Q1

(a) Explain, in terms of structure and bonding, why the melting point of magnesium is higher than the melting point of sodium.

_____

_____

_____

_____

_____

_____

_____

_____

(2)

Magnesium can be used in the extraction of titanium.

(b) Write an equation to show how magnesium is used to extract titanium from titanium(IV) chloride.

_____

(1)

(c) After the extraction of titanium in part (c), the unreacted magnesium can be removed using an aqueous solution of sulfuric acid to form magnesium sulfate.

The titanium does not react with the acid.

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

State why magnesium sulfate can be separated easily from titanium.

Equation _____

Why separated easily _____

_____

(2)

Q2 GROUP 2 + QUANTITATIVE

This question is about magnesium.

(a) Give the full electron configuration of magnesium.

_____

(1)

(b) Magnesium is used in the extraction of titanium metal from titanium(IV) chloride.

Write an equation for this reaction.

_____

(1)

(c) A sample of magnesium reacts completely with an excess of hydrochloric acid to form hydrogen.

$Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

At 298 K and 101 kPa, the hydrogen formed has a volume of 149 cm^3

Calculate the mass, in g, of the sample of magnesium.

Give your answer to 3 significant figures.

The gas constant, $R = 8.31\ J\ K^{-1}\ mol^{-1}$

Mass _____ g

(4)

(d) Calculate the minimum volume, in dm^3, of 0.500 mol dm^{-3} hydrochloric acid needed to react completely with all the sample of magnesium.

Volume _____ dm^3

(2)

(e) Magnesium reacts slowly with cold water to form magnesium hydroxide.

State **one** use of magnesium hydroxide.

_____

(1)

(f) Magnesium hydroxide decomposes on heating to form magnesium oxide.

Deduce an equation for the reaction.

_____

(1)

(Total 10 marks)

Q3

Test-tube reactions can be used to distinguish between pairs of colourless solutions.

(a) Identify a reagent that can be used to distinguish between aqueous solutions of sodium sulfate and sodium nitrate.

Give the observation that would be made in each case.

Reagent _____

Observation with sodium sulfate _____

_____

Observation with sodium nitrate _____

_____

(3)

(b) Identify a reagent that can be used to distinguish between aqueous solutions of potassium carbonate and potassium hydroxide.

Give the observation that would be made in each case.

Reagent _____

Observation potassium carbonate _____

_____

Observation with potassium hydroxide _____

_____

(3)

(c) Describe a test-tube reaction to show that a solution of ammonium chloride contains ammonium ions.

_____

_____

_____

_____

(2)

(d) Some acidified silver nitrate is added to separate aqueous solutions of two unknown potassium halides, **P** and **Q**.

A yellow precipitate is seen with **P**.

A colourless solution is seen with **Q**.

Give the formula of an acid that can be used to acidify the silver nitrate solution.

Give the formulas of the potassium halides **P** and **Q**.

Formula of acid _____

Formula of **P** _____

Formula of **Q** _____

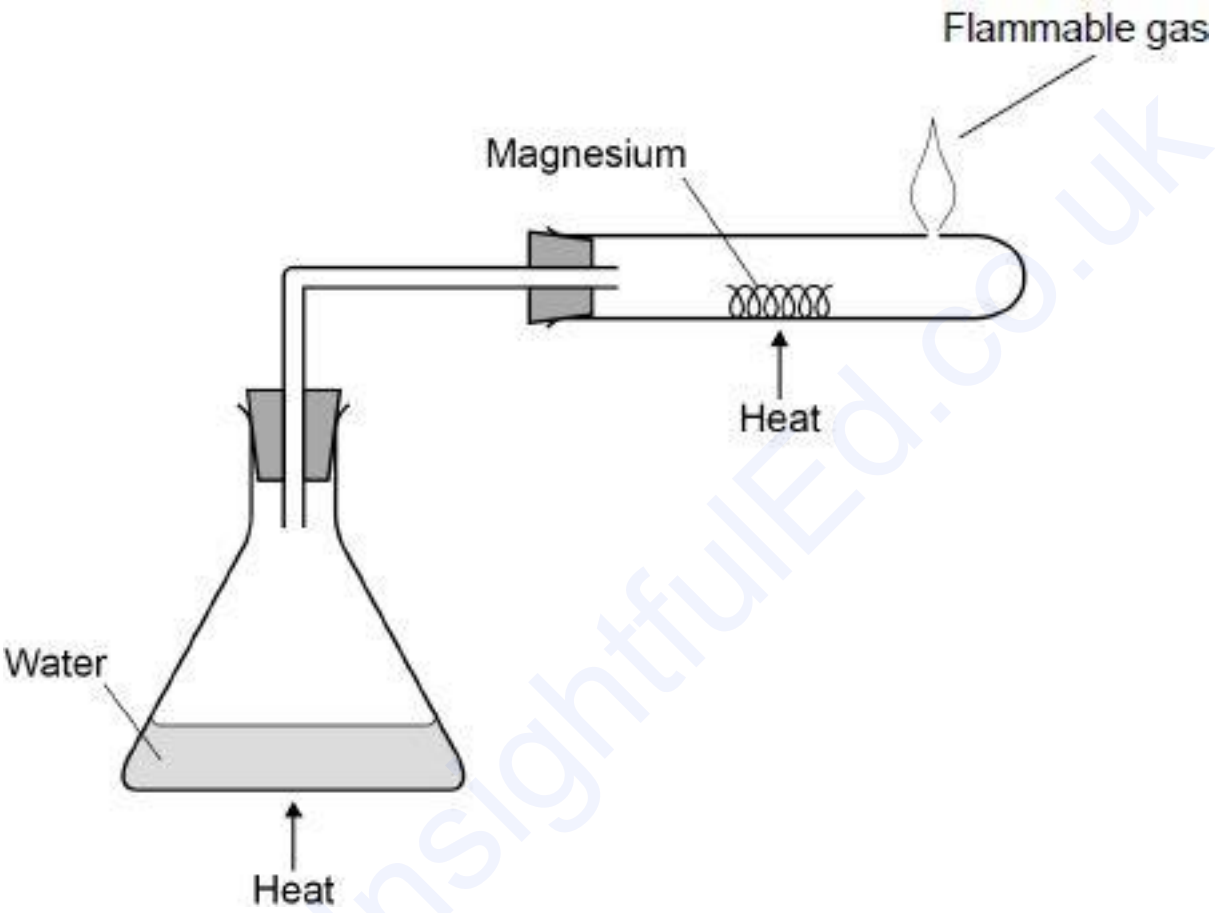
(3)

(Total 11 marks)

Q4

This question is about some compounds of Group 2 metals.

(a) The diagram below shows how magnesium can be reacted with steam.



A solid and a flammable gas are formed in this reaction.

Identify the gas and write an equation for the combustion of this flammable gas.

Gas _____

Equation

_____

(2)

(b) A student suggested that the solid product of the reaction in part (a) was either magnesium oxide or magnesium hydroxide.

Give a reason why the appearance of the solid product **cannot** be used to decide which of these two magnesium compounds was formed.

_____

_____

(1)

(c) Magnesium hydroxide is used in medicines to neutralise an excess of hydrochloric acid in the stomach.

Write an equation for this reaction.

_____

(1)

(d) A student was given a solution that contained either Mg^{2+} or Sr^{2+} ions.

Describe a test-tube reaction that the student could use to identify the metal ion in the solution.

_____

_____

_____

_____

(2)

(Total 6 marks)

Q5

A student is given three white solids, **A**, **B** and **C**. Each solid is thought to be one of these compounds:

magnesium carbonate, magnesium hydroxide, barium hydroxide, barium sulfate

The student carries out two tests on each solid to try to identify them.

Test 1 Add distilled water to a sample of the solid and stir.

Test 2 Add dilute hydrochloric acid to a sample of the solid.

The table shows the results.

Test	Solid	Result
1	**A**	Colourless solution forms
	B	No visible change, white solid remains
	C	No visible change, white solid remains
2	**A**	Colourless solution forms
	B	No visible change, white solid remains
	C	Effervescence and colourless solution forms

(a) Use the results from **Test 1** to identify solid **A**.

Write an equation for the reaction of **A** in **Test 2**.

Identity of A _____

Equation for **Test 2**

_____

(2)

(b) The student deduced that solid **B** was magnesium carbonate because it is insoluble in water.

Give a reason why this deduction is **not** correct.

Suggest the identity of **B**.

Reason _____

Identity of **B** _____

(2)

(c) Deduce the formula of each of the products responsible for the observations when **Test 2** is carried out on solid **C**.

_____

_____

(2)

(Total 6 marks)

Q6

This question is about the elements in Group 2 and their compounds.

(a) Use the Periodic Table to deduce the full electron configuration of calcium.

_____

(1)

(b) Write an ionic equation, with state symbols, to show the reaction of calcium with an excess of water.

_____

(1)

(c) State the role of water in the reaction with calcium.

_____

(1)

(d) Write an equation to show the process that occurs when the first ionisation energy of calcium is measured.

_____

(1)

(e) State and explain the trend in the first ionisation energies of the elements in Group 2 from magnesium to barium.

Trend _____

Explanation _____

_____

_____

_____

_____

_____

(3)

(Total 7 marks)

Q7

There are many uses for Group 2 metals and their compounds.

(a) State a medical use of barium sulfate.
State why this use of barium sulfate is safe, given that solutions containing barium ions are poisonous.

Use _____

Why this use is safe _____

_____

_____

(2)

(b) Magnesium hydroxide is used in antacid preparations to neutralise excess stomach acid.

Write an equation for the reaction of magnesium hydroxide with hydrochloric acid.

_____

(1)

(c) Solutions of barium hydroxide are used in the titration of weak acids.

State why magnesium hydroxide solution could not be used for this purpose.

_____

_____

(1)

(d) Magnesium metal is used to make titanium from titanium(IV) chloride.

Write an equation for this reaction of magnesium with titanium(IV) chloride.

_____

(1)

(e) Magnesium burns with a bright white light and is used in flares and fireworks.

Use your knowledge of the reactions of Group 2 metals with water to explain why water should not be used to put out a fire in which magnesium metal is burning.

_____

_____

_____

_____

(2)

(Total 7 marks)

Q8

(a) Strontium chloride is used in toothpaste for sensitive teeth.
Both strontium carbonate and strontium sulfate are white solids that are insoluble in water.

(i) Write an equation for the reaction between strontium chloride solution and sodium sulfate solution.
Include state symbols in your equation.

_____

(1)

(ii) Strontium carbonate reacts with nitric acid to produce a solution of strontium nitrate.
Strontium sulfate does not react with nitric acid.

Describe briefly how you could obtain strontium sulfate from a mixture of strontium carbonate and strontium sulfate.
You are not required to describe the purification of the strontium sulfate.

_____

_____

_____

_____

_____

(2)

(b) A solution of magnesium sulfate is sometimes given as first aid to someone who has swallowed barium chloride.

Explain why drinking magnesium sulfate solution is effective in the treatment of barium poisoning.

_____

_____

(1)

Q9

(a) Magnesium ribbon reacts with hot water. Heated magnesium ribbon reacts with steam. State two differences between these reactions.

Difference 1 _____

_____

Difference 2 _____

_____

(2)

(b) Pure magnesium reacts completely with an excess of dilute sulfuric acid.
The reaction of pure calcium with an excess of dilute sulfuric acid is very rapid initially. This reaction slows down and stops before all of the calcium has reacted.

Use your knowledge of the solubilities of Group 2 sulfates to explain why these reactions of magnesium and calcium with dilute sulfuric acid are so different.

_____

_____

_____

_____

_____

_____

_____

(3)

(C)

Barium chloride solution was added, dropwise, to magnesium sulfate solution until no more white precipitate was formed. The mixture was filtered.

Give the formulae of the two main ions in the filtrate.

_____

_____

(Total 1 mark)

Mark Scheme

(a) Mg has smaller ions

or

Mg ions have bigger charge density

or

Mg^{2+} has a higher charge than Na^{+}

or

Mg atoms are smaller than Na atoms

must be a comparison

ignore reference to nuclear charge

1

stronger attraction with delocalised / free / sea of electrons

allow metallic bonding is stronger

1

(b) $2\ Mg + TiCl_4 \rightarrow 2\ MgCl_2 + Ti$

allow multiples

1

(c) $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

1

$MgSO_4$ / it is soluble

allow $MgSO_4$ is in (aqueous) solution

1

2

(a) $1s^2 2s^2 2p^6 3s^2$

1

(b) $TiCl_4 + 2\ Mg \rightarrow Ti + 2\ MgCl_2$

allow multiples

1

(c) V = 149 × 10^{-6} m^3 **and** p = 101 000 Pa

M1 = unit conversions

1

n = pV ÷ RT

*M2 = <u>rearranged</u> ideal gas equation (**or** with values inserted)*

1

$$n\ H_2 = \left(\frac{101\,000 \times 149 \times 10^{-6}}{8.31 \times 298}\right) = 6.08 \times 10^{-3}$$

M3 = calculation of moles of H_2

1

(mol hydrogen = mol magnesium)

mass Mg = (n × M_r = 6.08 × 10^{-3} × <u>24.3</u>) = 0.148 g

need 3 sig figs for M4

M4 = M3 × 24.3

M4 use of 24 instead of 24.3 gives 0.146 = 3 marks

1

(d) n HCl = (2 × 6.08 × 10^{-3} mol) = 0.01216 (mol)

allow M3 from part (c) × 2

1

vol HCl = (0.01216 ÷ 0.50) = 0.024(3) dm^3

allow M1 ÷ 0.50

allow 2 significant figures or more

1

(e) antacid / laxative

allow to reduce stomach acid

allow neutralises excess stomach acid

allow used in indigestion tablets

ignore used in medicine

1

(f) $Mg(OH)_2(s) \rightarrow MgO(s) + H_2O(g)$

allow multiples

ignore state symbols

1

[10]

Q3

(a) barium chloride / $BaCl_2$ **or** barium nitrate / $Ba(NO_3)_2$

1

white precipitate

1

colourless solution **or** no (visible) change

ignore no observation / nothing

1

(b) any named acid **or** correct formula of acid

if 'acid' with no name or formula identified in M1 allow M2 and M3

1

fizzing

1

colourless solution **or** no (visible) change

allow gets warm

ignore no observation / nothing

1

(c) add sodium hydroxide or potassium hydroxide (and warm)

1

ammonia / gas evolved which turns (red) litmus (paper) blue

M2 dependent on M1

*M2 must test gas with litmus and **not** the solution after adding NaOH*

allow turns UI (paper) blue

1

(d) HNO_3

1

KI

1

KF

1

[11]

Q4

(a) Hydrogen / H_2

1

$2H_2 + O_2 \longrightarrow 2H_2O$

1

(b) Both white (solids)

Not same appearance

1

(c) $Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$

Allow multiples

1

(d) Add NaOH(aq)

1

White ppt indicates Mg^{2+}

Or

No ppt indicates Sr^{2+}

OR

Add soluble sulfate eg $Na_2SO_4(aq)$

Colourless soln indicates Mg^{2+}

Or

white ppt indicates Sr^{2+}

1

[6]

Q5

(a) (A) barium hydroxide / $Ba(OH)_2$

1

(equation) $Ba(OH)_2 + 2HCl \longrightarrow BaCl_2 + 2H_2O$

Accept multiples

Ignore state symbols

1

(b) (reason) magnesium carbonate reacts with HCl

Magnesium carbonate does not give 'no visible change' in Test 2

*Allow alternatives for reacts / fizzes or solid **B** does not fizz*

1

(identity) barium sulfate / $BaSO_4$

1

(c) (effervescence due to) CO_2

Apply list principle

Ignore 'water'

1

(colourless solution is) $MgCl_2$

1

[6]

Q6

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$

Allow correct numbers that are not superscripted

1

(b) $Ca(s) + 2H_2O(l) \longrightarrow Ca^{2+}(aq) + 2OH^-(aq) + H_2(g)$

State symbols essential

1

(c) Oxidising agent

1

(d) $Ca(g) \longrightarrow Ca^+(g) + e^-$

State symbols essential

Allow 'e' without the negative sign

1

(e) Decrease

If answer to 'trend' is not 'decrease', then chemical error = 0 / 3

1

Ions get bigger / more (energy) shells

Allow atoms instead of ions

1

Weaker attraction of ion to lost electron

1

[7]

Q7

(a) M1 Used in a barium meal / barium swallow / barium enema

OR (used to absorb) X-rays

Credit a correct reference to M1 written in the explanation in M2 unless contradictory.

M2 $\underline{BaSO_4}$ / barium sulfate / it is insoluble

For M2 penalise obvious reference to barium or to barium ions being insoluble.

2

(b) $Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$

Or multiples.

Ignore state symbols.

1

(c) It / magnesium hydroxide is insoluble / insufficiently soluble / sparingly soluble / less soluble than barium hydroxide / forms low concentration solutions

Weak alkali alone is insufficient.

Formation of a precipitate needs explanation.

1

(d) $TiCl_4 + 2Mg \longrightarrow 2MgCl_2 + Ti$

Or multiples.

Ignore state symbols.

1

(e) M1 Hydrogen / H_2 produced

OR an equation to produce $\underline{\text{hydrogen / } H_2}$

(eg $Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2$)

(eg $Mg + H_2O \longrightarrow MgO + H_2$)

For M1

Do not penalise an incorrect equation; the mark is for H_2 or hydrogen.

Award one mark only for '<u>exothermic reaction</u> with steam / H_2O' for a student who has not scored M1

M2 requires correct M1

risk of explosion

OR forms explosive mixture (with air)

OR (highly) flammable

Ignore 'violent' reaction.

2

[7]

Q8

(a) (i) $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$

Allow multiples, including fractions.

Allow ionic equations.

Lose this mark if any of the state symbols are missing or incorrect.

1

(ii) Add nitric acid to the mixture (until in excess)

Do not allow any suggestion that the solution is an emetic.

1

Filter (to isolate strontium sulfate)

1

(b) <u>Insoluble barium sulfate</u> is formed

Allow <u>'removes barium ions as a precipitate'</u>.

1

Q9

(a) Any two from:

Any order.

Slower with hot water or faster with steam

The hot water produces $Mg(OH)_2$ / the hydroxide OR steam produces MgO / the oxide

(Slow) bubbling with hot water OR bright white light / flame / white solid with steam

2 max

(b) Magnesium sulfate is soluble and calcium sulfate is insoluble / slightly soluble / magnesium sulfate is more soluble / calcium sulfate is less soluble / correct trend in solubility (M1)

Any order.

M1 requires a comparison of the two solubilities.

Calcium sulfate coats the surface of the calcium (M2)

Coating prevents further contact with / reaction by the acid (M3)

'Calcium sulfate forms a protective coating' scores M2 only.

3

(c)

Mg^{2+} and Cl^-

Do not allow names.

[1]