AQA GCSE Combined Science - Trilogy | 8464

SPECIFICATION POINT 5.5.1.3

The energy change of reactions (HT only)

Past-paper questions

Tier	**Higher**
Question groups	**5**
Available paper years	**2019–2025**

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.

5.5.1.3 The energy change of reactions (HT only)

Question 01

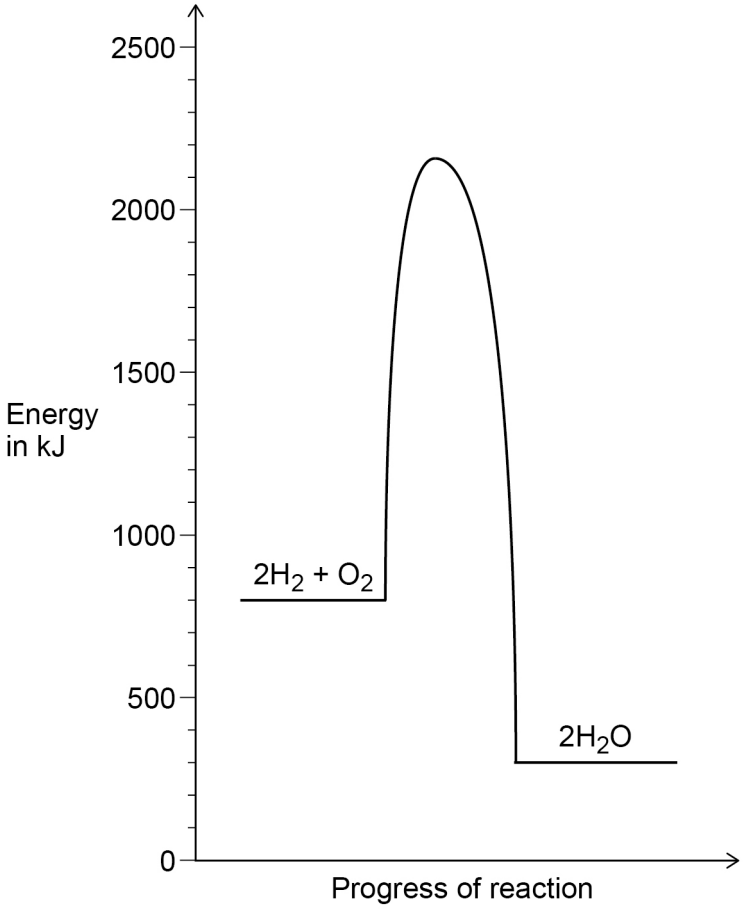
0 3 This question is about oxygen.

0 3 . 1 Hydrogen reacts with oxygen.

$$2\,H_2\,(g) + O_2\,(g) \rightarrow 2\,H_2O\,(g)$$

Figure 2 shows the relative energies of the reactants and products at a certain temperature.

Figure 2



Label the activation energy on **Figure 2**.

[1 mark]

5.5.1.3 The energy change of reactions (HT only)

Question 01 · continued

0 3 . 2 Determine the overall energy change for the reaction between hydrogen and oxygen shown in Question **03.1**

Use **Figure 2**.

[2 marks]

Energy change = _____ kJ

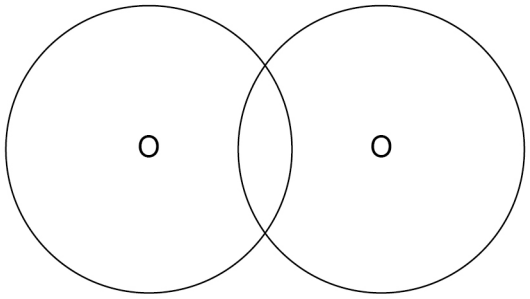
0 3 . 3 Oxygen is in Group 6 of the periodic table.

Figure 3 shows the outer energy levels in one molecule of oxygen (O_2).

Draw the electrons in the outer energy levels in **Figure 3**.

[2 marks]

Figure 3



Question 3 continues on the next page

5.5.1.3 The energy change of reactions (HT only)

Question 01 · continued

0 3 . 4 The equation shows the decomposition of hydrogen peroxide.

$$2\ H{-}O{-}O{-}H \rightarrow 2\ H{-}O{-}H + O{=}O$$

Table 1 shows the bond energies.

Table 1

Bond	**O–O**	**O=O**	**O–H**
Bond dissociation energy in kJ per mole	138	496	463

Calculate the overall energy change for the reaction.

[3 marks]

Energy change = _____ kJ

8

5.5.1.3 The energy change of reactions (HT only)

Question 02

November 2021 | 8464/C/1H | Original Q7

0 7 Methane, ethane, propane and butane all react with oxygen to produce carbon dioxide and water.

0 7 . 1 Suggest why a mixture of methane and oxygen does **not** react at room temperature.

Answer in terms of particles.

[2 marks]

0 7 . 2 **Table 3** shows the energy released when methane, ethane and propane react with oxygen to produce carbon dioxide and water.

Table 3

	Compound reacted with oxygen		
	Methane	Ethane	Propane
Formula of compound	CH_4	C_2H_6	C_3H_8
Energy released in kJ/mol	680	1160	1640

Predict the energy released when butane (C_4H_{10}) reacts with oxygen to produce carbon dioxide and water.

[1 mark]

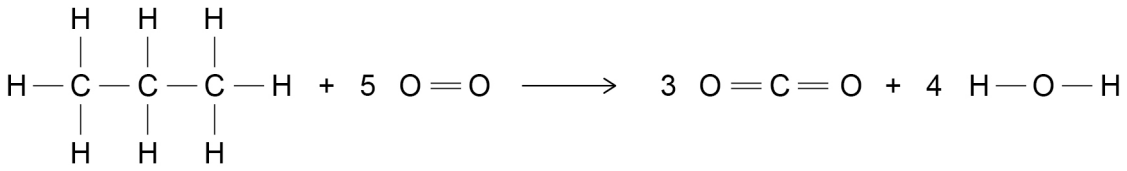
Energy released = _____ kJ/mol

5.5.1.3 The energy change of reactions (HT only)

Question 02 · continued

0 7 . 3 Propane reacts with oxygen to produce carbon dioxide and water.

The displayed formula equation for the reaction is:



The reaction is exothermic.

In the reaction, the energy released when forming new bonds is 1640 kJ/mol greater than the energy needed when breaking bonds.

Table 4 shows bond energies.

Table 4

Bond	**H–C**	**C–C**	**O=O**	**C=O**	**O–H**
Bond energy in kJ/mol	410	**X**	500	740	460

Calculate the C—C bond energy (**X**).

[5 marks]

X = _____ kJ/mol

8

5.5.1.3 The energy change of reactions (HT only)

Question 03

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

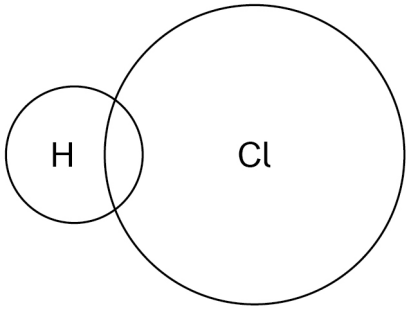
0 6 . 1 Complete the dot and cross diagram to represent the bonding in hydrogen chloride on **Figure 7**.

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]

5.5.1.3 The energy change of reactions (HT only)

Question 03 · continued

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

What is the change in pH?

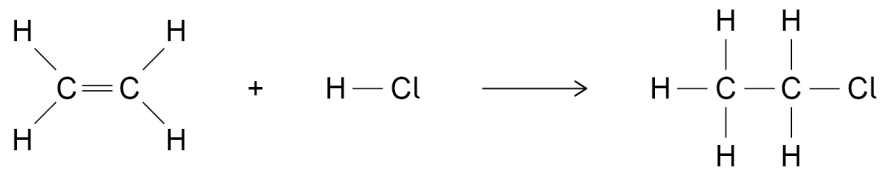
[2 marks]

Question 6 continues on the next page

Question 03 · 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

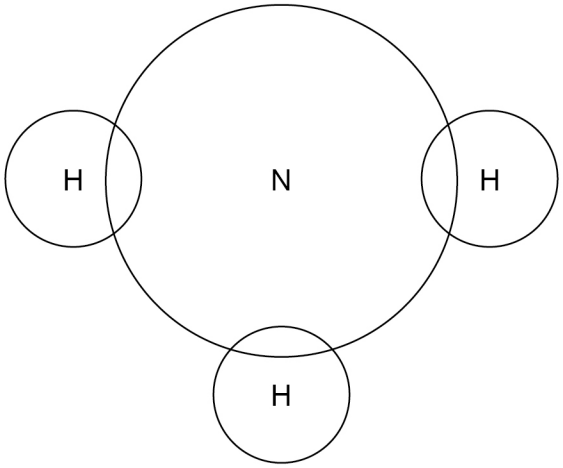
5.5.1.3 The energy change of reactions (HT only)

Question 04

0 5 Nitrogen reacts with hydrogen to produce ammonia (NH_3).

0 5 . 1 Complete the dot and cross diagram for an ammonia molecule.

[2 marks]



5.5.1.3 The energy change of reactions (HT only)

Question 04 · continued

0 5 . 2 The equation for the reaction between nitrogen and hydrogen to produce ammonia is:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Calculate the mass of hydrogen that is needed to produce 25 g of ammonia.

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

[4 marks]

Mass of hydrogen = _____ g

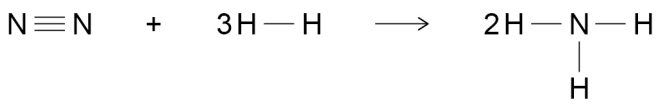
Question 5 continues on the next page

5.5.1.3 The energy change of reactions (HT only)

Question 04 · continued

Figure 7 shows the displayed formulae equation for the reaction of nitrogen with hydrogen.

Figure 7



In the reaction the energy released forming new bonds is 93 kJ/mol greater than the energy needed to break existing bonds.

Table 3 shows bond energies.

Table 3

Bond	N≡N	H—H	N—H
Bond energy in kJ/mol	945	**X**	391

0 5 . 3 Calculate the bond energy **X** for the H—H bond.

Use **Figure 7** and **Table 3**.

[5 marks]

X = _____ kJ/mol

5.5.1.3 The energy change of reactions (HT only)

Question 04 · continued

0 5 . 4 Energy is released from the reaction to produce ammonia.

Figure 8 shows part of the reaction profile for the reaction between nitrogen and hydrogen to produce ammonia.

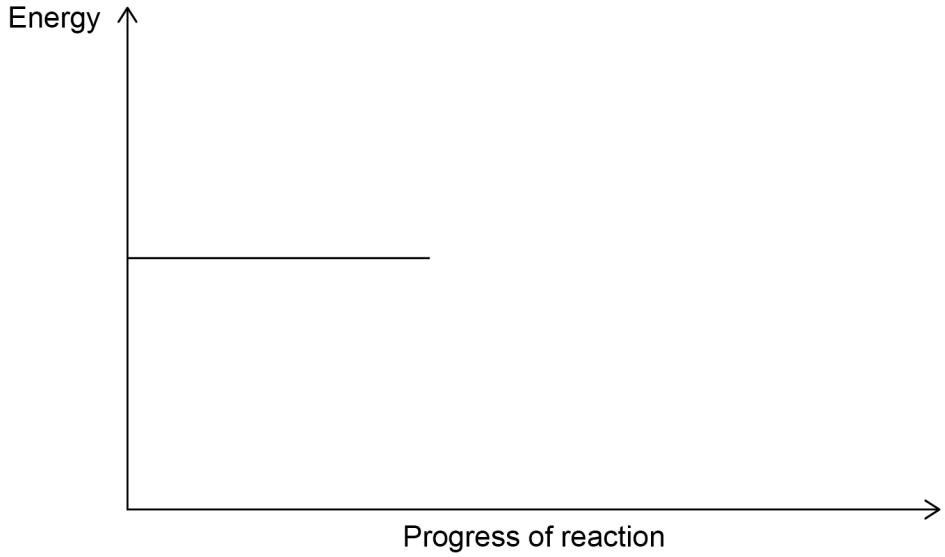
Complete **Figure 8**.

You should:

- complete the profile line
- label the energy level of the reactants and the product
- label the **overall** energy change.

[3 marks]

Figure 8



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5.5.1.3 The energy change of reactions (HT only)

Question 05

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

5.5.1.3 The energy change of reactions (HT only)

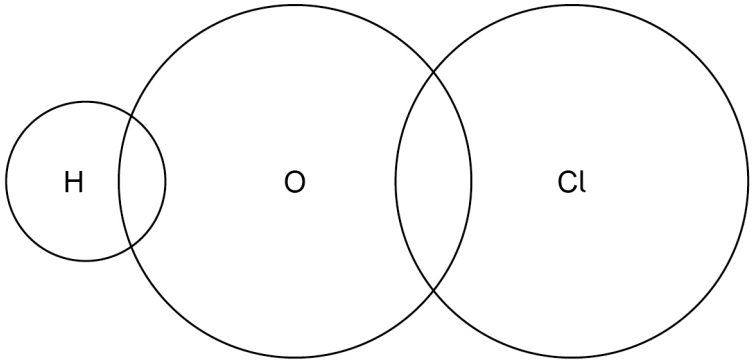
Question 05 · continued

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

5.5.1.3 The energy change of reactions (HT only)

Question 05 · 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

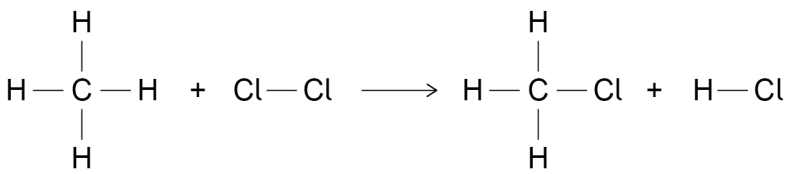


Table 4 shows the bond energies.

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

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