16)]

50.

In which row of the table are all statements comparing the compounds of magnesium and barium correct?

	solubility of hydroxides		solubility of sulfates	
	solubility of magnesium hydroxide	solubility of barium hydroxide	solubility of magnesium sulfate	solubility of barium sulfate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

[2013 M/J-11 (13)]

51.

Use of the Data Booklet is relevant to this question.

Magnesium nitrate, $Mg(NO_3)_2$, will decompose 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

[2013 M/J-11 (16)]

52.

The Group II metals have higher melting points than the Group I metals.

Which factors could contribute towards the higher melting points?

1 There are smaller interatomic distances in the metallic lattices of the Group II metals.

2 More electrons are available from each Group II metal atom for bonding the atom into the metallic lattice.

3 Group II metals have a higher first ionisation energy than the corresponding Group I metal.

[2013 M/J-11 (32)]

53.

Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**. When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 More acid is neutralised by 1 g of **W** than by 1 g of **X**.

2 The metallic element in **W** reacts with water more quickly than the metallic element in **Y**.

3 Adding **Z** to a soil decreases the pH of the soil.

[2013 M/J-11 (35)]

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54.

Use of the Data Booklet is relevant to this question.

Magnesium nitrate, $Mg(NO_3)_2$, will decompose when heated to give a white solid and a mixture of gases. One of the gases released is oxygen.

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

What mass of oxygen is produced?

A 3.2 g **B** 6.4 g **C** 12.8 g **D** 19.2 g

[2013 M/J-12 (13)]

55.

In which row of the table are all statements comparing the compounds of calcium and barium correct?

	solubility of calcium hydroxide	solubility of barium hydroxide	thermal stability of calcium carbonate	thermal stability of barium carbonate
A	higher	lower	higher	lower
B	higher	lower	lower	higher
C	lower	higher	higher	lower
D	lower	higher	lower	higher

[2013 M/J-12 (14)]

56.

Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**. When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 Adding **W** to water has less effect on pH than adding **Y**.

2 Adding **Z** to soil increases the pH of the soil.

3 The metallic element in **Y** reacts with cold water more quickly than the metallic element in **W**.

[2013 M/J-12 (34)]

57.

Use of the Data Booklet is relevant to this question.

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

Y is oxygen.

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

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

[2013 M/J-13 (12)]

58.

In which row of the table are all statements comparing magnesium and barium correct?

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

[2013 M/J-13 (13)]

59.

Solids **W**, **X**, **Y** and **Z** are compounds of two different Group II metals. Some of their applications are described below.

Compound **W** is used as a refractory lining material in kilns.

Compound **X** is used as a building material. It can also be heated in a kiln to form compound **Y**. When **Y** is hydrated, it forms compound **Z** which is used agriculturally to treat soils.

Which statements about these compounds are correct?

1 More acid is neutralised by 2.0 g of **X** than by 2.0 g of **W**.

2 The M_r of **X** is greater than the M_r of **Y** by 44.0.

3 The metallic element in **Y** reacts with cold water more quickly then the metallic element in **W**.

[2013 M/J-13 (35)]

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60.
A metal, **X**, reacts with water to produce a colourless solution which gives a white precipitate when mixed with aqueous sulfuric acid.

What is metal **X**?

A barium

B magnesium

C potassium

D sodium

[2013 O/N-11 (13)]

61.
Which property **increases** in value going down Group II?

A electronegativity

B ionic radius

C maximum oxidation number

D second ionisation energy

[2013 O/N-11 (14)]

62.
Which row correctly identifies the uses of some of the compounds of Group II metals?

	used as a refractory lining in kilns	used in agriculture to increase the pH of a soil
A	CaO	$Ca(OH)_2$
B	CaO	$Mg(OH)_2$
C	MgO	$Ca(OH)_2$
D	MgO	$Mg(OH)_2$

[2013 O/N-11 (15)]

63.
Use of the Data Booklet is relevant to this question.

Which calcium compound contains 54.1% by mass of calcium?

A calcium hydroxide

B calcium nitrate

C calcium oxide

D calcium sulfate

[2013 O/N-13 (11)]

64.
Use of the Data Booklet is relevant to this question.

The reaction between aluminium powder and anhydrous barium nitrate is used as the propellant in some fireworks. The reaction produces the metal oxides and nitrogen.

$$10Al + 3Ba(NO_3)_2 \rightarrow 5Al_2O_3 + 3BaO + 3N_2$$

Which mass of barium oxide is produced when 5.40g of aluminium powder reacts with an excess of anhydrous barium nitrate?

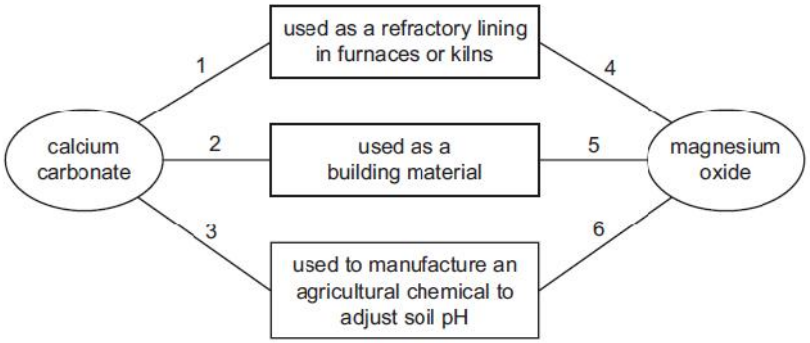
A 1.62g **B** 3.06g **C** 9.18g **D** 10.2g

[2013 O/N-13 (12)]

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65.

The diagram shows some applications of compounds of Group II elements.



Which numbered links are correct?

	calcium carbonate	magnesium oxide
A	1, 2 and 3	4 and 5 only
B	1, 2 and 3	5 and 6 only
C	2 and 3 only	4 only
D	2 and 3 only	6 only

[2013 O/N-13 (13)]

66.

River water in a chalky agricultural area may contain Ca^{2+}, Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl^- and NO_3^- ions. In a water treatment plant, such water is treated by adding a calculated quantity of calcium hydroxide.

What will be precipitated from the river water following the addition of calcium hydroxide?

A $CaCl_2$ **B** $CaCO_3$ **C** $Ca(NO_3)_2$ **D** $Mg(NO_3)_2$

[2013 O/N-13 (14)]

67.

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	$Ca(OH)_2$	$Ba(OH)_2$

[2014 M/J-11 (13)]

68.

When calcium is burnt in oxygen, what colour is the flame?

A green

B red

C white

D yellow

[2014 M/J-11 (15)]

69.

Group II nitrates undergo thermal decomposition according to the following equation.

$$X(NO_3)_2 \rightarrow XO + 2NO_2 + \tfrac{1}{2}O_2$$

Which Group II nitrate requires the highest temperature to bring about its thermal decomposition?

A barium nitrate

B calcium nitrate

C magnesium nitrate

D strontium nitrate

[2014 M/J-11 (17)]

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70.

When barium is burnt in oxygen, what colour is the flame?

A green

B orange

C red

D white

[2014 M/J-12 (12)]

71.

Which statement about the oxides and hydroxides of the Group II elements Mg, Ca, Sr and Ba is correct?

A Each of the oxides reacts readily with water to form a solution of pH 12 or above.

B Magnesium oxide is used as a furnace lining because it has a giant molecular structure and hence a high melting point.

C The hydroxides are produced directly by the thermal decomposition of the corresponding nitrates.

D The solubility of the hydroxides increases from $Mg(OH)_2$ to $Ba(OH)_2$.

[2014 M/J-12 (15)]

72.

A test-tube of HBr(g) and a test-tube of HI(g) are heated to the same temperature.

Which combination of observations is possible?

	tube of HBr(g)	tube of HI(g)
A	a brown vapour appears	no change is apparent
B	a purple vapour appears	no change is apparent
C	no change is apparent	a brown vapour appears
D	no change is apparent	a purple vapour appears

[2014 M/J-12 (18)]

73.

Use of the Data Booklet is relevant to this question.

X is an s-block element. **X** forms an insoluble carbonate with the formula XCO_3. **X** forms a hydroxide that is more soluble than strontium hydroxide.

What could be the identity of **X**?

A barium

B calcium

C cobalt

D rubidium

[2014 M/J-13 (13)]

74.

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

[2014 M/J-13 (15)]

75.

When strontium is burnt in oxygen, what colour is the flame?

A green

B red

C white

D yellow

[2014 M/J-13 (19)]

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76.

Use of the Data Booklet is relevant to this question.

Sir Humphrey Davy discovered boron, calcium, magnesium and sodium.

Which of these elements has the **second** smallest atomic radius in its group and the **third** lowest first ionisation energy in its period?

A boron

B calcium

C magnesium

D sodium

[2014 O/N-11 (14)]

77.

Which statements about calcium oxide are correct?

1 It reacts with cold water.

2 It is produced when calcium nitrate is heated.

3 It can be reduced by heating with magnesium.

[2014 O/N-11 (36)]

78.

Pieces of calcium and magnesium are reacted separately with cold water.

Pieces of calcium and magnesium are also burned separately with oxygen.

Which row correctly describes the observations from these reactions?

	calcium with cold water	magnesium with cold water	calcium with oxygen	magnesium with oxygen
A	rapid bubbling	slow bubbling	red flame	white flame
B	rapid bubbling	slow bubbling	white flame	red flame
C	slow bubbling	rapid bubbling	red flame	white flame
D	slow bubbling	rapid bubbling	white flame	red flame

[2014 O/N-13 (13)]

79.

X is a mixture of two compounds of Group II elements.

X can undergo 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 **X**?

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 $CaSO_4$

[2014 O/N-13 (16)]

.

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Group 2 - 2021

1. March/2020/Paper_42/No.2

(a) Group 2 metals form stable carbonates and sulfates.

(i) State and explain the trend in the thermal stability of the Group 2 carbonates down the group.

.....

.....

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.....

.....

..... [3]

(ii) The sulfates of Group 2 elements become less soluble down the group.

Explain this trend.

.....

.....

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.....

.....

..... [3]

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(b) Aluminium is extracted from Al_2O_3 by electrolysis. Al_2O_3 is dissolved in cryolite in this process.

(i) The half-equation for the reaction at the anode is shown.

$$O^{2-} + C \rightarrow CO + 2e^-$$

Use this half-equation to write the ionic equation for the electrolysis of Al_2O_3.

..... [1]

(ii) Aluminium oxide is electrolysed for 3.0 hours using carbon electrodes and a current of 3.5×10^5 A.

Calculate the mass of aluminium that is formed.

mass of aluminium = ... g [3]

(iii) Cryolite can be made from SiF_4.

The first step in this conversion is the reaction of SiF_4 with H_2O, forming H_2SiF_6 and SiO_2.

Write an equation for this reaction.

..... [1]

[Total: 11]

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2. June/2020/Paper_41/No.2

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

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.....

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.....

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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.

.....

.....

.....

..... [2]

[Total: 6]

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3. June/2020/Paper_42/No.2

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

.....

.....

.....

.....

.....

..... [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.

.....

.....

..... [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]

(d) Calcium iodate(V), $Ca(IO_3)_2$, is sparingly soluble in water.
The concentration of its saturated solution is 5.6×10^{-3} mol dm^{-3} at 298 K.

(i) Write an expression for the solubility product, K_{sp}, of $Ca(IO_3)_2$, and state its units.

K_{sp} =

units = ... [2]

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(ii) Calculate the numerical value for K_{sp} $Ca(IO_3)_2$ at 298 K.

K_{sp} = ... [1]

(iii) When a few cm^3 of concentrated $Ca(NO_3)_2(aq)$ is added to a saturated solution of $Ca(IO_3)_2$ a white precipitate forms.

Identify the white precipitate and give an explanation for this observation.

.....

.....

..... [2]

(e) Iodised salt is sodium chloride mixed with a small amount of sodium iodate(V), $NaIO_3$.

- 50.00 g of iodised salt is dissolved in distilled water and the solution made up to 250 cm^3 in a volumetric flask with distilled water.
- 50.0 cm^3 of this solution is pipetted into an excess of aqueous acidified potassium iodide.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$$

- The iodine produced requires 12.40 cm^3 of 0.00200 mol dm^{-3} aqueous sodium thiosulfate solution for complete reaction.

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$$

Calculate the mass of sodium iodate(V) present in 50.00 g of iodised salt.

mass of $NaIO_3$ = ... g [3]

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(f) The half-equation for the reduction of iodate(V) ions is shown.

$$IO_3^- + 6H^+ + 5e^- \rightarrow \tfrac{1}{2}I_2 + 3H_2O \qquad E^\ominus = +1.19\,V$$

Use data from the *Data Booklet* to predict whether a reaction is feasible when aqueous solutions of acidified iodate(V) ions and bromide ions are mixed. Explain your answer.

.....

..... [1]

(g) Iodate(V) ions react with sulfite ions in acidic solution at pH 5.00 as shown.

$$IO_3^- + 3SO_3^{2-} \rightarrow I^- + 3SO_4^{2-}$$

The initial rate of reaction was found to be first order with respect to IO_3^-, first order with respect to SO_3^{2-} and first order with respect to H^+.

(i) Write the rate equation for this reaction, stating the units of the rate constant, *k*.

rate = ... $mol\,dm^{-3}\,s^{-1}$

units of *k* = ...
[2]

(ii) The rate of reaction depends on the pH of the solution. Assume all other concentrations remain the same.

Use the expression $x = \dfrac{\text{rate at pH 5.00}}{\text{rate at pH 4.00}}$ to calculate the value of x.

x = ... [1]

[Total: 19]

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1. Nov/2021/Paper_41/No.4

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.

.....

.....

..... [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.

.....

.....

.....

..... [3]

(c) **(i)** Calculate the mass, in g, of CO_2 produced by the decomposition of 0.020 moles of calcium carbonate.

mass of CO_2 = ... g [1]

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(ii) Calculate the minimum mass, in g, of propane that would, on complete combustion, produce the same mass of CO_2 calculated in **(c)(i)**.
Give your answer to three significant figures.

mass of propane = ... g [2]

[Total: 8]

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2. Nov/2021/Paper_42/No.1

Radium is a Group 2 element.

The predicted lattice energy, $\Delta H^{\ominus}_{latt}$, of radium sulfide, RaS, is –2612 kJ mol^{-1}.

(a) Define $\Delta H^{\ominus}_{latt}$.

.....

..... [2]

Some data relating to radium and sulfur are listed. Select relevant data from this list for use in your answers to parts **(b)** to **(e)**.

process	value / kJ mol^{-1}
enthalpy change for $Ra(s) \rightarrow Ra^{2+}(g) + 2e^-$	+1619
first ionisation energy of sulfur	+1000
second ionisation energy of sulfur	+2260
first electron affinity of sulfur	–200
second electron affinity of sulfur	+532
enthalpy change for $\frac{1}{8}S_8(s) + 2e^- \rightarrow S^{2-}(g)$	+555
lattice energy of RaS(s)	–2612

(b) Write an equation for the process corresponding to the **second** electron affinity of sulfur. Include state symbols.

..... [1]

(c) Sulfur exists as S_8 molecules in the solid state.

Use the data in this question to calculate the enthalpy change for the reaction $S_8(s) \rightarrow 8S(g)$.

enthalpy change = ... kJ mol^{-1} [3]

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(d) Calculate the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of radium sulfide.

standard enthalpy change, $\Delta H_f^{\ominus}$ = ... $kJ\,mol^{-1}$ [2]

(e) (i) State the **two** major factors that affect the numerical magnitude of a lattice energy.

.....

..... [2]

(ii) For **each** factor you have identified in **(e)(i)**, state whether it tends to make the lattice energy of radium sulfide more or less exothermic than that of sodium chloride.

Explain your answer.

.....

.....

.....

..... [2]

(iii) The lattice energies of sodium chloride, NaC*l*, and radium sulfide, RaS, are $-771\,kJ\,mol^{-1}$ and $-2612\,kJ\,mol^{-1}$, respectively.

Identify the **dominant** factor in determining the relative numerical magnitudes of the lattice energies of radium sulfide and sodium chloride.

Explain your answer.

.....

..... [1]

[Total: 13]

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3. Nov/2021/Paper_42/No.4

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.

.....

.....

.....

..... [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.

.....

.....

.....

.....

..... [3]

(c) The nitrogen dioxide given off by the decomposition of 0.0100 mol of strontium nitrate is dissolved in water. The oxidising agent $H_2O_2(aq)$ is then added to give 150.0 cm^3 of a solution in which nitric acid, HNO_3, is the only nitrogen-containing product.

(i) Calculate the concentration, in mol dm^{-3}, of HNO_3 in the 150.0 cm^3 of solution.

concentration = ... mol dm^{-3} [1]

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(ii) The HNO_3 present in 25.0 cm^3 of this solution is neutralised using 0.125 mol dm^{-3} NaOH(aq).

Calculate the minimum volume, in cm^3, of NaOH(aq) needed. Give your answer to three significant figures.

volume = ... cm^3 [1]

[Total: 7]

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4. June/2021/Paper_41/No.1

(a) The carbonates and hydroxides of Group 2 elements show similar trends in thermal stability.

Suggest and explain the variation in the trend in the thermal stability of the Group 2 hydroxides.

.....

.....

.....

.....

..... [3]

(b) Calcium hydroxide is slightly soluble in water.

(i) Write an equation to show the dissociation of calcium hydroxide, $Ca(OH)_2(s)$, in aqueous solution. Include state symbols.

..... $\rightleftharpoons$ ..... [1]

(ii) Calculate the solubility, in mol dm^{-3}, of $Ca(OH)_2$.
[K_{sp}: $Ca(OH)_2$, 5.02×10^{-6} mol^3 dm^{-9}]

solubility = ... mol dm^{-3} [2]

(iii) Suggest how the solubility of $Ca(OH)_2$ in aqueous NaOH compares to its solubility in water.

Explain your reasoning.

.....

.....

..... [1]

[Total: 7]

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5. June/2021/Paper_42/No.2

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

.....

.....

.....

.....

..... [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*.

.....

..... [1]

(c) (i) Barium ethanedioate, BaC_2O_4, decomposes on heating to produce barium oxide and a mixture of two different gases.

Construct an equation for the decomposition of barium ethanedioate.

..... [1]

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(ii) An impure sample of BaC_2O_4, of mass 0.500 g, is added to 50.0 cm^3 of 0.0200 mol dm^{-3} acidified MnO_4^-(aq), an excess. A redox reaction takes place and all the BaC_2O_4 reacts.

The resulting solution, containing unreacted acidified MnO_4^-, is titrated with 0.0500 mol dm^{-3} Fe^{2+}(aq).

The end-point is reached when 30.40 cm^3 of 0.0500 mol dm^{-3} Fe^{2+}(aq) has been added.

$$C_2O_4^{2-} \rightleftharpoons 2CO_2 + 2e^-$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$$

$$Fe^{2+} \rightleftharpoons Fe^{3+} + e^-$$

Calculate the percentage by mass of BaC_2O_4 in the 0.500 g impure sample. Show your working.
[M_r: BaC_2O_4, 225.3]

percentage by mass of BaC_2O_4 = ... [4]

(d) Barium hydroxide, $Ba(OH)_2$, is completely dissociated in aqueous solution.

Calculate the pH of 0.120 mol dm^{-3} $Ba(OH)_2$(aq) at 298 K.

pH = ... [2]

[Total: 12]

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Group 2 – 2022 June A2 Chemistry 9701

1. June/2022/Paper_41/No.1(a)

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

Explain this trend.

.....

.....

.....

.....

..... [3]

2. June/2022/Paper_42/No.1(a)

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

Explain this trend.

.....

.....

.....

.....

..... [3]

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1. Nov/2023/Paper_9701/41/No.4(b)

(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 .....

.....

.....

.....

.....

[3]

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2. Nov/2023/Paper_9701/42/No.5

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.

.....

.....

..... [2]

(c) The ethanedioate ion is oxidised by acidified $KMnO_4$.

$$5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$$

An experiment is performed to find the solubility of MgC_2O_4 in water.

A 40.0 cm^3 sample of saturated aqueous MgC_2O_4 requires 27.05 cm^3 of 0.00200 mol dm^{-3} acidified $KMnO_4$ to oxidise all the $C_2O_4^{2-}$ ions.

Calculate the solubility, in mol dm^{-3}, of MgC_2O_4 in water. Show your working.

solubility = ... mol dm^{-3} [3]

[Total: 6]

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3. June/2023/Paper_9701/41/No.1(a, b)

(a) Group 2 nitrates decompose when heated.

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

Explain your answer.

.....

.....

.....

.....

..... [3]

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

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

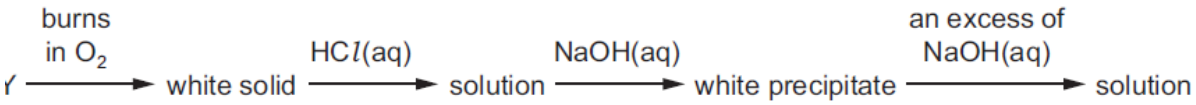
..... [1]

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Group 2 – 2021 AS

1. Nov/2021/Paper_11/No.13

An element, Y, reacts according to the following sequence.



What could be element Y?

A Na **B** Mg **C** Al **D** P

2. Nov/2021/Paper_11/No.15

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** $\frac{1}{3.43}$

3. Nov/2021/Paper_11/No.36

Which statements about calcium oxide are correct?

1 It can be reduced by heating with magnesium.

2 It is produced when calcium nitrate is heated.

3 It reacts with cold water.

4. Nov/2021/Paper_12/No.12

A mixture of two Period 3 oxides are added to water. A solution forms with a pH of just below 7.

What could be the constituents of the mixture?

A Al_2O_3 and MgO

B Na_2O and MgO

C Na_2O and P_4O_{10}

D SO_3 and P_4O_{10}

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5. Nov/2021/Paper_12/No.13

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.

6. Nov/2021/Paper_12/No.14

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

7. Nov/2021/Paper_12/No.16

Silver chloride and silver iodide form equilibria when added to water.

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq) \qquad K_c = K_1$$

$$AgI(s) \rightleftharpoons Ag^+(aq) + I^-(aq) \qquad K_c = K_2$$

Each equilibrium position lies well to the **left**.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.

$$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq) \qquad K_c = K_3$$

The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

	smallest ⟶		largest
A	K_3	K_2	K_1
B	K_3	K_1	K_2
C	K_2	K_1	K_3
D	K_1	K_2	K_3

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8. Nov/2021/Paper_12/No.17

X is the ion of a metal which burns with a red flame.

Y is an ion that reacts with concentrated H_2SO_4 to produce H_2S.

What could be the formula of a compound containing X and Y?

A $BaBr_2$ **B** BaI_2 **C** $SrBr_2$ **D** SrI_2

9. Nov/2021/Paper_12/No.19

Magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride.

Which statement explains this observation?

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.

10. Nov/2021/Paper_13/No.13

An element, Y, reacts according to the following sequence.

$$Y \xrightarrow{\text{burns in } O_2} \text{white solid} \xrightarrow{HCl(aq)} \text{solution} \xrightarrow{NaOH(aq)} \text{white precipitate} \xrightarrow{\text{an excess of } NaOH(aq)} \text{solution}$$

What could be element Y?

A Na **B** Mg **C** Al **D** P

11. Nov/2021/Paper_13/No.14

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

12. Nov/2021/Paper_13/No.15

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** $\frac{1}{3.43}$

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13. Nov/2021/Paper_13/No.19

The table describes two possible environmental consequences of adding too much ammonium nitrate fertiliser to the soil.

Which row is correct?

	increased plant growth in rivers	photochemical smog
A	✗	✗
B	✓	✗
C	✗	✓
D	✓	✓

14. Nov/2021/Paper_13/No.36

Which statements about calcium oxide are correct?

1 It can be reduced by heating with magnesium.

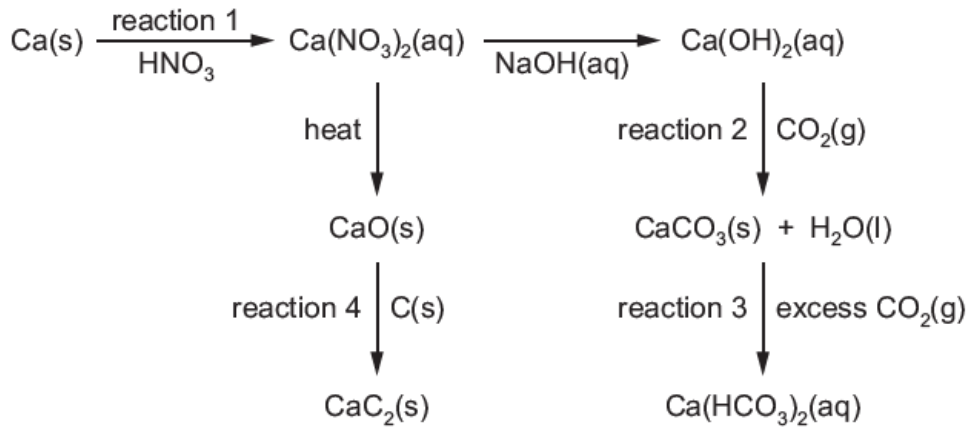
2 It is produced when calcium nitrate is heated.

3 It reacts with cold water.

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15. Nov/2021/Paper_21/No.2

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]

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(c) In reaction 4, calcium carbide, CaC_2, is formed from CaO.

CaC_2 contains the C_2^{2-} anion. Each carbon in C_2^{2-} is sp hybridised.

(i) Describe how sp hybridised orbitals are formed.

.....

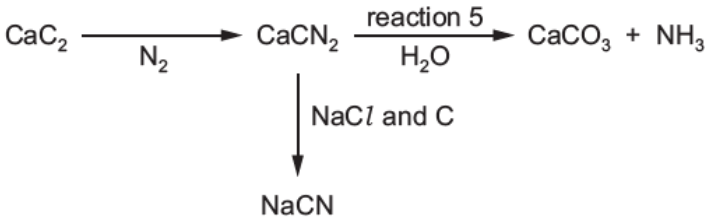
..... [1]

(ii) Sketch a diagram to show how two sp hybrid orbitals can form a sigma (σ) bond.

[2]

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(d) The flowchart shows some reactions of CaC_2.



(i) Reaction 5 can be used to prepare NH_3.

$$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$$

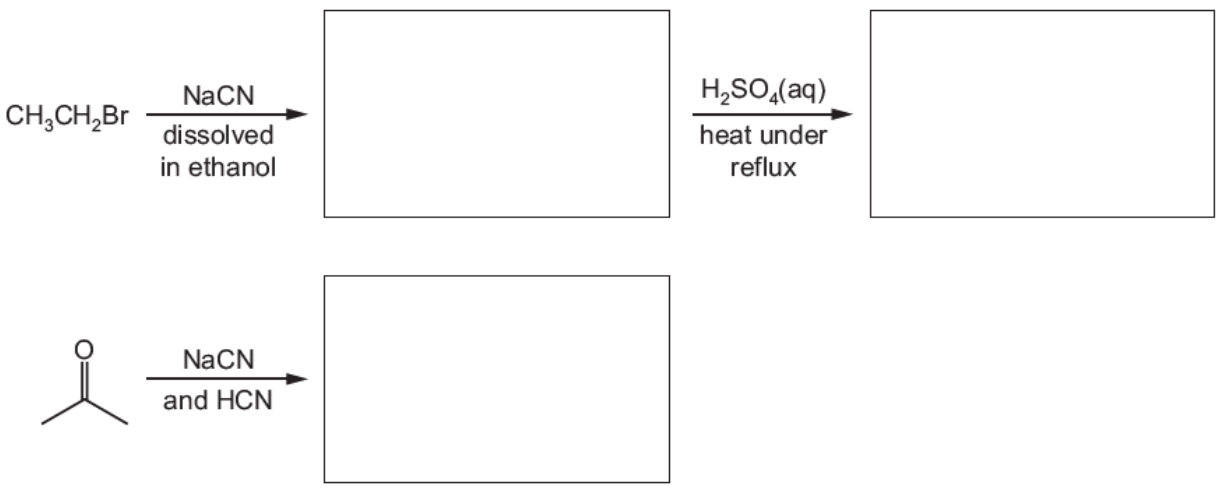
Calculate the minimum mass, in tonnes, of calcium cyanamide, $CaCN_2$, that is required to produce 1.50×10^6 tonnes of NH_3.

Show your working.

1 tonne = 1.00×10^6 g

minimum mass of $CaCN_2$ = ... tonnes
[2]

(ii) Draw the structure of the organic products formed in the following reactions.



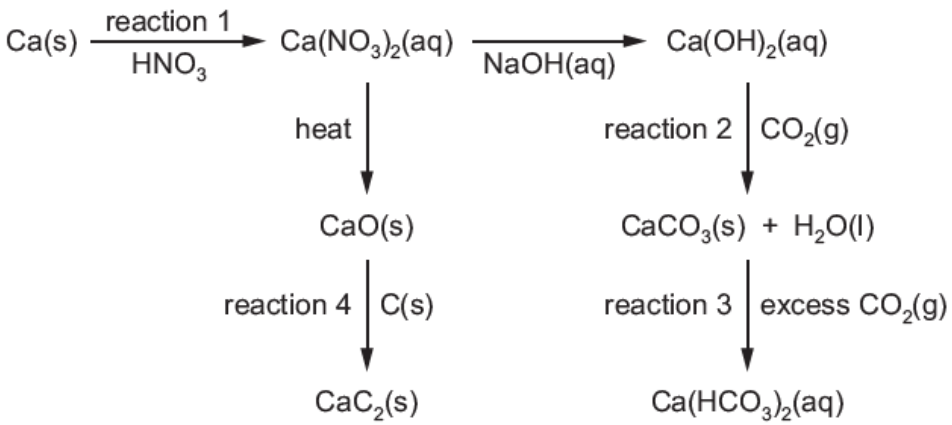
[3]

[Total: 13]

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16. Nov/2021/Paper_23/No.2

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]

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(c) In reaction 4, calcium carbide, CaC_2, is formed from CaO.

CaC_2 contains the C_2^{2-} anion. Each carbon in C_2^{2-} is sp hybridised.

(i) Describe how sp hybridised orbitals are formed.

.....

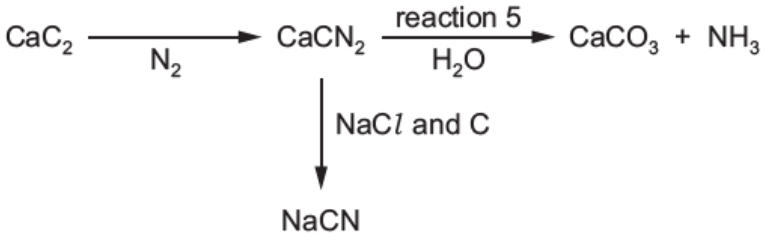
..... [1]

(ii) Sketch a diagram to show how two sp hybrid orbitals can form a sigma (σ) bond.

[2]

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(d) The flowchart shows some reactions of CaC_2.



(i) Reaction 5 can be used to prepare NH_3.

$$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$$

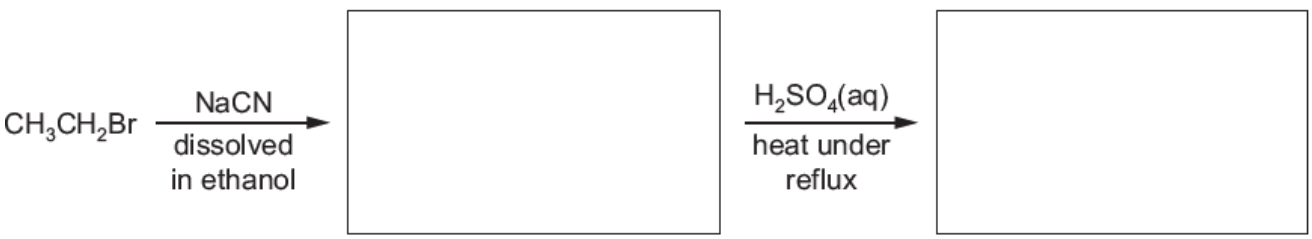
Calculate the minimum mass, in tonnes, of calcium cyanamide, $CaCN_2$, that is required to produce 1.50×10^6 tonnes of NH_3.

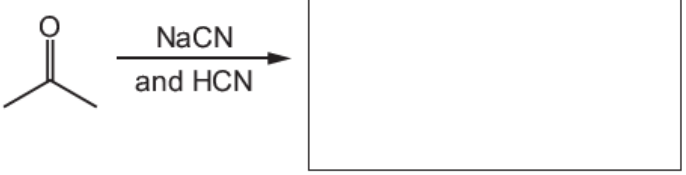
Show your working.

1 tonne = 1.00×10^6 g

minimum mass of $CaCN_2$ = ... tonnes
[2]

(ii) Draw the structure of the organic products formed in the following reactions.





[3]

[Total: 13]

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17. March/2021/Paper_12/No.14

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

18. March/2021/Paper_12/No.15

An anhydrous white salt, Z, is heated strongly for 30 minutes. A mixture of gases is given off. The solid remaining in the test-tube is then dissolved in a small volume of dilute hydrochloric acid. The addition of a few drops of dilute sulfuric acid to the test-tube causes a white precipitate to form.

Which substance could be Z?

A barium carbonate

B barium nitrate

C magnesium carbonate

D magnesium nitrate

19. June/2021/Paper_11/No.14

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 $MgO + MgSO_4$

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20. June/2021/Paper_11/No.15

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

21. June/2021/Paper_11/No.16

A $5\,cm^3$ sample of $0.05\,mol\,dm^{-3}$ sodium chloride is mixed with a $5\,cm^3$ sample of $0.05\,mol\,dm^{-3}$ potassium iodide. $10\,cm^3$ of acidified $0.05\,mol\,dm^{-3}$ silver nitrate is then added, followed by concentrated ammonia solution.

What is seen after the addition of an excess of concentrated ammonia solution?

A a cream precipitate

B a white precipitate

C a yellow precipitate

D no precipitate

22. June/2021/Paper_11/No.19

R is an oxide of Period 3 element T. 5.00 g of R contains 2.50 g of T.

What is T?

A magnesium

B aluminium

C silicon

D sulfur

23. June/2021/Paper_11/No.36

Which statements are correct?

1 Magnesium carbonate decomposes at a lower temperature than calcium carbonate.

2 Calcium hydroxide is more soluble in water than magnesium hydroxide.

3 Calcium is a stronger reducing agent than magnesium.

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24. June/2021/Paper_12/No.15

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

25. June/2021/Paper_12/No.36

Which reaction routes can be used to make a pure sample of barium sulfate?

1 $Ba \xrightarrow[\text{in } O_2]{\text{heat}} \text{product} \xrightarrow[HCl]{\text{dilute}} \text{product} \xrightarrow[H_2SO_4]{\text{dilute}} \text{product} \xrightarrow[\text{and dry}]{\text{filter, wash}}$

2 $Ba(NO_3)_2 \xrightarrow[\text{heat in air}]{\text{strong}} \text{solid product} \xrightarrow[\text{of water}]{\text{an excess}} \text{product} \xrightarrow[H_2SO_4]{\text{dilute}} \text{product} \xrightarrow[\text{and dry}]{\text{filter, wash}}$

3 $Ba(OH)_2 \xrightarrow[HNO_3]{\text{dilute}} \text{product} \xrightarrow[H_2SO_4]{\text{dilute}} \text{product} \xrightarrow[\text{and dry}]{\text{filter, wash}}$

26. June/2021/Paper_13/No.17

Which statement is correct?

A Doctors can use the very insoluble $MgSO_4$ to investigate the digestive system.

B Farmers can lower the pH of soil by spreading $CaCO_3$ on it.

C Students can test a solution for SO_4^{2-} ions by using $Ba(NO_3)_2(aq)$ followed by $HNO_3(aq)$.

D The insoluble hydroxide, $Ba(OH)_2$, can be safely used to lower the acidity of the stomach.

27. June/2021/Paper_13/No.18

A solid, X, was placed in an excess of the liquid Y.

A colourless gas was given off and a white precipitate was seen. The precipitate was not X.

What could be the identities of X and Y?

	X	Y
A	$BaCO_3$	H_2O
B	Ca	dilute H_2SO_4
C	Mg	dilute H_2SO_4
D	$SrCO_3$	dilute HCl

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28. June/2021/Paper_21/No.3

Sodium halide salts react with concentrated sulfuric acid at room temperature.

(a) (i) Write an equation to represent the reaction of NaCl(s) with concentrated sulfuric acid.

..... [1]

(ii) Name this type of reaction.

..... [1]

(b) NaI(s) reacts with concentrated sulfuric acid, at room temperature, to form steamy fumes.

(i) Identify the chemical responsible for the steamy fumes.

..... [1]

(ii) The reaction of NaI(s) with concentrated sulfuric acid continues, forming several other products, including a dark grey solid.

Identify the chemical responsible for the dark grey solid and **one** other product of this further reaction.

dark grey solid .....

other product .....

[2]

(c) Explain the differences in observations, at room temperature, when NaI(s) reacts with concentrated sulfuric acid compared to those for NaCl(s).

.....

.....

..... [2]

(d) Complete the equation for the reaction of Br^- with excess concentrated H_2SO_4 at room temperature.

.....Br^- + ...H^+ + ...H_2SO_4 → .....

[1]

[Total: 8]

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29. June/2021/Paper_22/No.1

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.

(a) State the formula and colour of the precipitate.

..... [2]

(b) Complete the equation to represent the reaction between **M**Br_2 and $AgNO_3$.

.....**M**Br_2 + ...$AgNO_3$ → ..... [1]

(c) A 0.250 g sample of pure **M**Br_2 contains 8.415×10^{-4} mol **M**Br_2.

Calculate the relative formula mass, M_r, of **M**Br_2. Use this to identify **M**.

Show your working.

M_r = ...

M = ...
[3]

(d) A sample of **M**Br_2 is dissolved in water. Chlorine gas is then bubbled into the solution.

(i) Describe the observations for this reaction.

.....

..... [1]

(ii) Name the type of reaction that occurs when **M**Br_2 reacts with chlorine gas.

..... [1]

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(e) Compound **Y** is a pure **insoluble** solid which contains halide ions.

A single reagent is added directly to compound **Y** to determine the halide ion present.

Identify the reagent added. State the observation which would confirm that **Y** contains bromide ions.

reagent .....

observation .....

[2]

(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]

[Total: 16]

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Group 2 – 2022 June AS Chemistry 9701

1. June/2022/Paper_11/No.20

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 HC*l*(aq), filter off the solid barium chloride.

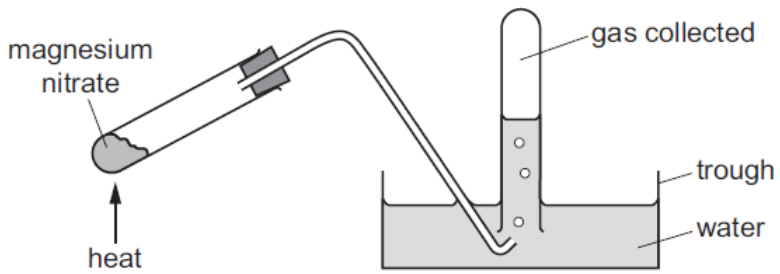
B Add HC*l*(aq), filter off the solid magnesium chloride.

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

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

2. June/2022/Paper_11/No.21

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

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3. June/2022/Paper_12/No.20

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

4. June/2022/Paper_12/No.21

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

5. June/2022/Paper_13/No.20

NaOH(aq) is added to separate samples of magnesium chloride and barium chloride solutions.

$H_2SO_4(aq)$ is then added slowly to each reaction mixture until in excess.

What is observed at the **end** of the reaction sequence?

	$MgCl_2(aq)$	$BaCl_2(aq)$
A	colourless solution only	colourless solution only
B	colourless solution only	white precipitate
C	white precipitate	colourless solution only
D	white precipitate	white precipitate

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6. June/2022/Paper_13/No.21

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

Which metal is present in Z?

A barium

B calcium

C magnesium

D strontium

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7. June/2022/Paper_21/No.1(a_ d)

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

(a) Identify the highest energy orbital which contains electrons in a calcium atom. Sketch the shape of this orbital.

identity of highest energy orbital in Ca .....

shape

[1]

(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]

(d) (i) $^{25}_{12}Mg$ is an isotope of magnesium.

Determine the number of protons and neutrons in an atom of $^{25}_{12}Mg$.

number of protons .....

number of neutrons .....
[1]

(ii) State the full electronic configuration of an atom of $^{25}_{12}Mg$.

..... [1]

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8. June/2022/Paper_22/No.2(a, b)

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.

(a) Predict the lattice structure of $RaCl_2(s)$ based on the properties described.

..... [1]

(b) Draw a dot-and-cross diagram to show the arrangement of outer electrons in $RaCl_2$.

[1]

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Group 2 – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.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

2. Nov/2022/Paper_12/No.19

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

3. Nov/2022/Paper_21/No.2

Magnesium shows reactions typical of a Group 2 metal.

(a) Draw a labelled diagram to show the bonding in magnesium metal.

[2]

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

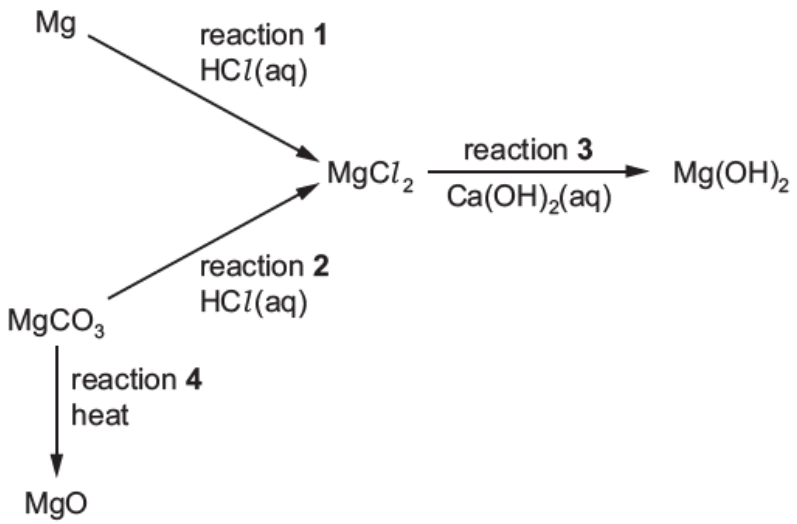


Fig. 2.1

(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]

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

..... [1]

(c) 1 cm^3 of $MgCl_2(aq)$ is placed in a test-tube. A few drops of $AgNO_3(aq)$ are added, followed by 1 cm^3 of dilute $NH_3(aq)$.

State in full what is observed in this experiment.

.....

..... [2]

(d) When 1 cm^3 of $MgCl_2(aq)$ is added to 1 cm^3 of $Br_2(aq)$ in a test-tube, the solution remains orange.

Explain this observation.

.....

.....

..... [1]

[Total: 9]

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Group 2 – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/11/No.19

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

2. Nov/2023/Paper_ 9701/11/No.20

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

3. Nov/2023/Paper_ 9701/11/No.21

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

4. Nov/2023/Paper_ 9701/12/No.21

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.

5. Nov/2023/Paper_ 9701/12/No.22

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}

6. Nov/2023/Paper_ 9701/12/No.23

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

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7. Nov/2023/Paper_ 9701/21/No.2

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

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

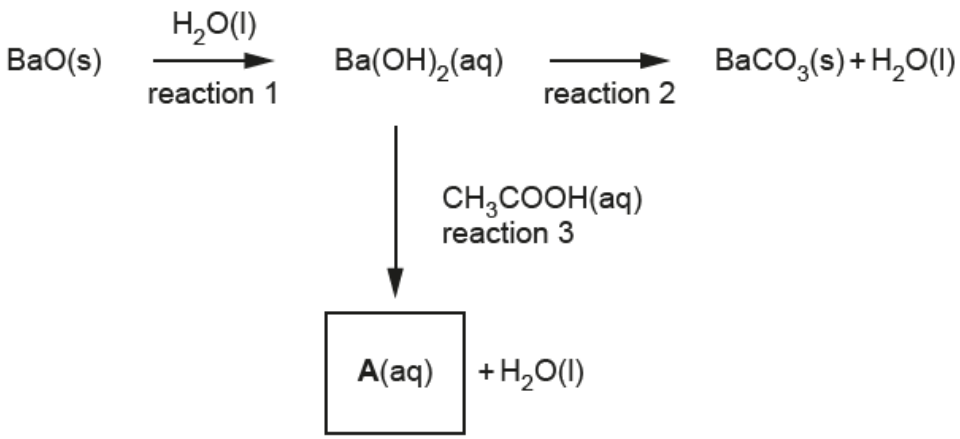


Fig. 2.1

(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]

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(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]

(c) $Ba(OH)_2$ is used to hydrolyse organic compounds.

Fig. 2.2 shows the reaction of **B** with $Ba(OH)_2$, followed by acidification.

Draw the structures of the organic products of the process shown in Fig. 2.2.

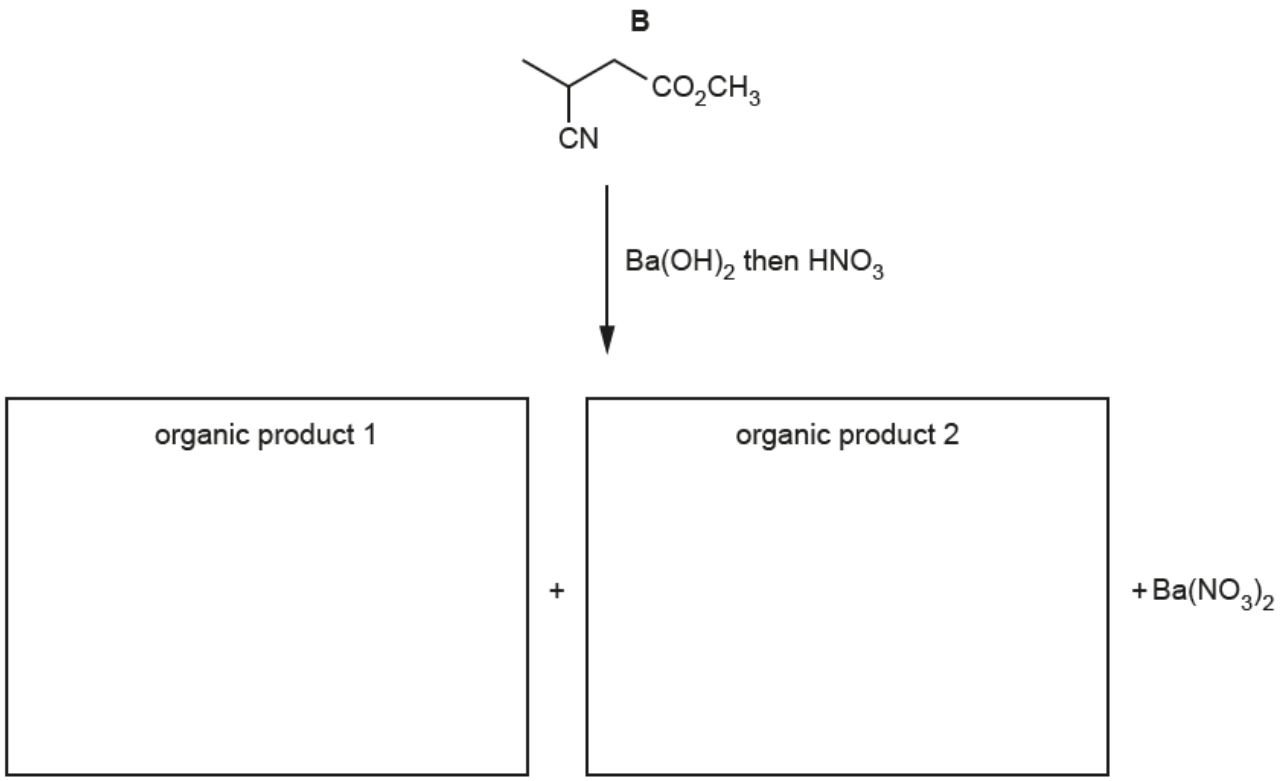


Fig. 2.2

[3]

[Total: 10]

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8. Nov/2023/Paper_ 9701/22/No.2(f)

(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]

9. June/2023/Paper_9701/11/No.23

A solution contains both $Mg^{2+}(aq)$ and $Sr^{2+}(aq)$ at the same concentration.

The solution is divided into two equal portions. Aqueous sodium hydroxide is added dropwise to one portion. Dilute sulfuric acid is added dropwise to the other portion.

Which row is correct?

	precipitate seen first when NaOH(aq) is added	precipitate seen first when $H_2SO_4(aq)$ is added
A	magnesium hydroxide	magnesium sulfate
B	magnesium hydroxide	strontium sulfate
C	strontium hydroxide	magnesium sulfate
D	strontium hydroxide	strontium sulfate

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10. June/2023/Paper_9701/12/No.20

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

11. June/2023/Paper_9701/12/No.21

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+}

12. June/2023/Paper_9701/13/No.23

Equal volumes of saturated solutions of magnesium hydroxide, calcium hydroxide and strontium hydroxide are completely neutralised with dilute sulfuric acid.

The water is gently evaporated from each of the resulting solutions, leaving the corresponding solid sulfates.

These solid sulfates are completely dissolved in the minimum volume of water needed to produce saturated solutions.

Which statement about the volumes of water needed to dissolve the sulfates is correct?

A The calcium sulfate will require the greatest volume of water.

B The magnesium sulfate will require the greatest volume of water.

C The strontium sulfate will require the greatest volume of water.

D They will all require the same volume of water.

13. March/2023/Paper_9701/12/No.21

A sample containing 0.010 mol of anhydrous calcium nitrate is heated strongly until it fully decomposes.

All the gas produced is collected and its volume measured at room conditions.

What is the volume of gas produced?

A 120 cm^3 **B** 600 cm^3 **C** 720 cm^3 **D** 840 cm^3

14. March/2023/Paper_9701/12/No.23

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

15. March/2023/Paper_9701/12/No.24

Four properties of beryllium, Be, or a beryllium compound are listed.

Which property is different from the property of magnesium or the equivalent magnesium compound?

A Be reacts with O_2 when heated in air; Mg does not.

B Be reacts with aqueous H_2SO_4 to form a metal sulfate and H_2; Mg does not.

C $Be(NO_3)_2$ decomposes on heating to form a metal oxide, NO_2 and O_2; $Mg(NO_3)_2$ does not.

D $BeCl_2$ reacts with water to form fumes of HCl; $MgCl_2$ does not.

16. March/2023/Paper_9701/22/No.2(b _ d)

The Group 2 elements Mg to Ba are all silvery-white reactive metals.

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

..... [1]

(c) Identify a single reagent that can be used to distinguish separate samples of dilute $Mg(NO_3)_2(aq)$ and dilute $Ba(NO_3)_2(aq)$.

Explain your answer.

reagent .....

explanation .....

.....

[2]

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(d) **(i)** Describe what is observed when $SrI_2(aq)$ reacts with concentrated sulfuric acid.

.....

..... [2]

(ii) Compound **X**, an anhydrous Group 2 bromide, is dissolved in water and titrated against aqueous silver nitrate.

A solution containing 0.250 g of **X** requires 33.65 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$ for complete reaction.

Identify **X**.

Show your working.

X = ... [3]

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