All questions are for both separate science and combined science students

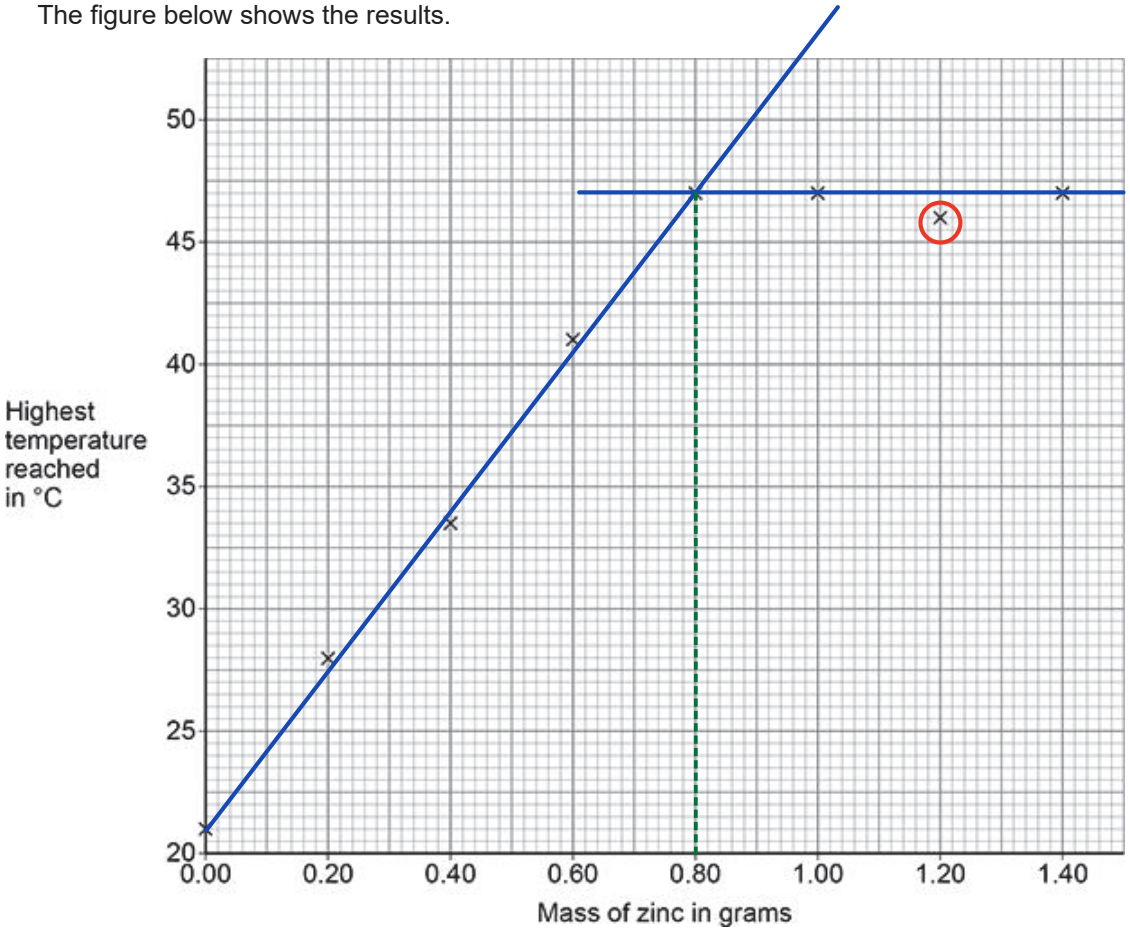
Q1.

A student investigated the energy change of the reaction between zinc and copper sulfate solution.

This is the method used.

1. Measure 25 cm^3 of copper sulfate solution into a polystyrene cup.
2. Measure the temperature of the copper sulfate solution.
3. Add 0.20 g of zinc powder to the copper sulfate solution.
4. Stir the reaction mixture.
5. Record the highest temperature reached.
6. Repeat steps 1 to 5 with different masses of zinc powder.

The figure below shows the results.



(a) Draw **two** lines of best fit on the figure above.

The lines should cross.

(2)

(b) Explain the results shown in above figure.

Do **not** refer to anomalous points.

Use data from the figure above.

The temperature rises as the reaction is exothermic.

Until 0·8g of Zn is added. Then there is no additional reaction because the $CuSO_4$ is used up and the Zn is now in excess.

(4)

(c) Explain why using a polystyrene cup gives more accurate results than using a glass beaker.

Polystyrene is a much better thermal insulator, so there is less energy transfer to the surroundings.

(2)

(d) Complete the ionic equation for the reaction between zinc and copper sulfate solution.

Include state symbols. **(HT only)**

$Zn(s) + Cu^{2+}(aq) \rightarrow$ Zn^{2+} (aq) + Cu (s)

(2)

A different student repeated steps 1 to 5 of the method four times using 0.50 g of zinc powder.

The table below shows the results.

	Trial 1	Trial 2	Trial 3	Trial 4
Highest temperature reached in °C	37.6	37.2	37.8	37.4

37·8 ±0·3
37·5 −0·3
37·2

(e) Calculate the mean highest temperature reached.

Include the uncertainty in your answer.

Mean = $\frac{37.6 + 37.2 + 37.8 + 37.4}{4}$

Mean = 37·5°C

Difference between mean and highest value
= 37·8 − 37·5 = 0·3°C

Mean highest temperature reached = 37·5 ± 0·3 °C

(3)

(f) The results show random errors.

The student did not make any measuring errors.

Suggest **one** reason for the random errors in this experiment.

Starting temperature may be different, inconsistent stirring.

(1)

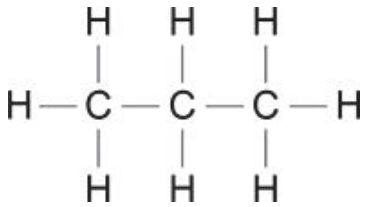
(Total 14 marks)

Q2.

This question is about propane (C_3H_8).

Figure 1 shows the displayed structural formula of propane.

Figure 1



(a) Explain why propane has a low boiling point.

Propane is a small molecule, so forces between molecules are weak, so little energy is required to overcome them.

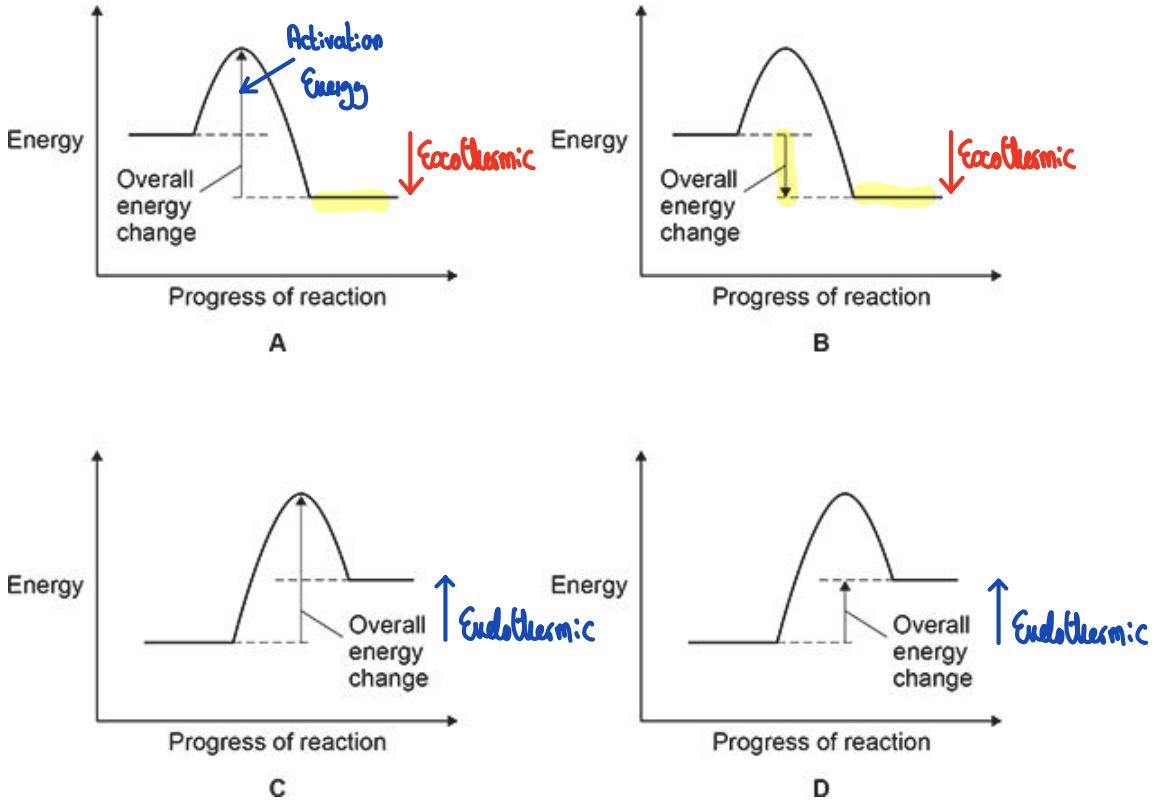
(3)

Propane reacts with oxygen to produce carbon dioxide and water.

The reaction is exothermic.

(b) **Figure 2** shows four reaction profiles.

Figure 2



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

Tick (✓) **one** box.

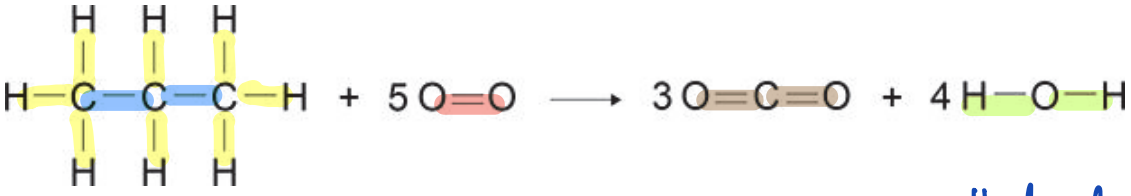
A ☐ B ☑ C ☐ D ☐

(1)

(c) **Figure 3** shows the displayed formula equation for the reaction between propane and oxygen.

8 × C—H
2 × C—C
5×O=O
3×2×C=O
4×2×O—H

Figure 3



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

Heat released
ΔH = − 2219

The table below shows the bond energies of the bonds in the reaction.

	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**). **(HT only)**

Energy change = Bonds broken − Bonds formed

$\Delta H = [(8 \times C-H) + (2 \times C-C) + (5 \times O=O)] - [(3 \times 2 \times C=O) + (4 \times 2 \times O-H)]$

$-2219 = [(8 \times X) + (2 \times 347) + (5 \times 498)] - [(6 \times 805) + (8 \times 464)]$

$-2219 = [8X + 694 + 2490] - [4830 + 3712]$

$-2219 = [8X + 3184] - [8542]$

$8542 - 2219 = 8X + 3184$

$6323 - 3184 = 8X$

$X = \frac{3139}{8}$

$X = 392.38$

Bond energy of the C — H bond (**X**) = 392 kJ/mol

(5)

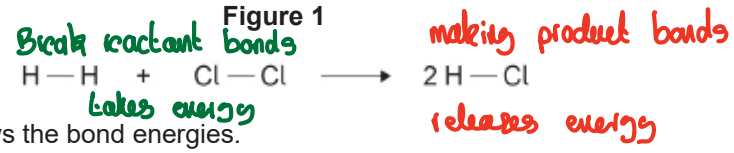
(Total 9 marks)

Q3.

This question is about hydrogen and compounds of hydrogen.

Figure 1 shows the displayed formulae for the reaction between hydrogen and chlorine.

Figure 1



The table below shows the bond energies.

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

(a) Which expression shows how to calculate the overall energy change for the reaction in **Figure 1**? **(HT only)**

Use the table above.

Tick (✓) **one** box.

Energy change = Bonds broken − Bonds formed
= (H − H, Cl − Cl) − (2 × H − Cl)
= [436 + 346] − [2 × 432]

- 436 + 346 + 432 kJ/mol ☐
- 436 + 346 + (2 × 432) kJ/mol ☐
- 436 + 346 − 432 kJ/mol ☐
- 436 + 346 − (2 × 432) kJ/mol ☑

(1)

The reaction between hydrogen and chlorine is exothermic.

(b) Explain why this reaction releases energy to the surroundings. **(HT only)**

Energy is needed to break bonds and energy is released when bonds form. This exothermic releases energy to the surroundings because the energy released is greater than the energy needed to break bonds

(2)

(c) **Figure 2** shows part of a reaction profile for the reaction between hydrogen and chlorine.

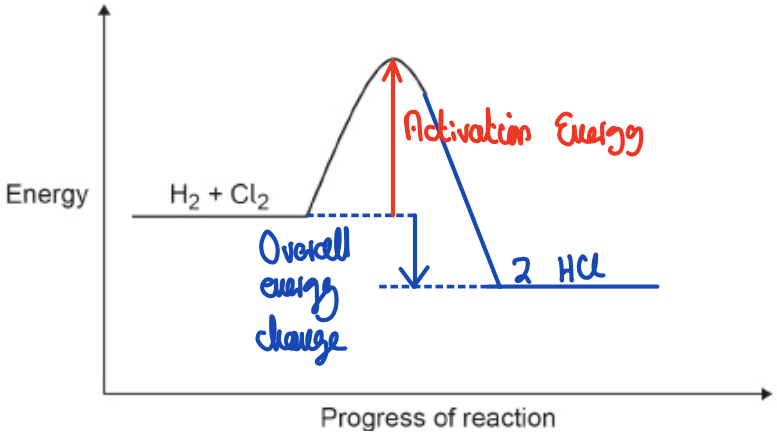
Exothermic!

Complete the reaction profile in **Figure 2**.

You should:

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

Figure 2

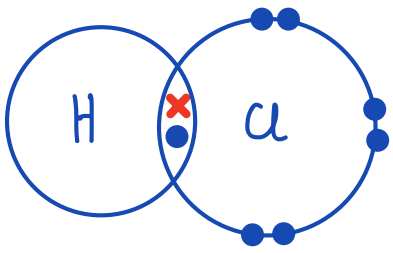


(3)

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

Show the outer shell electrons only.

H - Group 1
Cl - Group 7

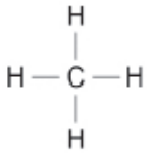


(2)

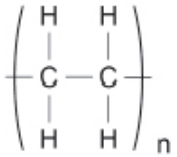
(e) **Figure 3** represents molecules of methane and of poly(ethene).

Figure 3

Methane



Poly(ethene)



n can be 1000s

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.

Methane has much smaller molecules, so has weaker intermolecular forces, which need less energy to overcome, so the boiling point is lower and methane is a gas.

Poly(ethene) has much larger molecules, so the intermolecular forces are much stronger.

(4)

(Total 12 marks)