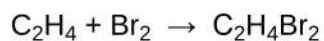




1.

This question is about the reaction of ethene and bromine.

The equation for the reaction is:

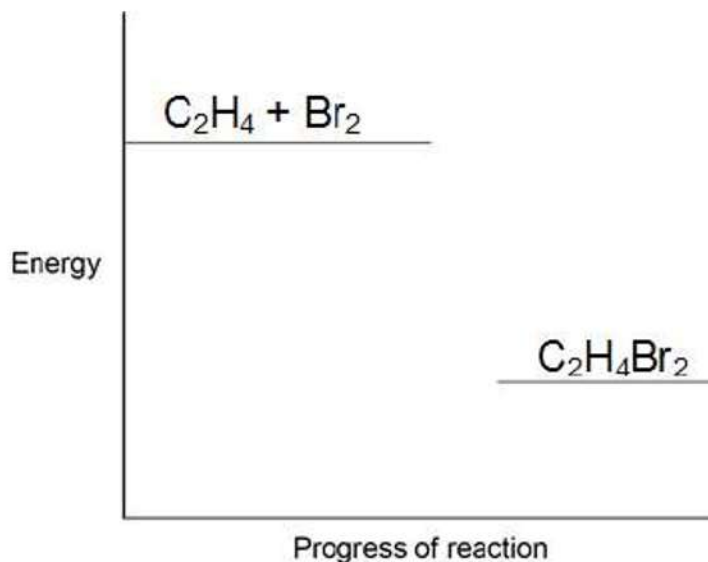


(a) Complete the reaction profile in **Figure 1**.

Draw labelled arrows to show:

- The energy given out (ΔH)
- The activation energy.

Figure 1



(3)

(b) When ethene reacts with bromine, energy is required to break covalent bonds in the molecules.

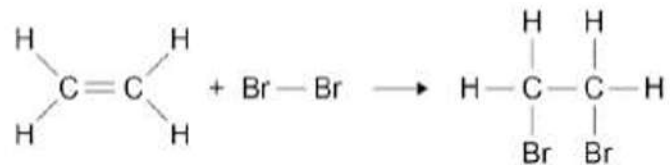
Explain how a covalent bond holds two atoms together.

(2)

- (c) **Figure 2** shows the displayed formulae for the reaction of ethene with bromine.



Figure 2



The bond enthalpies and the overall energy change are shown in the table below.

	C=C	C-H	C-C	C-Br	Overall energy change
Energy in kJ / mole	612	412	348	276	-95

Use the information in the table above and **Figure 2** to calculate the bond energy for the Br-Br bond.

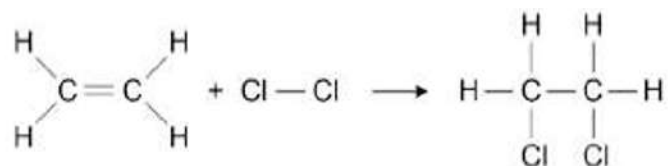
Bond energy _____ kJ / mole

(3)

(d) **Figure 3** shows the reaction between ethene and chlorine and is similar to the reaction between ethene and bromine.



Figure 3



“The more energy levels (shells) of electrons an atom has, the weaker the covalent bonds that it forms.”

Use the above statement to predict and explain how the overall energy change for the reaction of ethene with chlorine will differ from the overall energy change for the reaction of ethene with bromine.

(6)
(Total 14 marks)

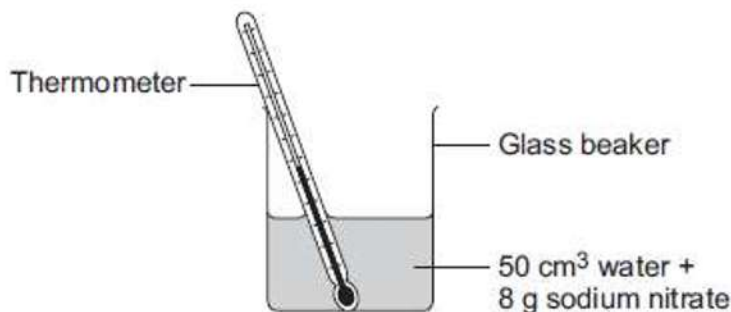
2.

This question is about temperature changes.



(a) A student investigated the temperature change when 8 g of sodium nitrate dissolves in 50 cm³ of water.

The diagram below shows the apparatus the student used.



The student did the experiment five times.

Table 1 shows the results.

Table 1

Experiment	Decrease in temperature of water in °C
1	5.9
2	5.7
3	7.2
4	5.6
5	5.8

- (i) Calculate the mean decrease in temperature.
Do not use the anomalous result in your calculation.

Mean decrease in temperature = _____ °C

(2)

(ii) Suggest **one** change in the apparatus in the diagram above which would improve the accuracy of the results.

Give a reason for your answer.



(2)

(b) The student investigated the temperature change when different masses of sodium carbonate were added to 50 cm³ of water at 20 °C.



Table 2 below shows the results.

Table 2

Mass of sodium carbonate in g	Final temperature of solution in °C
2.0	21.5
4.0	23.0
6.0	24.5
8.0	26.0
10.0	26.6
12.0	26.6
14.0	26.6

Describe the relationship between the mass of sodium carbonate added and the final temperature of the solution.

Use values from **Table 2** in your answer.

(3)

(Total 7 marks)

3.

This question is about energy changes in chemical reactions.

(a) Complete the word equation for the combustion of hydrogen.

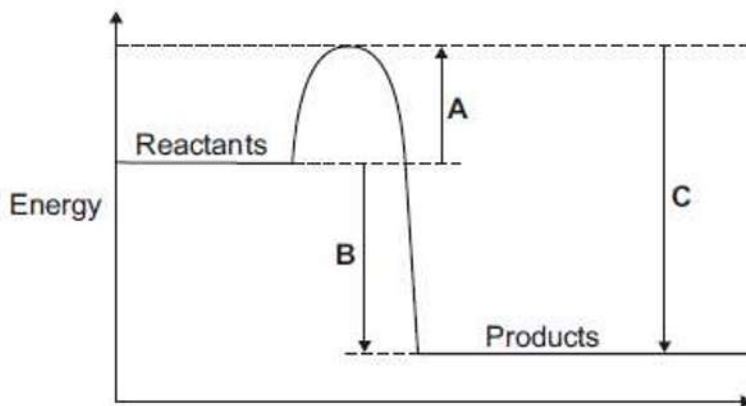


(1)

(b) **Figure 1** shows a simple energy level diagram.



Figure 1



(i) Which arrow, **A**, **B** or **C**, shows the activation energy?

Tick (✓) **one** box.

A

B

C

(1)

(ii) What type of reaction is shown by the energy level diagram in **Figure 1**?
Give a reason for your answer.

Type of reaction _____

Reason _____

(2)

(iii) For a reaction, the value of **A** is 1370 kJ and **C** is 3230 kJ.
Calculate the value of **B**.

B = _____ kJ

(1)

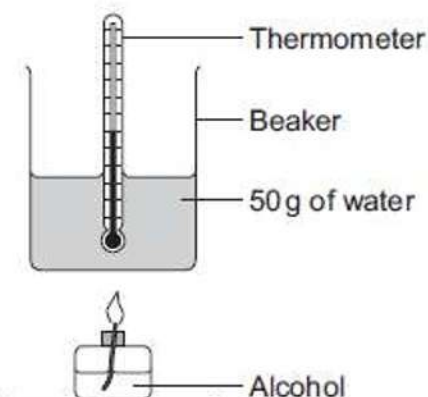
- (c) Alcohols are used as fuels.



A group of students investigated the amount of energy released when different alcohols are burned.

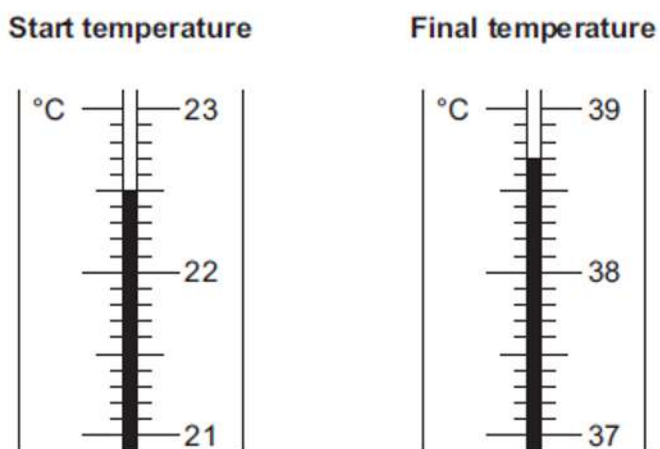
The students used the apparatus shown in **Figure 2**.

Figure 2



- (i) **Figure 3** shows the start temperature and the final temperature of the water.

Figure 3



Write the start temperature and the final temperature of the water in **Table 1**.
Work out the increase in temperature to complete **Table 1**.

Table 1

Start temperature of the water in °C	
Final temperature of the water in °C	
Increase in temperature in °C	



(ii) The students worked out the heat energy released by burning 1 g of each alcohol. The students used the equation:

$$\text{Heat energy released} = m \times 4.2 \times \text{increase in temperature}$$

Look at **Figure 2**. What is the value of m ?

$$m = \text{_____} \text{ g}$$

(1)

(iii) **Table 2** shows the students' results.

Table 2

Name of alcohol	Number of carbon atoms in one molecule of alcohol	Heat energy released when 1 g of alcohol is burned in kJ
Methanol	1	11.4
Ethanol	2	13.5
Propanol	3	20.1
Butanol	4	16.8
Pentanol	5	17.2

Which value of heat energy released is anomalous?

(1)

(iv) Look at **Table 2**.

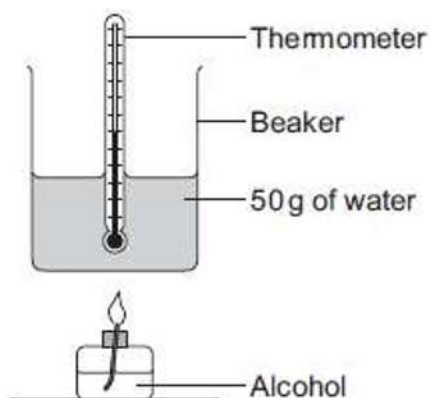
What is the relationship between the number of carbon atoms in one molecule of alcohol and the heat energy released when 1 g of the alcohol is burned?

(1)



(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 the diagram below.



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

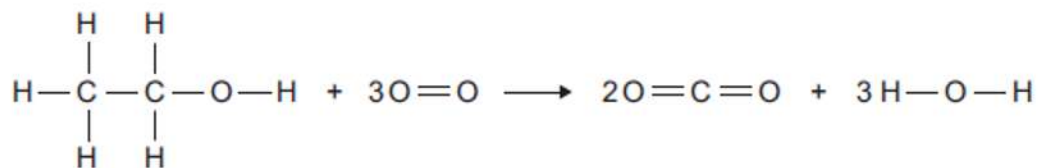
Heat energy (Q) = _____ J

(3)

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



(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.

Overall energy change = _____ kJ per mole

(3)

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

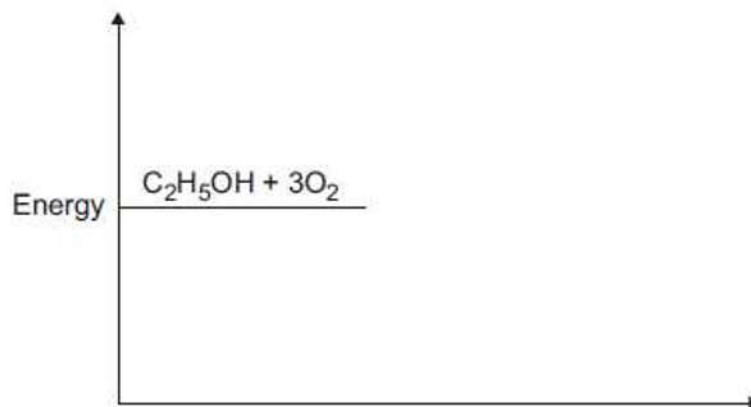
(2)

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



On the completed diagram, label:

- activation energy
- overall energy change.



(3)
(Total 12 marks)

5.

The equation for the reaction of ethene and bromine is:

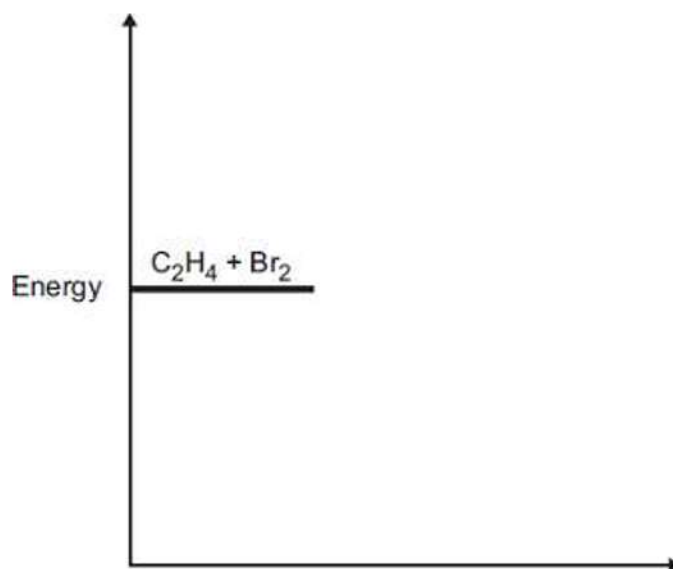


The reaction is exothermic.

(a) Complete the energy level diagram.

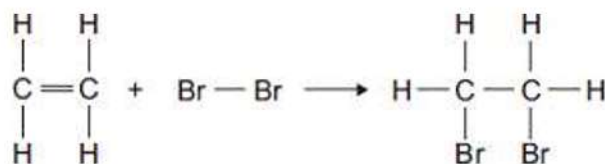
You should label:

- 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.

Enthalpy change (ΔH) = _____ kJ per mole

(3)

(ii) The reaction is exothermic.

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