AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.5.1.3

The energy change of reactions (HT only)

Past-paper questions

Tier	**Higher**
Question groups	**15**
Available paper years	**2008–2025**

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.

4.5.1.3 The energy change of reactions (HT only)

Question 01

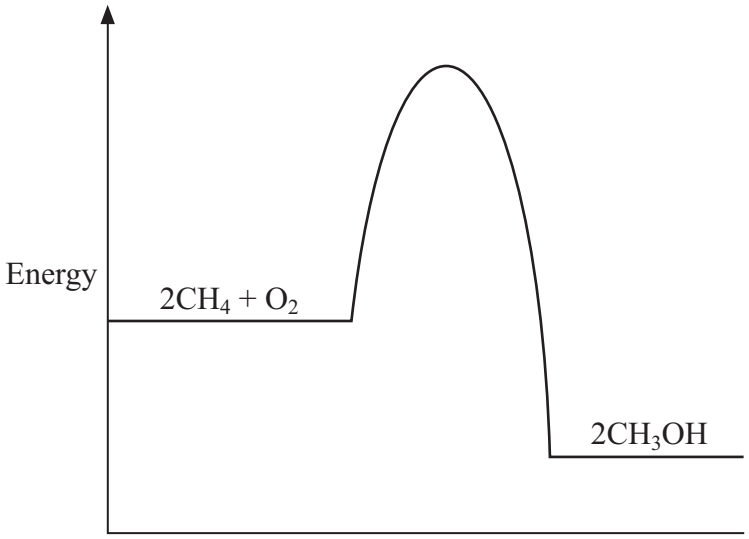
June 2008 | CHY3H | Original Q7 | Legacy

7 Methanol (CH_3OH) can be made by reacting methane (CH_4) and oxygen (O_2) in the presence of a platinum catalyst. The reaction is exothermic.

An equation that represents the reaction is:

$$2CH_4 + O_2 \rightarrow 2CH_3OH$$

7 (a) The energy level diagram for this reaction is given below.



7 (a) (i) Use the diagram to explain how you know that this reaction is exothermic.

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(1 mark)

7 (a) (ii) Explain, in terms of the energy level diagram, how the platinum catalyst increases the rate of this reaction.

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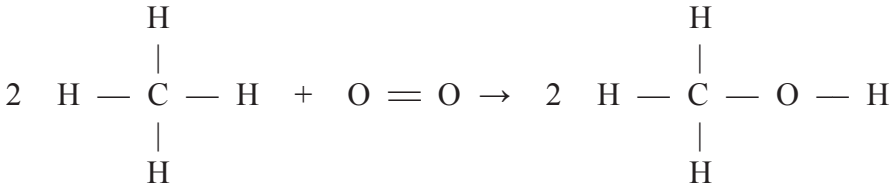
(1 mark)

4.5.1.3 The energy change of reactions (HT only)

Question 01 · continued

for mark

7 (b) The equation can also be written showing the structural formulae of the reactants and the product.



7 (b) (i) Use the bond energies given in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ
C — H	435
O = O	498
C — O	805
O — H	464

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Energy change = ... kJ

(3 marks)

7 (b) (ii) In terms of the bond energies, explain why this reaction is exothermic.

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(1 mark)

6

4.5.1.3 The energy change of reactions (HT only)

Question 02

January 2010 | CHY3H | Original Q6 | Legacy

6 During a thunderstorm lightning strikes the Eiffel Tower.

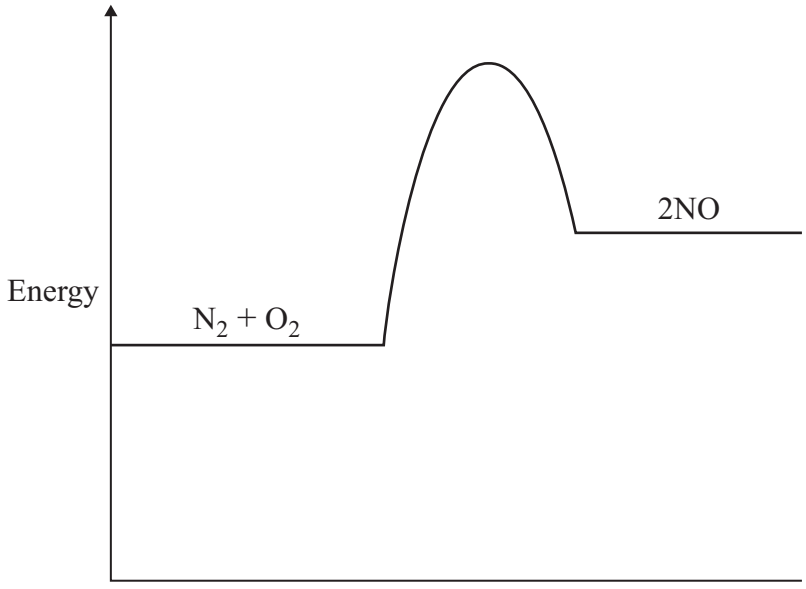


In lightning the temperature can reach 30 000 °C. This causes nitrogen and oxygen in the air to react, producing nitrogen oxide. This reaction has a high *activation energy* and is *endothermic*.

An equation that represents this endothermic reaction is:

$$N_2 + O_2 \rightarrow 2NO$$

The energy level diagram for this reaction is given below.



6 (a) The energy level diagram shows that this reaction is *endothermic*.

Explain how.

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(1 mark)

4.5.1.3 The energy change of reactions (HT only)

Question 02 · continued

for mark

6 (b) What is meant by the term *activation energy*?

.....

.....

(1 mark)

6 (c) The equation showing the structural formulae of the reactants and products is

$$N \equiv N \quad + \quad O = O \quad \rightarrow \quad 2\ N = O$$

Bond	Bond energy in kJ
N ≡ N	945
O = O	498
N = O	630

6 (c) (i) Use the bond energies in the table to calculate the energy change for this reaction.

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Energy change = ... kJ

(3 marks)

6 (c) (ii) In terms of bond energies, explain why this reaction is endothermic.

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(1 mark)

6

4.5.1.3 The energy change of reactions (HT only)

Question 03

January 2011 | CHY3H | Original Q7 | Legacy

7 Hydrogen peroxide is often used to bleach or lighten hair.

Hydrogen peroxide slowly decomposes to produce water and oxygen.

7 (a) The equation for the reaction can be represented using structural formulae.

$$2\ H-O-O-H \longrightarrow 2\ H-O-H + O=O$$

Use the bond energies in the table to help you to calculate the energy change for this reaction.

Bond	Bond energy in kJ per mole
H – O	464
O – O	146
O = O	498

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Energy change = ... kJ

(3 marks)

7 (b) Explain, in terms of bond making and bond breaking, why the reaction is exothermic.

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(1 mark)

4

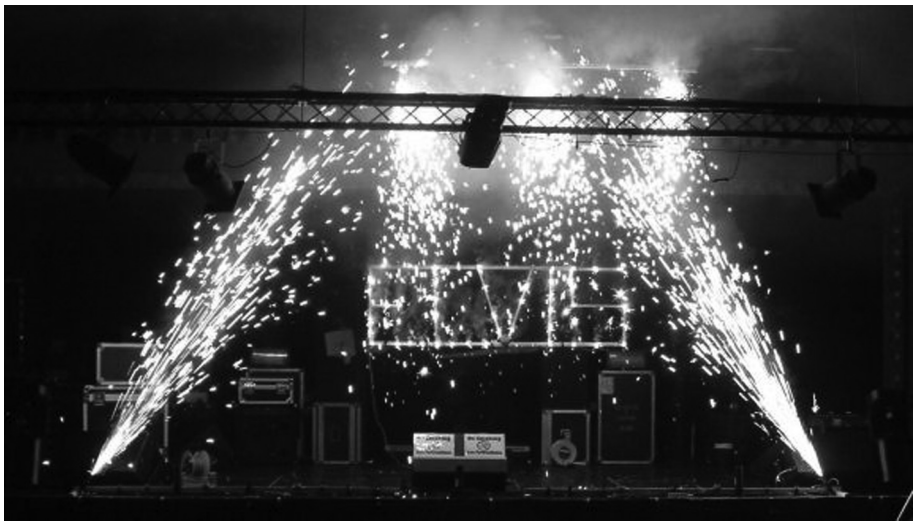
4.5.1.3 The energy change of reactions (HT only)

Question 04

June 2011 | CHY2H | Original Q4 | Legacy

4 Read the information in the box.

Flash powder is used to produce special effects at pop concerts.



Flash powder contains aluminium. The powder burns with a bright white flame and gives out lots of heat and light. It also produces white smoke.

The flash powder is placed on stage in a special container. At the bottom of the container there is a thin piece of wire. When the flash is needed, electricity is passed through the wire. The wire gets hot and starts the aluminium burning.

4 (a) When aluminium burns the reaction is *exothermic*.

What is the meaning of *exothermic?*

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.....

(1 mark)

4 (b) The hot wire provides energy to start the aluminium burning.

What is the name given to the heat energy needed to start a chemical reaction?

..... energy

(1 mark)

4.5.1.3 The energy change of reactions (HT only)

Question 04 · continued

4 (c) The white smoke produced is aluminium oxide.

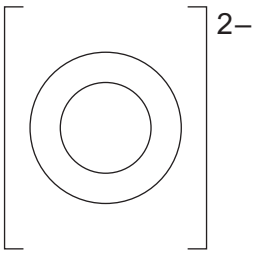
Aluminium oxide contains aluminium ions (Al^{3+}) and oxide ions (O^{2-}).

4 (c) (i) Complete the diagram to show the electronic structure of an oxide ion.

The atomic number of oxygen = 8

Use crosses (x) to represent the electrons.

oxide ion



(1 mark)

4 (c) (ii) The bonding in aluminium oxide is ionic.

What causes the aluminium ions and oxide ions to be held together strongly?

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(1 mark)

4

4.5.1.3 The energy change of reactions (HT only)

Question 05

June 2011 | CHY3H | Original Q4 | Legacy

4 Hydrogen peroxide decomposes to give water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The reaction is *exothermic.*

4 (a) Explain, in terms of bond breaking and bond making, why the decomposition of hydrogen peroxide is *exothermic*.

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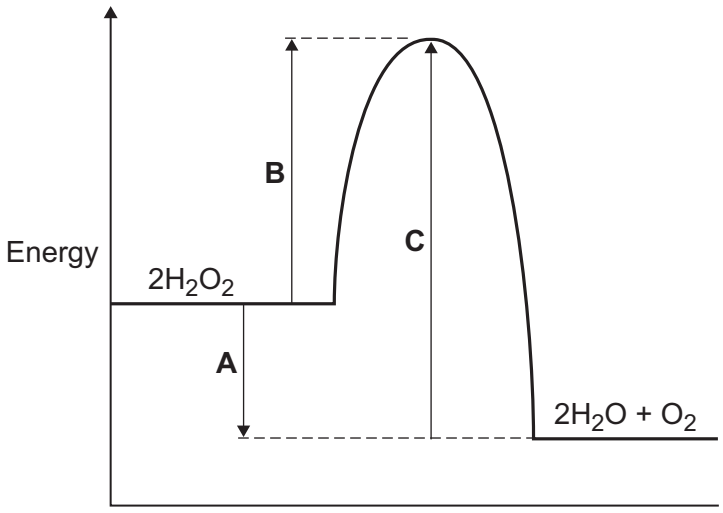
(1 mark)

4 (b) The energy level diagram for this reaction is shown below.



The energy changes, **A**, **B** and **C**, are shown on the diagram.

Use the diagram to help you answer these questions.

4 (b) (i) How do you know that this reaction is *exothermic*?

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(1 mark)

4 (b) (ii) The decomposition of hydrogen peroxide is slow.
What does this suggest about energy change **B**?

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(1 mark)

4.5.1.3 The energy change of reactions (HT only)

Question 05 · continued

4 (b) (iii) Hydrogen peroxide decomposes quickly when a small amount of manganese(IV) oxide is added.

Explain why.

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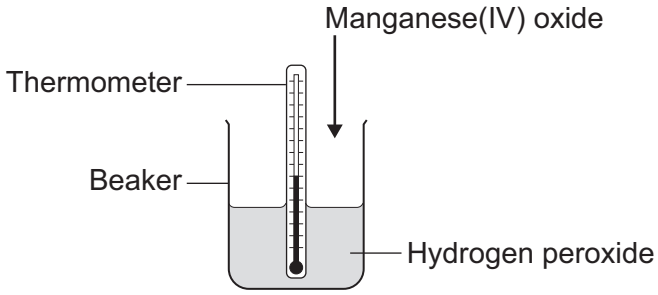
(2 marks)

4 (c) A student did an experiment to find the amount of energy produced when hydrogen peroxide solution is decomposed using manganese(IV) oxide.

The apparatus the student used is shown in the diagram.



The student first measured the temperature of the hydrogen peroxide. Then the student added the manganese(IV) oxide and recorded the highest temperature.

The temperature rise was smaller than expected.

Suggest why.

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(2 marks)

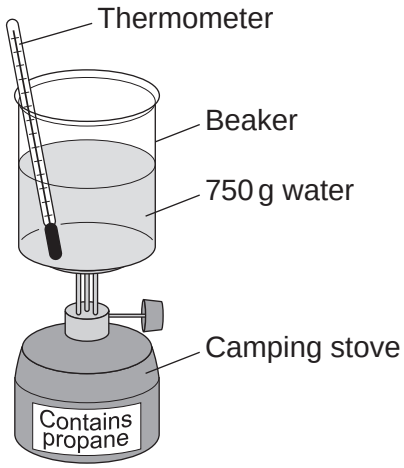
7

4.5.1.3 The energy change of reactions (HT only)

Question 06

June 2013 | CH3HP | Original Q7 | Legacy

7 A camping stove uses propane gas.



7 (a) A student did an experiment to find the energy released when propane is burned.

The student:

- put 750 g water into a beaker
- measured the temperature of the water, which was 17 °C
- heated the water by burning propane
- measured the temperature of the water again, which was then 64 °C.

The student calculated the energy released using the equation

$$Q = m \times 4.2 \times \Delta T$$

Where:
Q = energy released (J)
m = mass of water (g)
ΔT = temperature change (°C)

7 (a) (i) Use the student's results to calculate the energy released in joules (J).

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Energy released = ... J

(3 marks)

4.5.1.3 The energy change of reactions (HT only)

Question 06 · continued

7 (a) (ii) To find how much propane had been used the student weighed the camping stove before and after the experiment. The mass of the camping stove decreased by 6.0 g.

Using this information and your answer to part **7(a)(i)**, calculate the energy in kJ released when 1 mole of propane burns.

(If you have no answer for part **7(a)(i)**, assume the energy released during the experiment is 144 000 J. This is **not** the answer to part **7(a)(i)**.)

Relative formula mass (M_r) of propane = 44.

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Energy released = ... kJ

(2 marks)

7 (a) (iii) Suggest **two** things the student could do to make his results more accurate.

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(2 marks)

7 (a) (iv) The student's method does **not** give accurate results.

However, this method is suitable for comparing the energy released by different fuels.

Suggest why.

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(1 mark)

Question 7 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 06 · continued

7 (b) The student used bond energies to calculate the energy released when propane is burned.

The equation for the combustion of propane is:

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

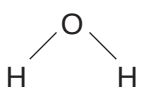
Some bond energies are given in the table.

Bond	Bond Energy in kJ per mole
C ═ O	803
O — H	464

The displayed structures of the products are:

carbon dioxide O ═ C ═ O

water



4.5.1.3 The energy change of reactions (HT only)

Question 06 · continued

7 (b) (i) Calculate the energy released by bond making when the products are formed.

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Energy released = ... kJ per mole
(3 marks)

7 (b) (ii) The energy used for bond breaking of the reactants in the equation is 6481 kJ per mole.

Calculate the overall energy change of this reaction.

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Overall energy change = ... kJ per mole
(1 mark)

12

4.5.1.3 The energy change of reactions (HT only)

Question 07

June 2014 | CH3HP | Original Q6 | Legacy

6 Some cars are powered by hydrogen fuel cells.

Figure 6



6 (a) What type of energy is released by hydrogen fuel cells?

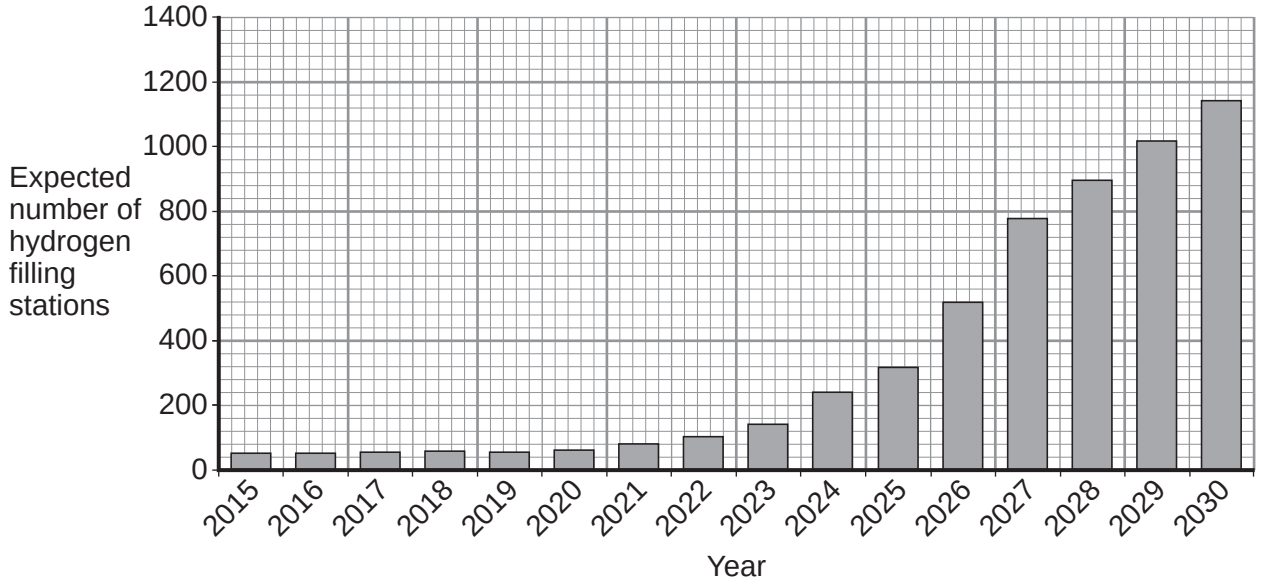
[1 mark]

.....

6 (b) Owners of cars powered by fuel cells buy hydrogen from hydrogen filling stations.

Figure 7 shows how the number of hydrogen filling stations in the UK is expected to increase up to the year 2030.

Figure 7



4.5.1.3 The energy change of reactions (HT only)

Question 07 · continued

Use the information in **Figure 7** and your own knowledge to answer this question.

Suggest **two** reasons why the UK government might encourage the building of more hydrogen filling stations.

[2 marks]

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Question 6 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 07 · continued

6 (c) The equation for the reaction of hydrogen with oxygen is:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

During the reaction, energy is used to break the bonds of the reactants.

Energy is released when new bonds are made to form the product.

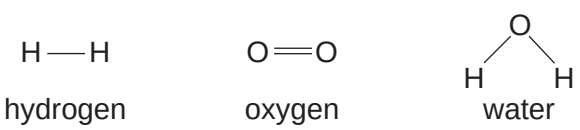
Bond energies for the reaction are given in **Table 1**.

Table 1

Bond	Bond energy in kJ
H—H	436
O=O	498
O—H	464

The structures of the reactants and product are shown in **Figure 8**.

Figure 8



hydrogen oxygen water

6 (c) (i) Calculate the energy change for the reaction:

$$2H_2 + O_2 \longrightarrow 2H_2O$$

[3 marks]

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Energy change = ... kJ

4.5.1.3 The energy change of reactions (HT only)

Question 07 · continued

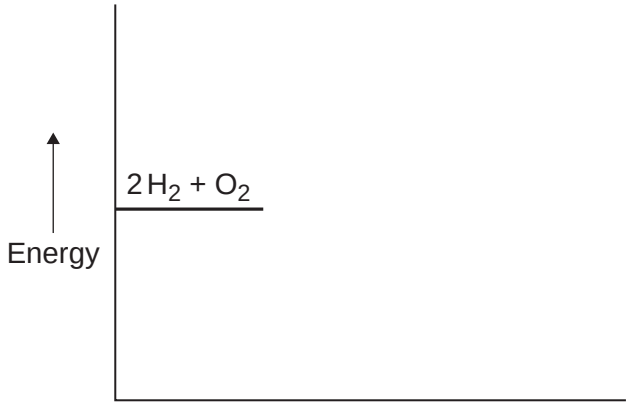
6 (c) (ii) The reaction of hydrogen with oxygen is exothermic.

Complete the energy level diagram for this reaction on **Figure 9**.

Clearly label the activation energy.

[3 marks]

Figure 9



9

4.5.1.3 The energy change of reactions (HT only)

Question 08

June 2016 | CH3HP | Original Q5 | Legacy

5 This question is about energy changes in chemical reactions.

5 (a) Balance the chemical equation for the combustion of methane.

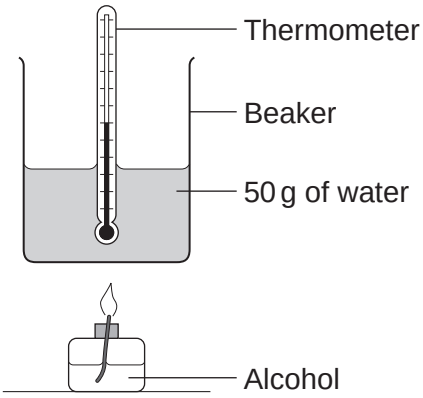
[1 mark]

$$CH_4 \quad + \quad O_2 \quad \longrightarrow \quad CO_2 \quad + \quad H_2O$$

5 (b) Alcohols are used as fuels.

A group of students investigated the amount of energy released when an alcohol was burned. The students used the apparatus shown in **Figure 5**.

Figure 5



In one experiment the temperature of 50 g of water increased from 22.0 °C to 38.4 °C. The mass of alcohol burned was 0.8 g.

Calculate the heat energy (Q) in joules, released by burning 0.8 g of the alcohol.
Use the equation:

$$Q = m \times c \times \Delta T$$

Specific heat capacity (c) = 4.2 J/g/°C

[3 marks]

Heat energy (Q) = _____ J

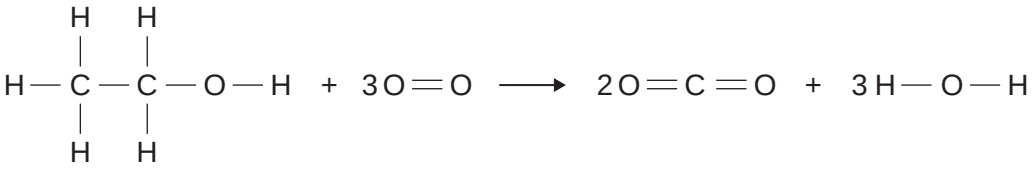
4.5.1.3 The energy change of reactions (HT only)

Question 08 · continued

5 (c) The chemical equation for the combustion of ethanol is:

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

5 (c) (i) The equation for the reaction can be shown as:



Bond	Bond energy in kJ per mole
C — H	413
C — C	347
C — O	358
C = O	799
O — H	467
O = O	495

Use the bond energies to calculate the overall energy change for this reaction.

[3 marks]

Overall energy change = _____ kJ per mole

Question 5 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 08 · continued

5 (c) (ii) The reaction is exothermic.
Explain why, in terms of bonds broken and bonds formed.

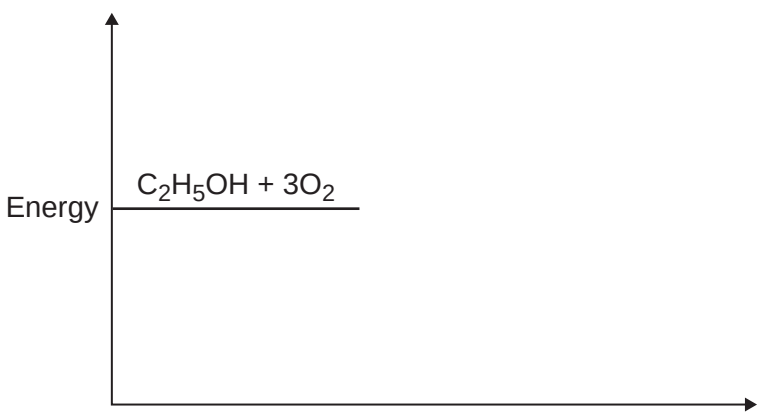
[2 marks]

5 (c) (iii) Complete the energy level diagram for the combustion of ethanol.

[3 marks]

On the completed diagram, label:

- activation energy
- overall energy change.



12

4.5.1.3 The energy change of reactions (HT only)

Question 09

6 This question is about ammonia and a compound produced from ammonia.

6 (a) Ammonia is produced by the Haber process.

6 (a) (i) The reactants in the Haber process are nitrogen and hydrogen.

Give the source of the hydrogen used for the Haber process.

[1 mark]

_____

6 (a) (ii) The Haber process produces a mixture of the gases ammonia, hydrogen and nitrogen.

Table 3 shows boiling points for ammonia, hydrogen and nitrogen.

Table 3

	Boiling point in °C
Ammonia	–33
Hydrogen	–260
Nitrogen	–196

Explain how to separate ammonia from the mixture of gases.

Use the information in **Table 3** to help you.

[2 marks]

_____

_____

_____

_____

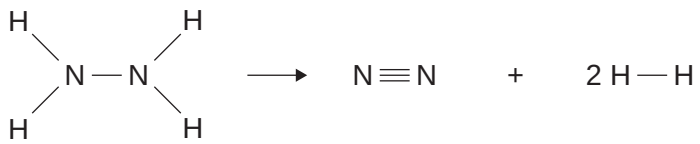
Question 6 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 09 · continued

6 (b) Ammonia is used to produce hydrazine (N_2H_4).

6 (b) (i) The equation for the decomposition of hydrazine is:



Bond energies are given in **Table 4**.

Table 4

Bond	Bond energy in kJ
N — N	160
N — H	391
N ≡ N	941
H — H	432

Calculate the energy change for the decomposition of hydrazine.

[3 marks]

Energy change = _____ kJ

4.5.1.3 The energy change of reactions (HT only)

Question 09 · continued

6 (b) (ii) The decomposition of hydrazine is exothermic.

Explain why, in terms of bond making and bond breaking.

[2 marks]

8

4.5.1.3 The energy change of reactions (HT only)

Question 10

June 2018 | 8462/1H | Original Q7

0 7 This question is about Group 7 elements.

Chlorine is more reactive than iodine.

0 7 . 1 Name the products formed when chlorine solution reacts with potassium iodide solution.

[1 mark]

0 7 . 2 Explain why chlorine is more reactive than iodine.

[3 marks]

0 7 . 3 Chlorine reacts with hydrogen to form hydrogen chloride.

Explain why hydrogen chloride is a gas at room temperature.

Answer in terms of structure and bonding.

[3 marks]

0 7 . 4 Bromine reacts with methane in sunlight.

Figure 9 shows the displayed formulae for the reaction of bromine with methane.

Figure 9

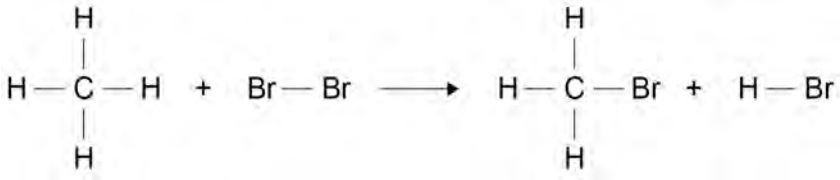


Table 3 shows the bond energies and the overall energy change in the reaction.

Table 3

	C—H	**Br—Br**	**C—Br**	**H—Br**	**Overall energy change**
Energy in kJ/mol	412	193	**X**	366	– 51

Calculate the bond energy **X** for the C—Br bond.

Use **Figure 9** and **Table 3**.

[4 marks]

Bond energy **X** = _____ kJ/mol

1

4.5.1.3 The energy change of reactions (HT only)

Question 11

June 2019 | 8462/1H | Original Q5

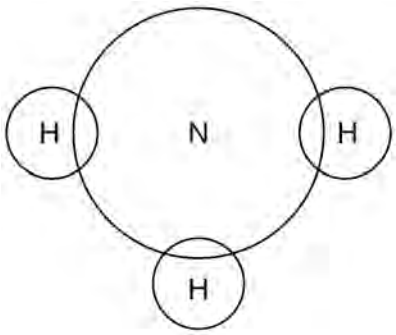
0 5 This question is about ammonia, NH_3

0 5 . 1 Complete the dot and cross diagram for the ammonia molecule shown in **Figure 6**.

Show only the electrons in the outer shell of each atom.

[2 marks]

Figure 6



0 5 . 2 Give **one** limitation of using a dot and cross diagram to represent an ammonia molecule.

[1 mark]

0 5 . 3 Explain why ammonia has a low boiling point.

You should refer to structure and bonding in your answer.

[3 marks]

Ammonia reacts with oxygen in the presence of a metal oxide catalyst to produce nitrogen and water.

0 5 . 4 Which metal oxide is most likely to be a catalyst for this reaction?

[1 mark]

Tick (✓) **one** box.

- CaO ☐
- Cr_2O_3 ☐
- MgO ☐
- Na_2O ☐

Figure 7 shows the displayed formula equation for the reaction.

Figure 7

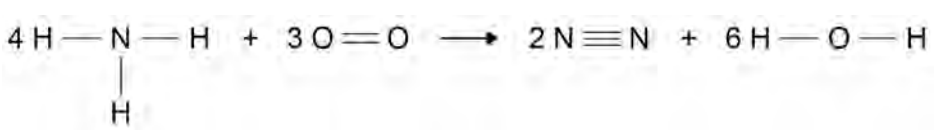


Table 3 shows some bond energies.

Table 3

Bond	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	391	498	945	464

4.5.1.3 The energy change of reactions (HT only)

Question 11 · continued

0 5 . 5 Calculate the overall energy change for the reaction.

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

[3 marks]

Overall energy change = _____ kJ

0 5 . 6 Explain why the reaction between ammonia and oxygen is exothermic.

Use values from your calculation in Question **05.5**

[2 marks]

Question 5 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 11 · continued

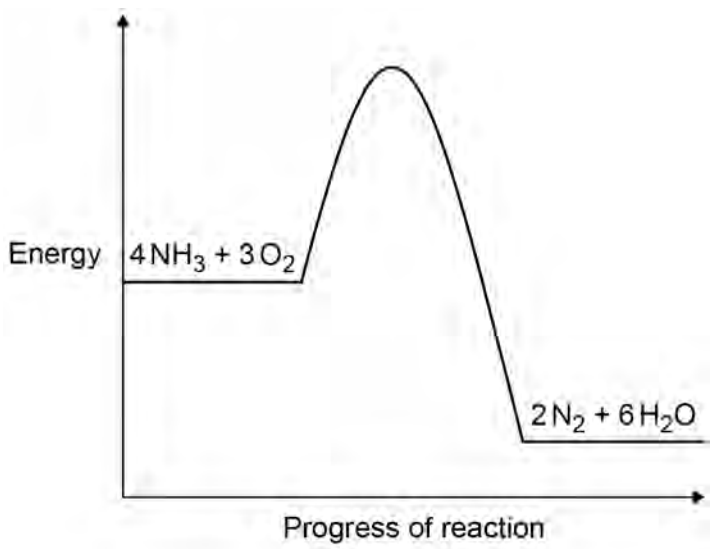
0 5 . 7 **Figure 8** shows the reaction profile for the reaction between ammonia and oxygen.

Complete **Figure 8** by labelling the:

- activation energy
- overall energy change.

[2 marks]

Figure 8



14

4.5.1.3 The energy change of reactions (HT only)

Question 12

0 8 This question is about the reaction between hydrogen sulfide (H_2S) and oxygen.

The equation for the reaction is:

$$2\,H_2S(g) + 3\,O_2(g) \rightarrow 2\,H_2O(g) + 2\,SO_2(g)$$

0 8 . 1 What does $H_2O(g)$ represent?

[1 mark]

0 8 . 2 Calculate the volume of oxygen required to react with 50 cm^3 of hydrogen sulfide.

[1 mark]

Volume = _____ cm^3

0 8 . 3 **Figure 6** shows part of the reaction profile for the reaction.

The reaction is exothermic.

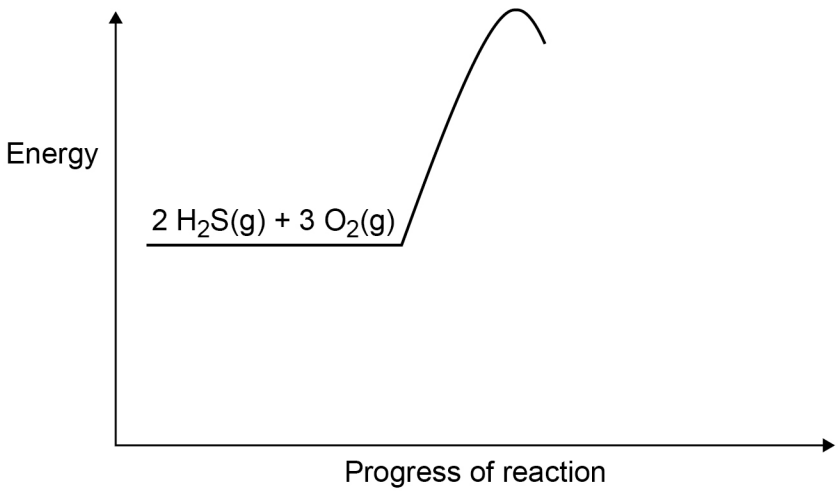
Complete **Figure 6**.

You should:

- complete the profile line
- label the activation energy
- label the overall energy change.

[3 marks]

Figure 6



4.5.1.3 The energy change of reactions (HT only)

Question 12 · continued

0 8 . 4 **Figure 7** shows the displayed formula equation for the reaction of hydrogen sulfide with oxygen.

Figure 7

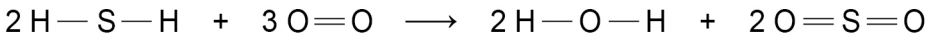


Table 5 shows some of the bond energies.

Table 5

Bond	H — S	O = O	H — O	S = O
Energy in kJ/mol	364	498	464	**X**

In the reaction the energy released forming new bonds is 1034 kJ/mol greater than the energy needed to break existing bonds.

Calculate the bond energy **X** for the S = O bond.

Use **Figure 7** and **Table 5.**

[5 marks]

X = _____ kJ/mol

10

4.5.1.3 The energy change of reactions (HT only)

Question 13

June 2023 | 8462/1H | Original Q4

0 4 This question is about hydrogen and compounds of hydrogen.

Figure 3 shows the displayed formulae for the reaction between hydrogen and chlorine.

Figure 3

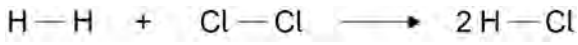


Table 4 shows the bond energies.

Table 4

Bond	H — H	Cl — Cl	H — Cl
Bond energy in kJ/mol	436	346	432

0 4 . 1 Which expression shows how to calculate the overall energy change for the reaction in **Figure 3**?

Use **Table 4**.

[1 mark]

Tick (✓) **one** box.

436 + 346 + 432 kJ/mol ☐

436 + 346 + (2 × 432) kJ/mol ☐

436 + 346 − 432 kJ/mol ☐

436 + 346 − (2 × 432) kJ/mol ☐

4.5.1.3 The energy change of reactions (HT only)

Question 13 · continued

The reaction between hydrogen and chlorine is exothermic.

0 4 . 2 Explain why this reaction releases energy to the surroundings.

[2 marks]

0 4 . 3 **Figure 4** shows part of a reaction profile for the reaction between hydrogen and chlorine.

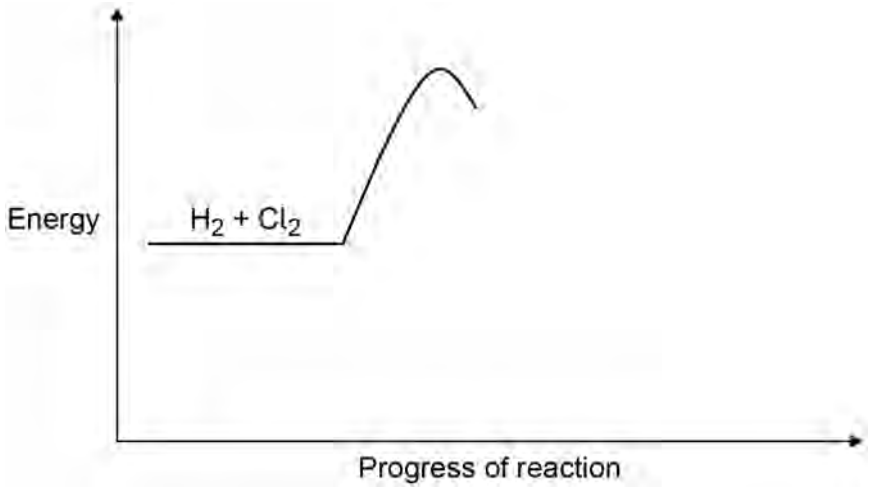
Complete the reaction profile in **Figure 4**.

You should:

- label the activation energy
- label the overall energy change.

[3 marks]

Figure 4



Question 4 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 13 · continued

0 4 . 4 Draw a dot and cross diagram for a molecule of hydrogen chloride (HCl).

Show the outer shell electrons only.

[2 marks]

4.5.1.3 The energy change of reactions (HT only)

Question 13 · continued

0 4 . 5 **Figure 5** represents molecules of methane and of poly(ethene).

Figure 5



Methane is a gas at room temperature but poly(ethene) is a solid at room temperature.

Explain why methane and poly(ethene) exist in different states at room temperature.

[4 marks]

12

4.5.1.3 The energy change of reactions (HT only)

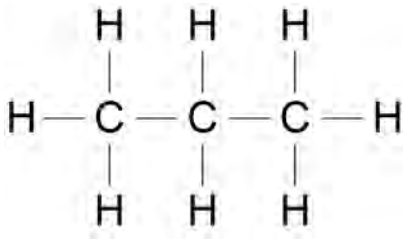
Question 14

June 2024 | 8462/1H | Original Q8

0 8 This question is about propane (C_3H_8).

Figure 7 shows the displayed structural formula of propane.

Figure 7



0 8 . 1 Explain why propane has a low boiling point.

[3 marks]

4.5.1.3 The energy change of reactions (HT only)

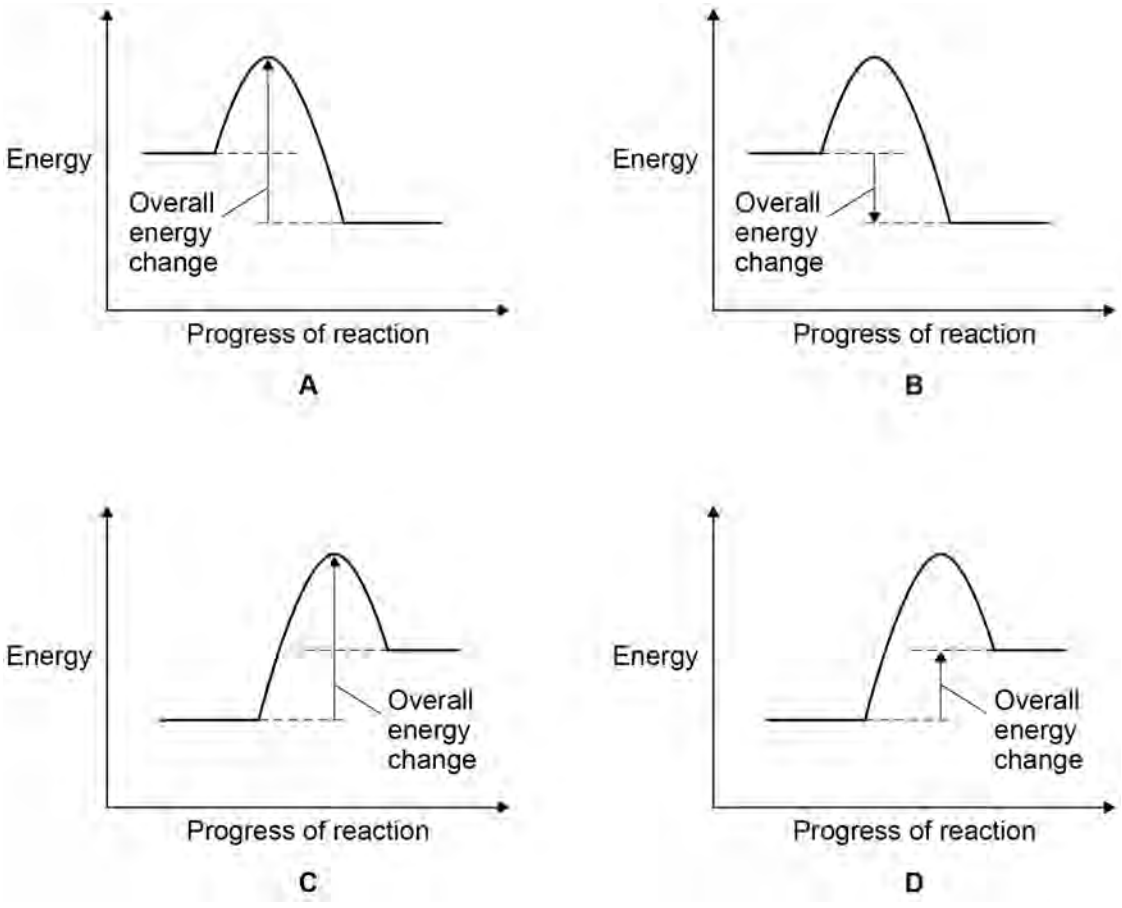
Question 14 · continued

Propane reacts with oxygen to produce carbon dioxide and water.

The reaction is exothermic.

0 8 . 2 **Figure 8** shows four reaction profiles.

Figure 8



Which is the correct reaction profile and labels for the reaction between propane and oxygen?

Tick (✓) **one** box.

[1 mark]

A ☐ B ☐ C ☐ D ☐

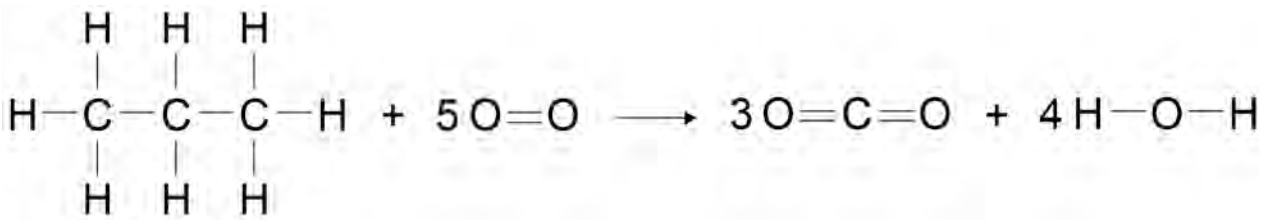
Question 8 continues on the next page

4.5.1.3 The energy change of reactions (HT only)

Question 14 · continued

0 8 . 3 **Figure 9** shows the displayed formula equation for the reaction between propane and oxygen.

Figure 9



The overall energy change of this exothermic reaction is 2219 kJ/mol.

Table 4 shows the bond energies of the bonds in the reaction.

Table 4

	C — C	C — H	O = O	C = O	O — H
Energy in kJ/mol	347	**X**	498	805	464

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

[5 marks]

Bond energy of the C — H bond (**X**) = _____ kJ/mol

9

4.5.1.3 The energy change of reactions (HT only)

Question 15

June 2025 | 8462/1H | Original Q7

0 7 Hydrazine (N_2H_4) is a compound of nitrogen and hydrogen.

0 7 . 1 Scientists are researching the use of hydrazine in fuel cells.

Table 2 gives some information about the use of hydrogen and hydrazine in fuel cells.

Table 2

	Hydrogen	**Hydrazine**
State at room temperature	Gas	Liquid
Hazards	Explosive	Toxic
Equation for fuel cell reaction	$2\ H_2\ +\ O_2\ \longrightarrow\ 2\ H_2O$	$N_2H_4\ +\ O_2\ \longrightarrow\ N_2\ +\ 2\ H_2O$
Voltage produced in volts	1.23	1.61
Catalyst needed for reaction	Platinum	None

Evaluate the use of hydrazine instead of hydrogen in a fuel cell.

[4 marks]

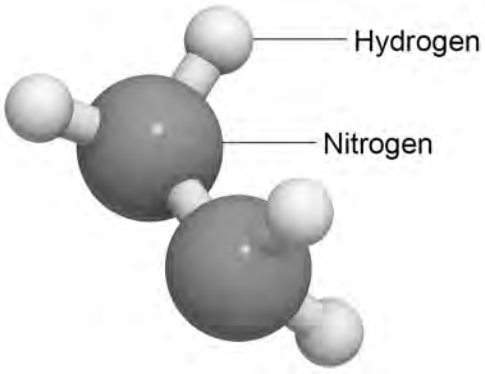
Extra space

4.5.1.3 The energy change of reactions (HT only)

Question 15 · continued

Figure 6 shows a model of the hydrazine molecule.

Figure 6

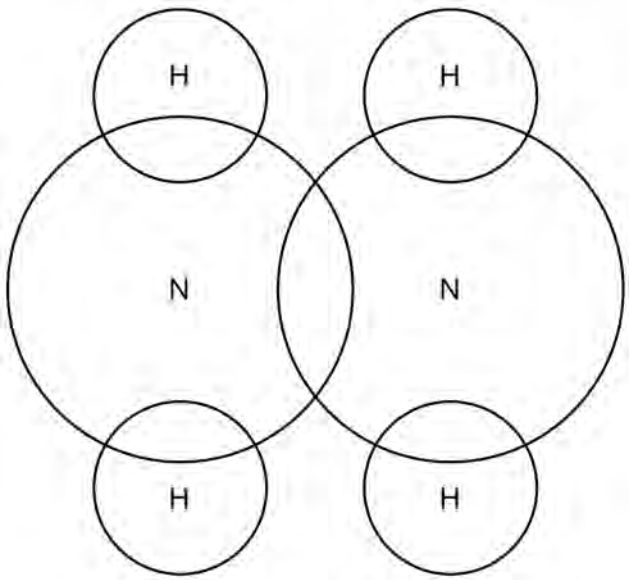


0 7 . 2 Complete the dot and cross diagram for hydrazine in **Figure 7**.

Show the outer shell electrons only.

[2 marks]

Figure 7

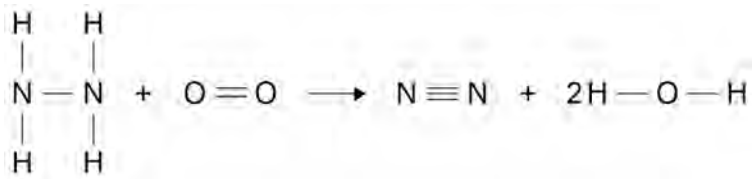


0 7 . 3 Give **one** advantage of the ball and stick model in **Figure 6** compared to the dot and cross diagram.

[1 mark]

0 7 . 4 **Figure 8** shows the displayed formula equation for the reaction of hydrazine with oxygen.

Figure 8



The reaction is exothermic.

The energy released forming new bonds is 581 kJ/mol greater than the energy needed to break existing bonds.

Table 3 shows some bond energies.

Table 3

Bond	N — N	N — H	O = O	N ≡ N	O — H
Bond energy in kJ/mol	X	391	498	945	464

Calculate the bond energy (**X**) of the N — N bond.

[4 marks]

X = _____ kJ/mol

11