Group 2 metals and their compounds

AQA Chemistry (7404 / 7405) · AS and A level

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Calcium atoms and ions

Write the outer-shell electron configuration of calcium and an ionic half-equation for its oxidation to a calcium ion.

2. Strontium and water

Strontium is placed in cold water. Write a balanced equation. Describe a test for the gas and identify the dissolved ion that gives a reading above pH 7.

3. Extract titanium

Magnesium can extract titanium from $TiCl_4$. Write the balanced equation and identify the element oxidised and the element reduced.

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4. Calcium and strontium

Which atom requires less energy to lose both outer electrons, calcium or strontium? Explain why the difference in nuclear charge alone gives the wrong prediction.

5. Treating acidic soil

Calcium hydroxide is sometimes used on acidic soil. State its effect on soil pH and write an ionic equation for the acid-base reaction.

6. An antacid calculation

A sample contains 0.438 g of $Mg(OH)_2$. Calculate the maximum volume of 0.200 mol dm^{-3} HCl that it could neutralise. Use $M_r(Mg(OH)_2) = 58.3$. Give your answer in cm^3.

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7. Barium ions and an unknown

An unknown may contain sulfate or carbonate. Dilute hydrochloric acid is followed by barium chloride solution. A white solid forms. Identify it, give its ionic equation and explain why acid is added first.

8. Compare results with two anions

Magnesium chloride and barium chloride are tested separately with sodium hydroxide or sodium sulfate. Which chloride gives a precipitate more readily with each reagent, and why?

9. Extra challenge · Evaluate a flue-gas treatment

A batch of flue gas contains 1.60 kg SO_2. A scrubber must remove 92.0% using limestone that is 80.0% $CaCO_3$ by mass. Each mole of reacting $CaCO_3$ removes one mole of SO_2. M_r values are 64.0 and 100.0 respectively.

Write the equation using calcium sulfite as the solid product. Calculate the minimum mass of limestone.

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Worked answers

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1. Calcium atoms and ions

Calcium has the outer-shell configuration $4s^2$.

$Ca \rightarrow Ca^{2+} + 2e^-$. It loses both 4s electrons.

2. Strontium and water

$Sr + 2H_2O \rightarrow Sr(OH)_2 + H_2$. A lit splint gives a squeaky pop with hydrogen. Hydroxide ions, OH^-, make the liquid alkaline.

3. Extract titanium

$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$. Magnesium is oxidised from 0 to +2. Titanium is reduced from +4 to 0.

4. Calcium and strontium

Strontium's outer electrons occupy a higher shell and are farther from the nucleus. More filled inner shells increase shielding.

The attraction to the outer electrons is weaker despite the higher nuclear charge. The first and second ionisation energies are lower.

5. Treating acidic soil

It raises the pH by neutralising acid in the soil.

$H^+ + OH^- \rightarrow H_2O$. Calcium ions are spectators in this ionic equation.

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Worked answers

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6. An antacid calculation

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$.

n(HCl) = 2 × 0.438 ÷ 58.3 = 0.0150257… mol. V = n ÷ c = 0.0751286… dm^3 = 75.1 cm^3.

7. Barium ions and an unknown

The solid is barium sulfate. $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$. The acid removes carbonate as carbon dioxide and water. Otherwise carbonate can also give a white precipitate with barium.

8. Compare results with two anions

Magnesium hydroxide is less soluble than barium hydroxide, so magnesium chloride gives the hydroxide precipitate more readily. Barium sulfate is much less soluble than magnesium sulfate, so barium chloride gives the sulfate precipitate more readily.

9. Extra challenge · Evaluate a flue-gas treatment

$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$.

SO_2 removed = 0.920 × 1600 = 1472 g = 23.0 mol. This needs 23.0 mol $CaCO_3$, or 2300 g of pure $CaCO_3$.

Limestone mass = 2300 ÷ 0.800 = 2875 g = 2.88 kg.

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