Exothermic and Endothermic Reactions

Question Paper 1

Level	GCSE (9-1)
Subject	Combined Science: Trilogy - Chemistry
Exam Board	AQA
Topic	5.5 Energy Changes
Sub-Topic	Exothermic and Endothermic Reactions
Difficulty Level	Gold Level
Booklet	Question Paper 1

Time Allowed: **59 minutes**

Score: **/58**

Percentage: **/100**

Grade Boundaries:

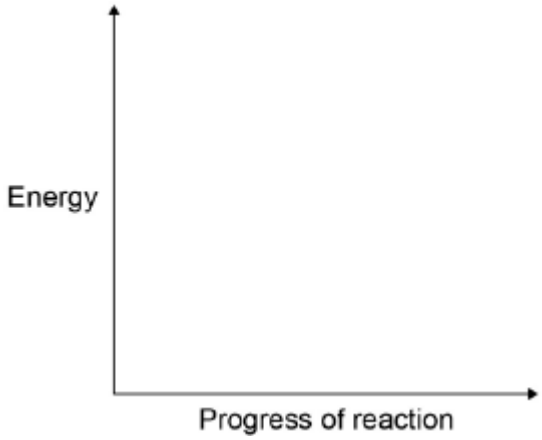
Q1. Exothermic reactions transfer energy to the surroundings.

(a) Draw a reaction profile for an exothermic reaction using the axes in **Figure 1**.

Show the:

- relative energies of the reactants and products
- activation energy and overall energy change.

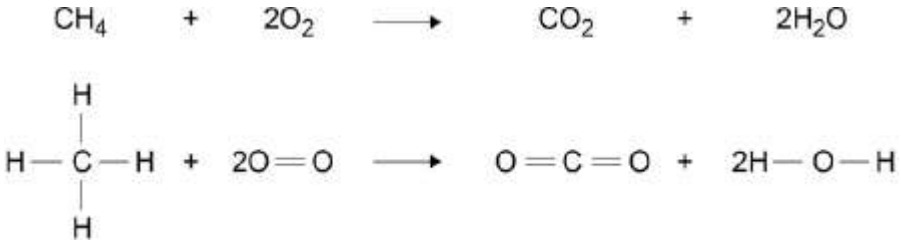
Figure 1



(2)

(b) Combustion is an exothermic reaction.

Calculate the overall energy change for the complete combustion of one mole of methane in oxygen.



Bond	Bond energy in kJ / mol
C — H	413
O = O	498
C = O	805
O — H	464

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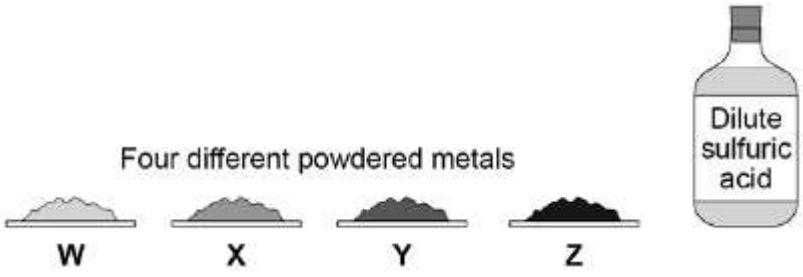
Overall energy change = ... kJ / mol

(3)

(c) **Figure 2** shows the chemicals given to a student.

Figure 2



The student wants to investigate the reactivity of the four metals.

Outline a plan the student could use to investigate the relative reactivity of the four metals, **W**, **X**, **Y** and **Z**.

The plan should use the fact that all four metals react exothermically with dilute sulfuric acid.

You should name the apparatus used and comment on the safe use of the chemicals.

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(6)

(d) Another student used displacement reactions to investigate the relative reactivity of the four metals, **W**, **X**, **Y** and **Z**.

The table below shows the student's results.

	Observations			
Solution	**Metal W**	**Metal X**	**Metal Y**	**Metal Z**
Copper nitrate	Brown layer formed on metal	Brown layer formed on metal	Brown layer formed on metal	No change
Magnesium sulfate	No change	No change	No change	No change
Sulfuric acid	Gas bubbles produced	Few gas bubbles produced	Gas bubbles produced	No change
Zinc chloride	Grey layer formed on metal	No change	No change	No change

Give the order of reactivity of metals, **W**, **X**, **Y** and **Z**.

Use the results in the table above to justify your answer.

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(3)

(e) The student concluded that these results could also be used to justify the order of reactivity of copper, magnesium, hydrogen and zinc.

The student is **not completely** correct. Use the results in the table above to explain why.

Suggest one further experiment that would provide evidence for the student's conclusion.

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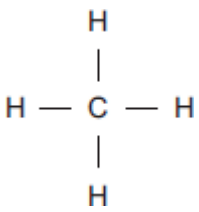
(4)
(Total 18 marks)

Q2. Methane (CH_4) is used as a fuel.

(a) The displayed structure of methane is:



Draw a ring around a part of the displayed structure that represents a covalent bond.

(1)

(b) Why is methane a compound?

Tick (✓) **one** box.

Methane contains atoms of two elements, combined chemically. ☐

Methane is not in the periodic table. ☐

Methane is a mixture of two different elements. ☐

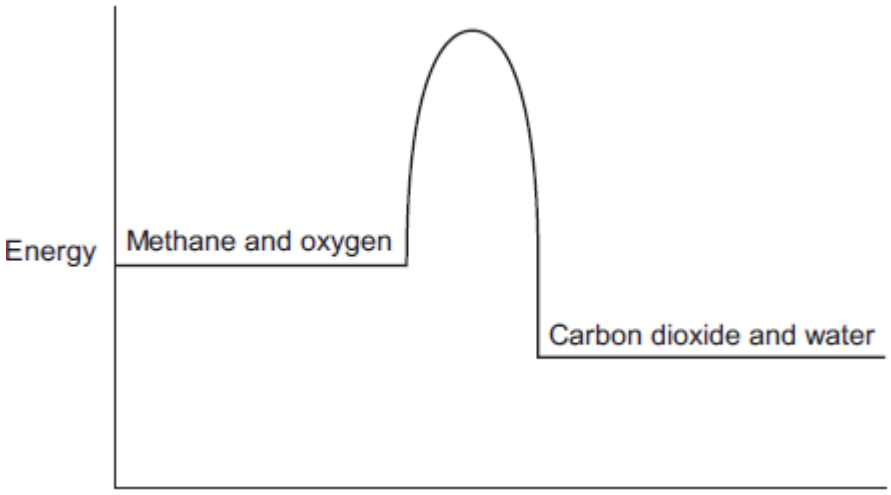
(1)

(c) Methane burns in oxygen.

(i) The diagram below shows the energy level diagram for the complete combustion of methane.

Draw and label arrows on the diagram to show:

- the activation energy
- the enthalpy change, ΔH.



(2)

(ii) Complete and balance the symbol equation for the complete combustion of methane.

$$CH_4 + \text{.....} \longrightarrow CO_2 + \text{.....}$$

(2)

(iii) Explain why the **incomplete** combustion of methane is dangerous.

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(2)

(iv) Explain why, in terms of the energy involved in bond breaking and bond making, the combustion of methane is exothermic.

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(3)

(d) Methane reacts with chlorine in the presence of sunlight.

The equation for this reaction is:

Some bond dissociation energies are given in the table.

Bond	**Bond dissociation energy in kJ per mole**
C−H	413
C−Cl	327
Cl−Cl	243

H−Cl	432

(i) Show that the enthalpy change, *ΔH*, for this reaction is −103 kJ per mole.

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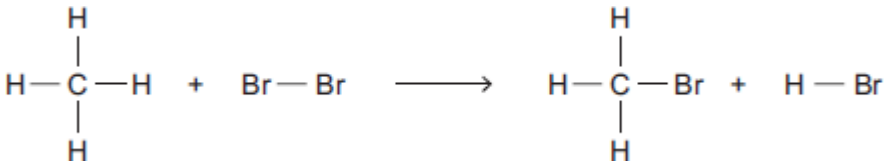
(3)

(ii) Methane also reacts with bromine in the presence of sunlight.



This reaction is less exothermic than the reaction between methane and chlorine.

The enthalpy change, *ΔH*, is −45 kJ per mole.

What is a possible reason for this?

Tick (✓) **one** box.

CH_3Br has a lower boiling point than CH_3Cl ☐

The C−Br bond is weaker than the C−Cl bond. ☐

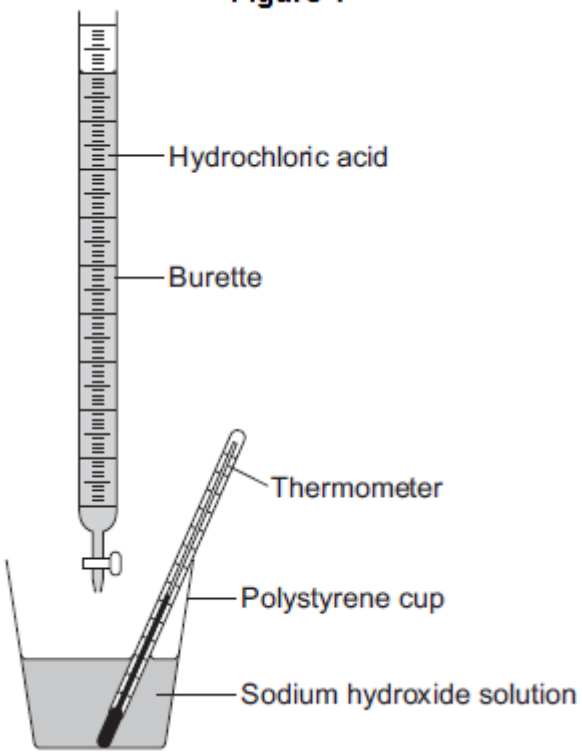
The H−Cl bond is weaker than the H−Br bond. ☐

Chlorine is more reactive than bromine. ☐

(1)
(Total 15 marks)

Q3. A student investigates the energy released when hydrochloric acid completely neutralises sodium hydroxide solution.
The student uses the apparatus shown in **Figure 1**.

Figure 1



The student:

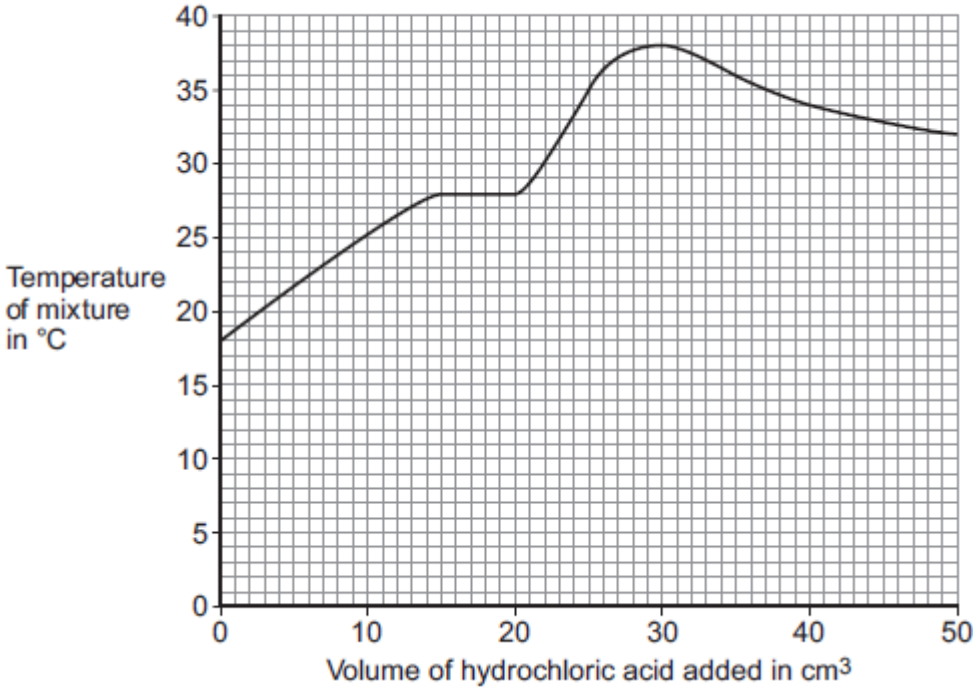
- measures 25 cm^3 sodium hydroxide solution into a polystyrene cup
- fills a burette with hydrochloric acid
- measures the temperature of the sodium hydroxide solution
- adds 5 cm^3 hydrochloric acid to the sodium hydroxide solution in the polystyrene cup
- stirs the mixture and measures the highest temperature of the mixture
- continues to add 5 cm^3 portions of hydrochloric acid, stirring and measuring the highest temperature of the mixture after each addition.

(a) The student has plotted a graph of the results.

The graph line has been incorrectly drawn by including an anomalous result.

The graph is shown in **Figure 2**.

Figure 2



(i) Suggest a cause for the anomalous result when 20 cm^3 of hydrochloric acid is added.

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(1)

(ii) Suggest the true value of the temperature of the anomalous point.

Temperature = ... °C

(1)

(iii) What was the **total** volume of the mixture when the maximum temperature was reached?

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Total volume of the mixture = ... cm^3

(1)

(iv) Calculate the overall temperature increase in this experiment.

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Overall temperature increase = ... °C

(1)

(v) Use your answers to (iii) and (iv) and the equation to calculate the energy released in the reaction. Give the unit.

Assume the volume in cm^3 is equivalent to the mass of solution in grams.

Equation: $Q = mc\Delta T$

where:
Q = energy released
m = mass of solution (g)
c = 4.2 (J per g per °C)
ΔT = change in temperature (°C)

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Energy released = ... Unit = ...

(2)

(b) The student did the experiment again, starting with 50 cm^3 of sodium hydroxide solution instead of 25 cm^3.

Explain why this would make no difference to the overall temperature increase.

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(2)
(Total 8 marks)

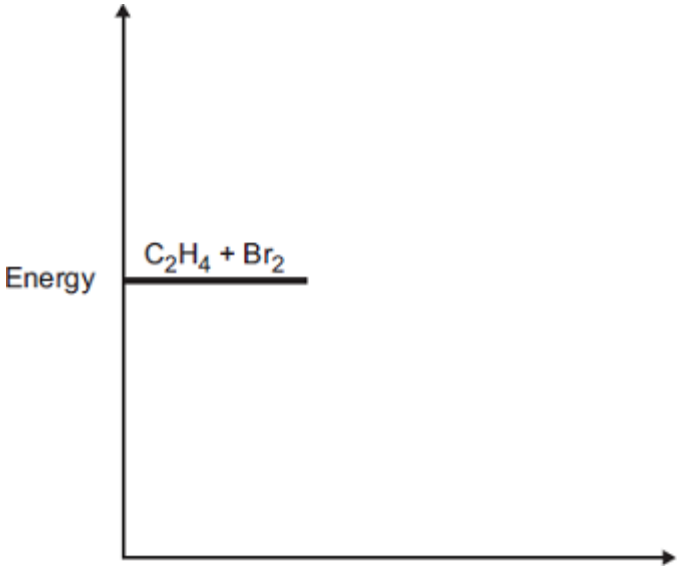
Q4. The equation for the reaction of ethene and bromine is:

$$C_2H_4(g) + Br_2(l) \longrightarrow C_2H_4Br_2(l)$$

The reaction is exothermic.

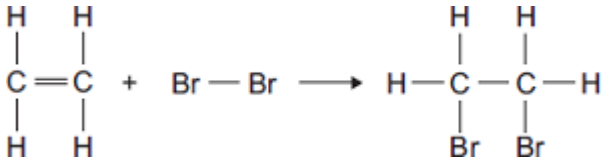
(a) Complete the energy level diagram.

You should label:
- the activation energy
- the enthalpy change (ΔH).



(3)

(b) (i) The equation for the reaction can be represented as:



Bond	Bond dissociation energy in kJ per mole
C—H	413
C = C	614
Br—Br	193
C—C	348
C—Br	276

Use the bond dissociation energies in the table to calculate the enthalpy change (ΔH) for this reaction.

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Enthalpy change (ΔH) = ... kJ per mole

(3)

(ii) The reaction is exothermic.

Explain why, in terms of bonds broken and bonds formed.

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(2)
(Total 8 marks)

Q5. A company manufactures ethanol (C_2H_5OH).

The reaction for the process is:

$$C_2H_4(g) + H_2O(g) \rightleftharpoons C_2H_5OH(g) \qquad \Delta H = -45 \text{ kJ per mole}$$

The temperature and pressure can be changed to increase the yield of ethanol at equilibrium.

(a) Explain what is meant by equilibrium.

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(3)

(b) (i) How would increasing the temperature change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(ii) How would increasing the pressure change the **yield** of ethanol at equilibrium?

Give a reason for your answer.

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(2)

(c) A catalyst is added to increase the rate of the reaction.

Explain how adding a catalyst increases the rate of a chemical reaction.

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(2)

(Total 9 marks)