AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.4.2.4

The pH scale and neutralisation

Past-paper questions

Tier	**Higher**
Question groups	**10**
Available paper years	**2018–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

5.4.2.4 The pH scale and neutralisation

Question 01

June 2018 | 8464/C/1H | Original Q7

0 7 A scientist does two tests on four white solids. The solids are labelled **A**, **B**, **C** and **D**.

Test 1 Adds the sample of the solid to distilled water and stirs.

Test 2 Measures the pH of the solution after **Test 1**

Table 2 shows the results.

Table 2

Solid	Appearance after stirring	pH
A	colourless solution, no solid	14
B	colourless solution, no solid	3
C	colourless solution, solid remains	9
D	colourless liquid, solid remains	7

These four solids are:

- magnesium oxide
- phosphorus oxide
- silicon dioxide
- sodium oxide.

Table 3 shows the solubility of these four solids in water.

Table 3

Solid	Solubility in grams per 100 cm^3 of water
Magnesium oxide	0.01
Phosphorus oxide	52
Silicon dioxide	0
Sodium oxide	109

5.4.2.4 The pH scale and neutralisation

Question 01 · continued

0 7 . 1 Identify the solids **A**, **B**, **C** and **D**.

Explain your answers.

[6 marks]

Question 7 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 01 · continued

0 7 . 2 10 cm^3 of solution **B** is added to a beaker.

Distilled water is added to the beaker until the final volume in the beaker is 1000 cm^3

The pH of the solution is measured before and after distilled water is added.

Table 4 shows the results.

Table 4

Volume of solution in beaker	pH of solution B
10 cm^3	3
1000 cm^3	**X**

Calculate the value of **X**.

[2 marks]

X = _____

8

5.4.2.4 The pH scale and neutralisation

Question 02

June 2019 | 8464/C/1H | Original Q2

0 2 This question is about salts.

Ammonium nitrate solution is produced when ammonia gas reacts with nitric acid.

0 2 . 1 Give the state symbol for ammonium nitrate solution.

[1 mark]

_____

0 2 . 2 What is the formula of nitric acid?

[1 mark]

Tick (✓) **one** box.

HCl ☐

HNO_3 ☐

H_2SO_4 ☐

NH_4OH ☐

0 2 . 3 Ammonia gas dissolves in water to produce ammonia solution.

Ammonia solution contains hydroxide ions, OH^-

A student adds universal indicator to solutions of nitric acid and ammonia.

What colour is observed in each solution?

[2 marks]

Colour in nitric acid _____

Colour in ammonia solution _____

5.4.2.4 The pH scale and neutralisation

Question 02 · continued

0 2 . 4 The student gradually added nitric acid to ammonia solution.

Which row, **A**, **B**, **C** or **D**, shows the change in pH as the nitric acid is added until in excess?

[1 mark]

Tick (✓) **one** box.

	pH of ammonia solution at start	pH after addition of excess nitric acid	
A	10	7	☐
B	2	10	☐
C	7	1	☐
D	10	2	☐

0 2 . 5 Calculate the percentage by mass of oxygen in ammonium nitrate (NH_4NO_3).

Relative atomic masses (A_r): H = 1 N = 14 O = 16

Relative formula mass (M_r): NH_4NO_3 = 80

[3 marks]

Percentage by mass of oxygen = _____ %

Question 2 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 02 · continued

0 2 . 6 Describe a method to investigate how the temperature changes when different masses of ammonium nitrate are dissolved in water.

You do **not** need to write about safety precautions.

[6 marks]

14

5.4.2.4 The pH scale and neutralisation

Question 03

November 2020 | 8464/C/1H | Original Q4

0 4 This question is about acids, alkalis and bases.

A student reacted zinc oxide powder with hydrochloric acid to produce zinc chloride solution.

0 4 . 1 Complete the equation for the reaction by writing the state symbols.

[2 marks]

$$ZnO(\quad) + 2\,HCl(\quad) \rightarrow ZnCl_2(\quad) + H_2O(\quad)$$

0 4 . 2 Give **one** way that the student could speed up the reaction between zinc oxide powder and hydrochloric acid.

[1 mark]

Hydrochloric acid was the limiting reactant.

0 4 . 3 How could the student know when all the hydrochloric acid has reacted?

[1 mark]

0 4 . 4 How could the student obtain zinc chloride solution from the reaction mixture when all the hydrochloric acid has reacted?

[1 mark]

5.4.2.4 The pH scale and neutralisation

Question 03 · continued

0 4 . 5 Describe how zinc chloride crystals are produced from zinc chloride solution.

[2 marks]

Sulfuric acid and sodium hydroxide react to produce sodium sulfate.

0 4 . 6 Sulfuric acid is gradually added to sodium hydroxide solution.

The pH of the mixture changes as the sulfuric acid is added until in excess.

Suggest the pH at:

- the start before sulfuric acid is added
- the end when sulfuric acid is in excess.

[2 marks]

pH at start = _____

pH at end = _____

0 4 . 7 Complete the symbol equation for the preparation of sodium sulfate.

You should balance the equation.

[2 marks]

_____ $NaOH$ + H_2SO_4 → _____ + _____

Question 4 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 03 · continued

0 4 . 8 A solution of hydrochloric acid had a hydrogen ion concentration of 1.0 mol/dm^3

Water was added to the hydrochloric acid until the pH increased by 1

What was the hydrogen ion concentration of the hydrochloric acid after water had been added?

[1 mark]

Tick (✓) **one** box.

100 mol/dm^3 ☐

10 mol/dm^3 ☐

0.10 mol/dm^3 ☐

0.010 mol/dm^3 ☐

12

5.4.2.4 The pH scale and neutralisation

Question 04

November 2021 | 8464/C/1H | Original Q2

0 2 Acids react to produce salts.

Universal indicator is added to water and then nitric acid is added to the mixture.

0 2 . 1 Give the colour change when nitric acid is added to the mixture of universal indicator and water.

[1 mark]

Tick (✓) **one** box.

- Blue to red ☐
- Green to purple ☐
- Green to red ☐
- Red to purple ☐

0 2 . 2 What happens to the pH of water when nitric acid is added?

[1 mark]

Tick (✓) **one** box.

- Decreases ☐
- Stays the same ☐
- Increases ☐

0 2 . 3 What is the state symbol for nitric acid?

[1 mark]

_____

5.4.2.4 The pH scale and neutralisation

Question 04 · continued November 2021 | 8464/C/1H | Original Q2

Zinc carbonate reacts with nitric acid.

The word equation for the reaction is:

zinc carbonate + nitric acid → zinc nitrate + water + carbon dioxide

white solid — colourless solution

0 2 . 4 Give **two** observations that would be made when zinc carbonate is added to nitric acid until the zinc carbonate is in excess.

[2 marks]

1 _____

_____

2 _____

_____

0 2 . 5 The formula of the zinc ion is Zn^{2+}

The formula of the nitrate ion is NO_3^-

What is the formula for zinc nitrate?

[1 mark]

Tick (✓) **one** box.

$ZnNO_3$ ☐

$Zn(NO_3)_2$ ☐

Zn_2NO_3 ☐

$Zn_2(NO_3)_2$ ☐

Question 2 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 04 · continued

0 2 . 6 Acids react with insoluble metal oxides to produce salts.

Plan a method to produce a pure, dry sample of the soluble salt copper chloride from an acid and a metal oxide.

[6 marks]

12

5.4.2.4 The pH scale and neutralisation

Question 05

June 2022 | 8464/C/1H | Original Q1

0 1 This question is about salts.

Green copper carbonate and sulfuric acid can be used to produce blue copper sulfate crystals.

0 1 . 1 **Excess** copper carbonate is added to sulfuric acid.

Give **three** observations you would make.

[3 marks]

1 _____

_____

2 _____

_____

3 _____

_____

0 1 . 2 How can the excess copper carbonate be removed?

[1 mark]

_____

_____

0 1 . 3 The pH of the solution changes during the reaction.

What is the pH of the solution at the end of the reaction?

[1 mark]

pH = _____

0 1 . 4 Copper carbonate and sulfuric acid react to produce copper sulfate.

What type of reaction is this?

[1 mark]

_____

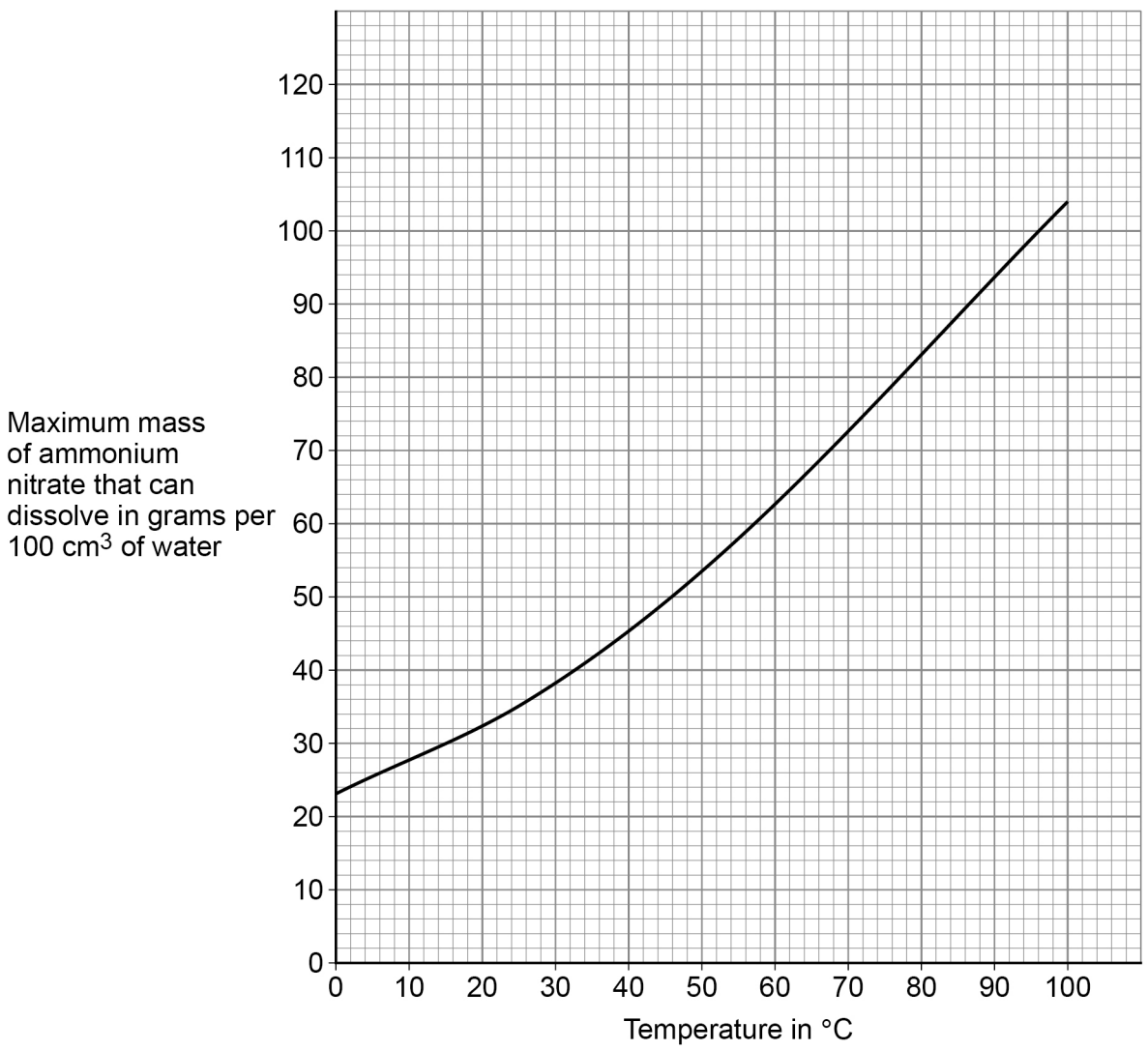
5.4.2.4 The pH scale and neutralisation

Question 05 · continued

0 1 . 5 Ammonium nitrate is a salt.

Figure 1 shows the maximum mass of ammonium nitrate that can dissolve in 100 cm^3 of water at different temperatures.

Figure 1



5.4.2.4 The pH scale and neutralisation

Question 05 · continued

A student adds ammonium nitrate to water at 80 °C until no more dissolves.

The student cools 100 cm^3 of this solution of ammonium nitrate from 80 °C to 20 °C to produce crystals of ammonium nitrate.

Determine the mass of ammonium nitrate that crystallises on cooling 100 cm^3 of this solution from 80 °C to 20 °C

[3 marks]

Mass = _____ g

9

5.4.2.4 The pH scale and neutralisation

Question 06

0 6 This question is about hydrogen chloride and hydrochloric acid.

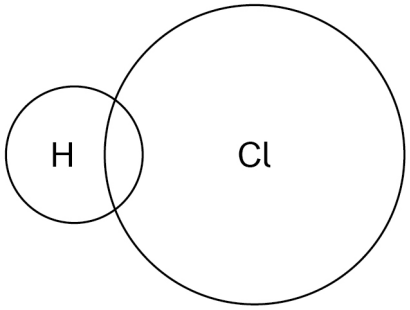
0 6 . 1 Complete the dot and cross diagram to represent the bonding in hydrogen chloride on **Figure 7**.

Use dots (o) and crosses (x) to represent electrons.

You should show only the electrons in the outer shells.

[2 marks]

Figure 7



0 6 . 2 Hydrogen chloride dissolves in water to produce hydrochloric acid.

Hydrochloric acid is a strong acid.

What is meant by the term strong acid?

[1 mark]

0 6 . 3 Describe how magnesium can be used to distinguish between a strong acid and a weak acid of the same concentration.

[2 marks]

5.4.2.4 The pH scale and neutralisation

Question 06 · continued

0 6 . 4 The concentration of hydrochloric acid is increased by a factor of 100

What is the change in pH?

[2 marks]

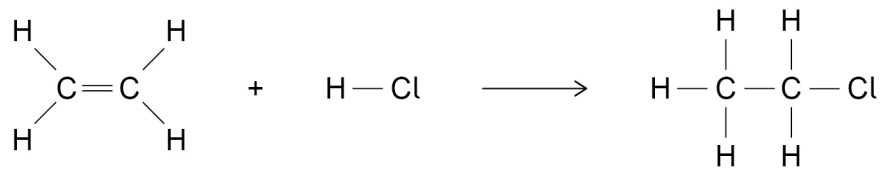
Question 6 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 06 · continued

0 6 . 5 Ethene and hydrogen chloride react to produce chloroethane.

The displayed formulae equation for the reaction is:



The reaction is exothermic.

In the reaction the energy released forming new bonds is 56 kJ/mol greater than the energy needed to break existing bonds.

Table 1 shows some bond energies.

Table 1

Bond	H–C	C=C	H–Cl	C–C	C–Cl
Bond energy in kJ/mol	413	**X**	431	346	339

Calculate the bond energy **X**.

[4 marks]

X = _____ kJ/mol

11

5.4.2.4 The pH scale and neutralisation

Question 07

0 1 This question is about carbon dioxide.

Carbon dioxide is soluble in water and forms an acidic solution.

0 1 . 1 Which ion makes the solution acidic?

[1 mark]

_____

0 1 . 2 Name an indicator that could be used to test if the solution is acidic.

Give the result of the test.

[2 marks]

Indicator _____

Result _____

_____

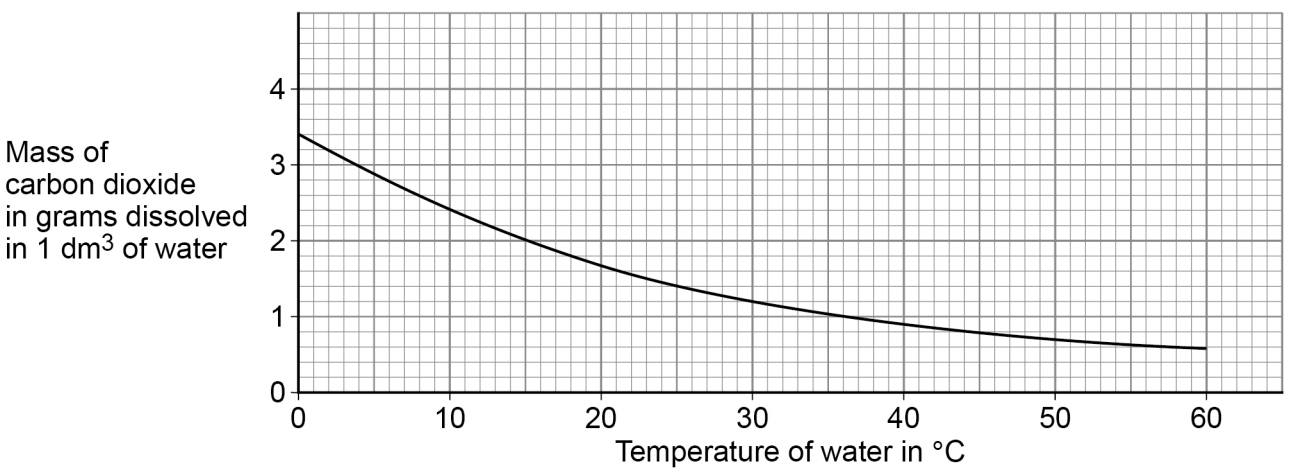
Question 1 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 07 · continued

Figure 1 shows the mass of carbon dioxide that will dissolve in 1 dm^3 of water at different temperatures.

Figure 1



0 1 . 3 How does the solubility of carbon dioxide change as the temperature of the water increases?

[1 mark]

Tick (✓) **one** box.

- The solubility decreases ☐
- The solubility does not change ☐
- The solubility increases ☐

5.4.2.4 The pH scale and neutralisation

Question 07 · continued

0 1 . 4 Carbon dioxide dissolves in water to form an acidic solution.

How does the pH of the solution change as the temperature of the water increases?

Use **Figure 1**.

[1 mark]

Tick (✓) **one** box.

pH of the solution decreases ☐

pH of the solution does not change ☐

pH of the solution increases ☐

Calcium carbonate reacts with hydrochloric acid to produce carbon dioxide.

The equation for the reaction is:

$$CaCO_3(s) + 2\,HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(\mathbf{x})$$

0 1 . 5 What is the state symbol (**x**) in the equation?

[1 mark]

Tick (✓) **one** box.

(aq) ☐ (g) ☐ (l) ☐ (s) ☐

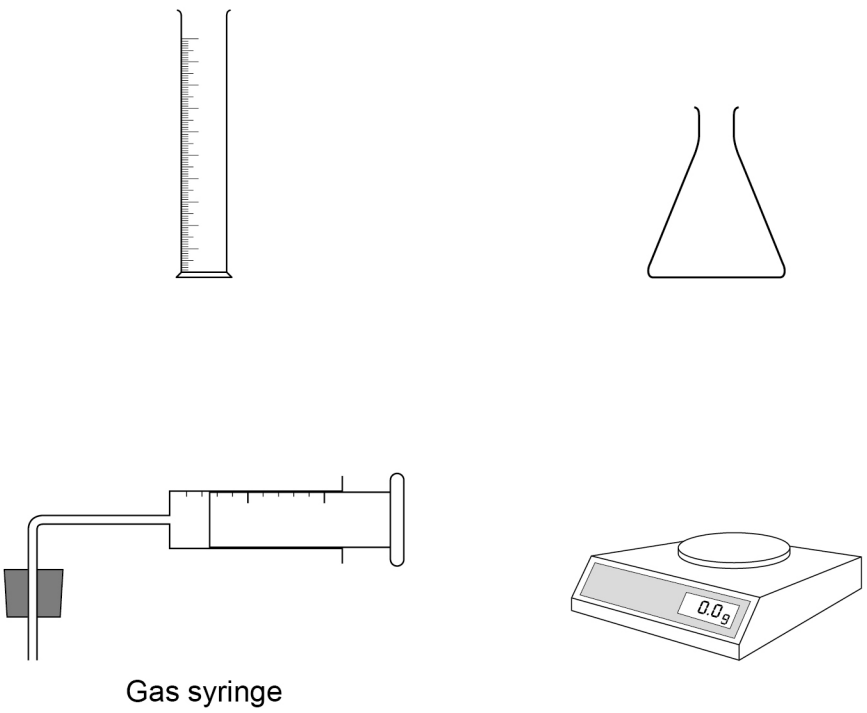
Question 1 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 07 · continued

0 1 . 6 **Figure 2** shows equipment a student used for an investigation.

Figure 2



Gas syringe

5.4.2.4 The pH scale and neutralisation

Question 07 · continued

The student investigated the volume of carbon dioxide produced when different masses of calcium carbonate react with hydrochloric acid.

Describe a method the student could use.

[6 marks]

12

5.4.2.4 The pH scale and neutralisation

Question 08

June 2023 | 8464/C/1H | Original Q5

0 5 During electrolysis ions are discharged at the electrodes to produce elements.

A student investigates the electrolysis of sodium chloride.

0 5 . 1 Why does solid sodium chloride **not** conduct electricity?

[1 mark]

0 5 . 2 Sodium chloride solution conducts electricity.

Complete the sentence.

[1 mark]

Sodium chloride **also** conducts electricity when _____ .

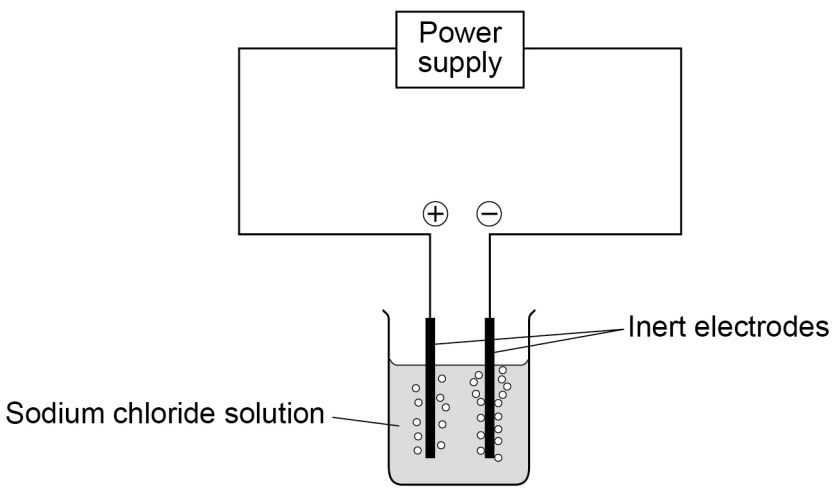
Question 5 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 08 · continued

Figure 5 shows the apparatus for the electrolysis of sodium chloride solution.

Figure 5



0 5 . 3 Suggest an element that could be used to make the inert electrodes.

[1 mark]

0 5 . 4 Complete the half equation for the production of chlorine (Cl_2) at the positive electrode.

[2 marks]

____ Cl^- → _____ + _____

5.4.2.4 The pH scale and neutralisation

Question 08 · continued

0 5 . 5 Sodium chloride solution has a pH of 7

During the electrolysis of sodium chloride solution:

- hydrogen gas is produced at the negative electrode
- the pH of the solution increases.

Explain why.

[4 marks]

9

5.4.2.4 The pH scale and neutralisation

Question 09

0 4 Nitric acid (HNO_3) is a strong acid.

0 4 . 1 What is meant by a 'strong acid'?

[1 mark]

0 4 . 2 Nitric acid is used as a dilute aqueous solution.

What is meant by 'dilute aqueous solution'?

[1 mark]

Question 4 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 09 · continued June 2024 | 8464/C/1H | Original Q4

0 4 . 3 10 cm^3 of a nitric acid solution has a pH of 1

Water is added to the nitric acid solution to change the pH of the nitric acid solution to pH 3

How does the hydrogen ion concentration change?

[1 mark]

Tick (✓) **one** box.

- Decreases by a factor of 100 ☐
- Decreases by a factor of 10 ☐
- Increases by a factor of 10 ☐
- Increases by a factor of 100 ☐

0 4 . 4 Write the **ionic** equation for the reaction between an acid and an alkali.

[1 mark]

_____ + _____ → _____

5.4.2.4 The pH scale and neutralisation

Question 09 · continued June 2024 | 8464/C/1H | Original Q4

The equation shows the reaction between magnesium carbonate and nitric acid.

$$MgCO_3 + 2\,HNO_3 \rightarrow Mg(NO_3)_2 + H_2O + CO_2$$

0 4 . 5 What is the ratio of the number of moles of magnesium carbonate to the number of moles of nitric acid in the reaction?

[1 mark]

Tick (✓) **one** box.

- 1 : 1 ☐
- 1 : 2 ☐
- 2 : 1 ☐
- 2 : 2 ☐

0 4 . 6 A student mixed some magnesium carbonate with excess nitric acid.

The student then added two drops of universal indicator to the solution.

What colour was the solution after the addition of universal indicator?

[1 mark]

Tick (✓) **one** box.

- Red ☐
- Green ☐
- Blue ☐

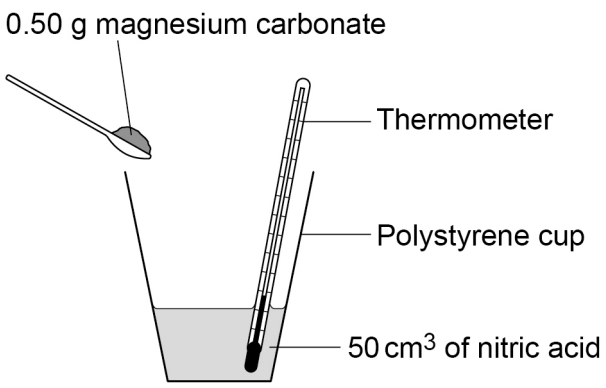
5.4.2.4 The pH scale and neutralisation

Question 09 · continued

A student investigated the temperature change when different masses of magnesium carbonate were reacted with excess nitric acid.

Figure 6 shows the apparatus.

Figure 6



This is the method used.

1. Pour 50 cm^3 of nitric acid into a polystyrene cup.
2. Measure the temperature of the solution.
3. Add 0.50 g of magnesium carbonate.
4. Stir the mixture.
5. Measure the temperature.
6. Repeat steps 1 to 5 with different masses of magnesium carbonate.

0 4 . 7 Give **two** improvements to the **method** to produce more accurate results.

Do **not** refer to improvements to the apparatus in your answer.

[2 marks]

1 _____

_____

2 _____

_____

8

5.4.2.4 The pH scale and neutralisation

Question 10

June 2025 | 8464/C/1H | Original Q5

0 5 This question is about hydrogen chloride (HCl) and hydrogen chlorate (HOCl).

Hydrogen chloride and hydrogen chlorate both form acids when dissolved in water.

0 5 . 1 Hydrogen chloride gas dissolves in water to form hydrochloric acid.

Give the state symbols for:

- hydrogen chloride
- water
- hydrochloric acid.

[1 mark]

Hydrogen chloride _____

Water _____

Hydrochloric acid _____

0 5 . 2 A solution of hydrochloric acid has:

- a pH of 2.5
- a concentration of H^+ ions of 3.16×10^{-3} mol/dm^3.

What is the concentration of H^+ ions in a solution of hydrochloric acid that has a pH of 3.5?

[1 mark]

Concentration = _____ mol/dm^3

5.4.2.4 The pH scale and neutralisation

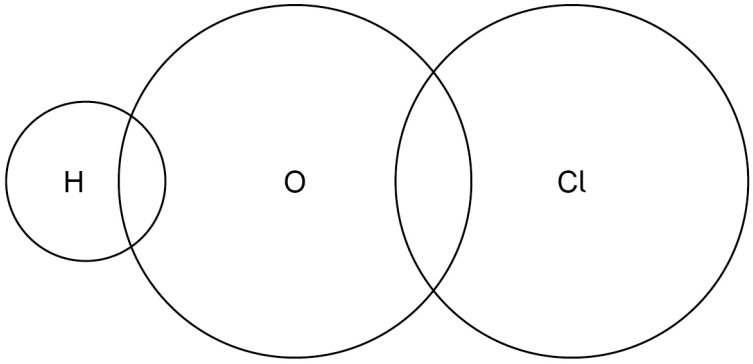
Question 10 · continued

0 5 . 3 **Figure 5** shows the outer shells in one molecule of hydrogen chlorate (HOCl).

Complete the dot and cross diagram to show the electrons in the outer shells.

[2 marks]

Figure 5



0 5 . 4 Hydrogen chlorate dissolves in water to form a weak acid.

Explain why a weak acid has a higher pH than a strong acid of the same concentration.

[2 marks]

Question 5 continues on the next page

5.4.2.4 The pH scale and neutralisation

Question 10 · continued

0 5 . 5 Hydrogen chloride is produced in the reaction between methane and chlorine.

Figure 6 represents the equation for the reaction.

Figure 6

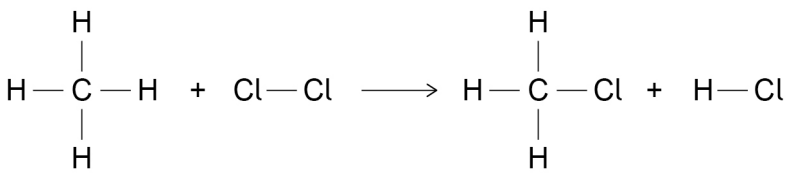


Table 4 shows the bond energies.

Table 4

Bond	C — H	Cl — Cl	C — Cl	H — Cl
Bond energy in kJ/mol	413	243	346	432

Calculate the overall energy change for the reaction.

[3 marks]

Overall energy change = _____ kJ/mol

9