Past-paper walk-through

Similarities and trends in the properties of the Group 2 metals, magnesium ▪ 10.1

eXercise

Questions in this set

- 9701/11 N25 Q19 ▪ 1 mark
- 9701/11 N25 Q20 ▪ 1 mark
- 9701/12 N25 Q19 ▪ 1 mark
- 9701/12 N25 Q20 ▪ 1 mark
- 9701/14 N25 Q19 ▪ 1 mark
- 9701/14 N25 Q20 ▪ 1 mark
- 9701/41 N25 Q1 ▪ 15 marks
- 9701/42 N25 Q1 ▪ 7 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 19

9701/11 N25 ▪ Q19 ▪ 1 mark

19 The trends seen in Group 2 can be used to predict the properties of radium and its compounds.

Which statement is correct?

A Radium has the highest second ionisation energy of the elements in Group 2.

B Radium hydroxide is the least soluble of the hydroxides of the elements in Group 2.

C Radium carbonate has the lowest thermal stability of the carbonates of the elements in Group 2.

D Radium reacts faster with water than the other elements in Group 2.

Solution 19

Answer: **D**

Why

- Down Group 2 the hydroxides get *more* soluble and the carbonates *more* thermally stable, so B and C are reversed.
- The atoms get bigger, so ionisation energies fall – A is wrong too.
- Reactivity with water increases down the group, so radium reacts fastest.

Question 20

9701/11 N25 ▪ Q20 ▪ 1 mark

20 Equal masses of $CaCO_3$, $Ca(NO_3)_2$, $BaCO_3$ and $Ba(NO_3)_2$ are thermally decomposed. The volume of gas produced in each experiment is measured under the same conditions.

Which compound will produce the greatest volume of gas?

A $CaCO_3$ **B** $Ca(NO_3)_2$ **C** $BaCO_3$ **D** $Ba(NO_3)_2$

Solution 20

Answer: **B**

Why

- Per mole a nitrate gives $2\mathrm{NO_2} + \frac{1}{2}\mathrm{O_2} = 2.5$ mol of gas; a carbonate gives only 1 mol of $\mathrm{CO_2}$.
- Equal *masses* means dividing by M_r: $\mathrm{Ca(NO_3)_2}$ gives $2.5/164 = 0.0152$ mol $\mathrm{g^{-1}}$.
- That beats $\mathrm{CaCO_3}$ (0.0100) and both barium salts, which are heavier.

Question 19

9701/12 N25 ▪ Q19 ▪ 1 mark

19 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 $3Mg(NO_3)_2 \rightarrow Mg_2N_3 + MgO + 3NO + 7O_2$

Solution 19

Answer: **C**

Why

- Group 2 nitrates decompose to the oxide, nitrogen dioxide and oxygen.
- Balanced: $2\mathrm{Mg(NO_3)_2} \rightarrow 2\mathrm{MgO} + 4\mathrm{NO_2} + \mathrm{O_2}$.
- Check the oxygens: 12 on the left and $2 + 8 + 2 = 12$ on the right.

Question 20

9701/12 N25 ▪ Q20 ▪ 1 mark

20 R is the aqueous solution of an ionic compound.

- A white precipitate is formed when R is added to $Sr(NO_3)_2(aq)$.
- No visible reaction is seen when R is added to dilute $HNO_3(aq)$.

What is the anion present in compound R?

A Cl^- **B** SO_4^{2-} **C** HCO_3^- **D** CO_3^{2-}

Solution 20

Answer: **B**

Why

- A white precipitate with Sr^{2+} suggests a carbonate or a sulfate, since $SrCl_2$ is soluble.
- A carbonate would fizz with dilute nitric acid, giving carbon dioxide.
- Nothing happens with the acid, so the anion must be the sulfate.

Question 19

9701/14 N25 ▪ Q19 ▪ 1 mark

19 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.

Which mass of oxygen is produced?

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

Solution 19

Answer: **A**

Why

- $M_r(\mathrm{Mg(NO_3)_2}) = 24.3 + 2(62.0) = 148.3$, so $n = 29.7/148.3 = 0.200$ mol.
- The equation gives one O_2 for every two nitrates: 0.100 mol.
- Mass $= 0.100 \times 32.0 = 3.2$ g.

Question 20

9701/14 N25 ▪ Q20 ▪ 1 mark

20 Which row shows the trends in the named properties going down the Group 2 nitrates?

	thermal stability	volume of gas produced, measured at room conditions, when 1.0 g of anhydrous solid nitrate is thermally decomposed
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

Solution 20

Answer: **B**

Why

- Thermal stability increases down the group: the larger cation polarises the nitrate ion less.
- Each mole always releases the same 2.5 mol of gas, but the molar mass rises down the group.
- So a fixed 1.0 g contains fewer moles and yields *less* gas.

Question 1

9701/41 N25 ▪ Q1 ▪ 15 marks

1 **(a)** Solutions of Group 2 hydrogencarbonates, $M(HCO_3)_2$, decompose on heating to give the corresponding metal carbonate, carbon dioxide and water.

(i) Write an equation for the decomposition of strontium hydrogencarbonate, $Sr(HCO_3)_2$.

Question 1

(ii) The thermal stability of Group 2 carbonates increases down the group.

Explain this trend.

Question 1

(b) The hydroxides and fluorides of Group 2 elements show similar trends in solubility.

Describe the trend in the solubility of the fluorides of calcium, strontium and barium.

Explain your answer.

Question 1

least soluble

most soluble

Question 1

(c) **(i)** Define enthalpy change of hydration, ΔH_{hyd}.

Question 1

(ii) State the main factors that affect the magnitude of enthalpy change of hydration.

Explain your answer.

Question 1

(d) Table 1.1 shows various energy changes.

Table 1.1

energy change	value / kJ mol^{-1}
lattice energy of MgF_2	–2957
enthalpy change of hydration, ΔH_{hyd}, of Mg^{2+}	–1926
enthalpy change of hydration, ΔH_{hyd}, of F^-	–505

Use data from Table 1.1 to calculate the enthalpy change of solution, ΔH_{sol}, for $MgF_2(s)$.

It may be helpful to draw a labelled energy cycle. Show your working.

Question 1

Question 1

Question 1

(e) Mercury(I) fluoride, Hg_2F_2, is sparingly soluble in water.

The cation in Hg_2F_2 exists as the diatomic ion Hg_2^{2+} with a covalent Hg–Hg bond.

(i) Write the expression for the solubility product, K_{sp}, of Hg_2F_2. Include the units.

K_{sp} =

Question 1

[2]

(ii) The solubility of Hg_2F_2 is 9.20×10^{-3} mol dm^{-3} at 298 K.

Calculate the value of K_{sp} of Hg_2F_2 at 298 K.

Question 1

[Total: 15]

Solution 1

(a)(i)

Mark scheme

- $Sr(HCO3)2 \rightarrow SrCO3 + CO2 + H2O$
- 1

Solution 1

(a)(ii)

Mark scheme

- M1: radius of cation / M2+ increases OR charge density of cation / M2+ decreases
- M2: less polarisation / less distortion of the anion / carbonate ion
- 2

Solution 1

(b)

Mark scheme

- M1: least soluble $CaF_2 < SrF_2 < BaF_2$ most soluble
- M2: ΔH_{latt} and ΔH_{hyd} both become less exothermic / less negative
- M3: ΔH_{hyd} changes less / becomes less exothermic by a smaller extent
- OR ΔH_{latt} changes more / becomes less exothermic by a larger extent
- M4: ΔH_{sol} becomes more exothermic / more negative
- 4

Solution 1

(c)(i)

Mark scheme

- enthalpy change when one mole of gaseous ions dissolve in water to form a solution
- 1

Solution 1

(c)(ii) Mark scheme

- M1: ionic radii AND ionic charge
- M2: (ionic) radii increase / charge density decreases AND H_{hyd} decreases/less exothermic AND less attraction between
- water molecules and (gaseous) ions
- OR
- as ionic charge increases / charge density increases AND H_{hyd} increases/more exothermic AND more attraction between
- water molecules and (gaseous) ions
- 2

Solution 1

(d)

Mark scheme

- M1: use of –2957 / –1926 / –505 AND 2 × (–505)
- M2: correct signs and evaluation
- Hsol of MgF2(s) = –1926 + (2 × –505) – (–2957) = (+)21 kJ mol–1
- 2

Solution 1

(e)(i)

Mark scheme

- M1: Ksp = [Hg22+] [F–]2
- M2: units = mol3 dm–9
- 2

Solution 1

(e)(ii)

Mark scheme

- Ksp = 22 × (9.20 × 10–3)3 = 3.11 × 10–6 min 2sf
- 1
- 9701/41
- October/November 2025

Question 1

9701/42 N25 ▪ Q1 ▪ 7 marks

1 Magnesium nitrate, $Mg(NO_3)_2$, and strontium nitrate, $Sr(NO_3)_2$, both decompose when heated to form the metal oxide and a mixture of gases.

(a) Write an equation for the thermal decomposition of $Mg(NO_3)_2$.

Question 1

(b) State which of $Mg(NO_3)_2$ or $Sr(NO_3)_2$ decomposes at a lower temperature.

Explain your answer.

Question 1

[2]

(c) Magnesium oxide, MgO, and strontium oxide, SrO, both react with dilute sulfuric acid.

MgO forms a soluble salt, **A**.

SrO forms an insoluble salt, **B**.

(i) Identify the products formed when MgO reacts with dilute sulfuric acid.

Question 1

(ii) Explain why **A** is more soluble than **B**.

Question 1

[Total: 7]

Solution 1

(a)

Mark scheme

- $Mg(NO3)2 \rightarrow MgO + 2NO2 + ½O2$ OR $2Mg(NO3)2 \rightarrow 2MgO + 4NO2 + O2$
- 1

Solution 1

(b)

Mark scheme

- M1: Mg(NO3)2 / magnesium nitrate
- AND magnesium ion / Mg2+
- AND is smaller / has higher charge density
- M2: nitrate ion / anion is more distorted / polarised
- 2

Solution 1

(c)(i)

Mark scheme

- magnesium sulfate and water / MgSO4 and H2O
- 1

Solution 1

(c)(ii)

Mark scheme

- M1: magnesium sulfate / A has a more exothermic ΔHlatt and ΔHhyd
- M2: difference in ΔHhyd is greater
- M3: magnesium sulfate / A has a more exothermic ΔHsol
- 3