

5.3 Bond Enthalpy

Question Paper

Course	DPIB Chemistry
Section	5. Energetics / Thermochemistry
Topic	5.3 Bond Enthalpy
Difficulty	Medium

Time allowed: 60
Score: /43
Percentage: /100

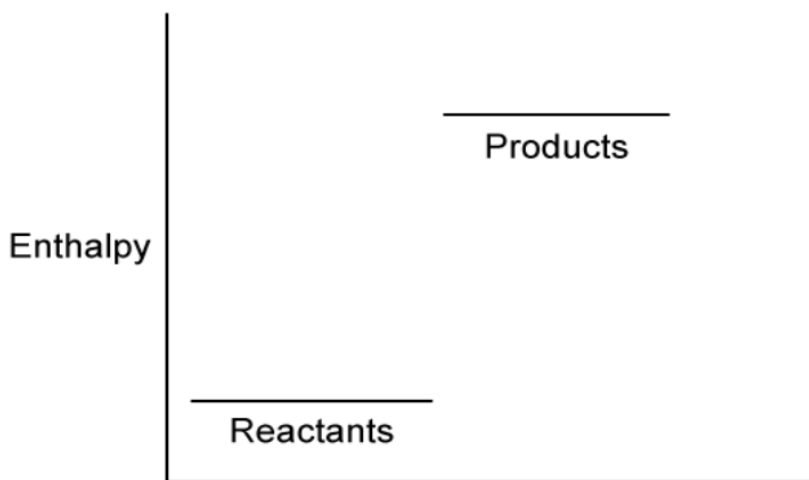
Question 1a

- a) Explain what is meant by the *standard enthalpy change of reaction*.

[1 mark]

Question 1b

- b) An enthalpy level diagram for the reaction between solid ammonium nitrate and water is shown below.

Figure 1

- i) Give the sign of ΔH for the reaction and state whether the reaction is endothermic or exothermic.
- ii) State the relative strength of the chemical bonds in the products and in the reactants.

[3 marks]

Question 1c

- c) The enthalpy of combustion for propanol is, ΔH_c^\ominus , is $-2021 \text{ kJ mol}^{-1}$. Draw a labelled energy level diagram for this reaction.

[3 marks]**Question 1d**

- d) Explain why the strength of the hydrogen halide bonds decreases down the group.

[3 marks]

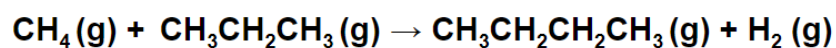
Question 2a

- a) Enthalpy changes can be found using bond enthalpy data. Some bond enthalpy values are shown below in **Table 1**.

Table 1

Bond	Mean Bond Enthalpy ΔH^\ominus (kJ mol ⁻¹)
C-C	346
C-H	414
H-H	436

The balanced equation for the reaction between methane and propane is



Use the equation and bond enthalpy data to calculate the enthalpy change for the above reaction.

[3 marks]

Question 2b

- b) Define the term *average bond enthalpy*.

[1 mark]

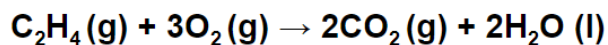
Question 2c

- c) Enthalpy changes can be found using bond enthalpy data. Some bond enthalpy values are shown below in **Table 2**.

Table 2

Bond	Mean Bond Enthalpy ΔH^\ominus (kJ mol ⁻¹)
C=C	614
C-H	414
O-H	463
C=O	804
O=O	498

The balanced equation for the combustion of ethene is



Use the equation and bond enthalpy data to calculate the enthalpy of combustion of ethene.

[3 marks]

Question 2d

- d) Bond enthalpies can be found using Hess's Law or from experimental data.

Outline the difference between the two ways of finding bond enthalpy.

[1 mark]

Question 3a

- a) Alkanes can be used as fuels in internal combustion engines. When sufficient oxygen is present, they undergo complete combustion reactions.

Write an equation for the enthalpy of combustion of butane.

[1 mark]

Question 3b

- b) Define the term *standard enthalpy of combustion*, ΔH_c^\ominus .

[3 marks]

Question 3c

- c) **Table 1** below contains bond enthalpy data for the reaction shown in part (a).

Table 1

	C-C	C-H	O=O	C=O	O-H
Mean bond enthalpy (kJ mol⁻¹)	346	414	498	804	463

Using the data in **Table 1** and the equation in part (a), calculate the enthalpy change of combustion of butane.

[3 marks]

Question 3d

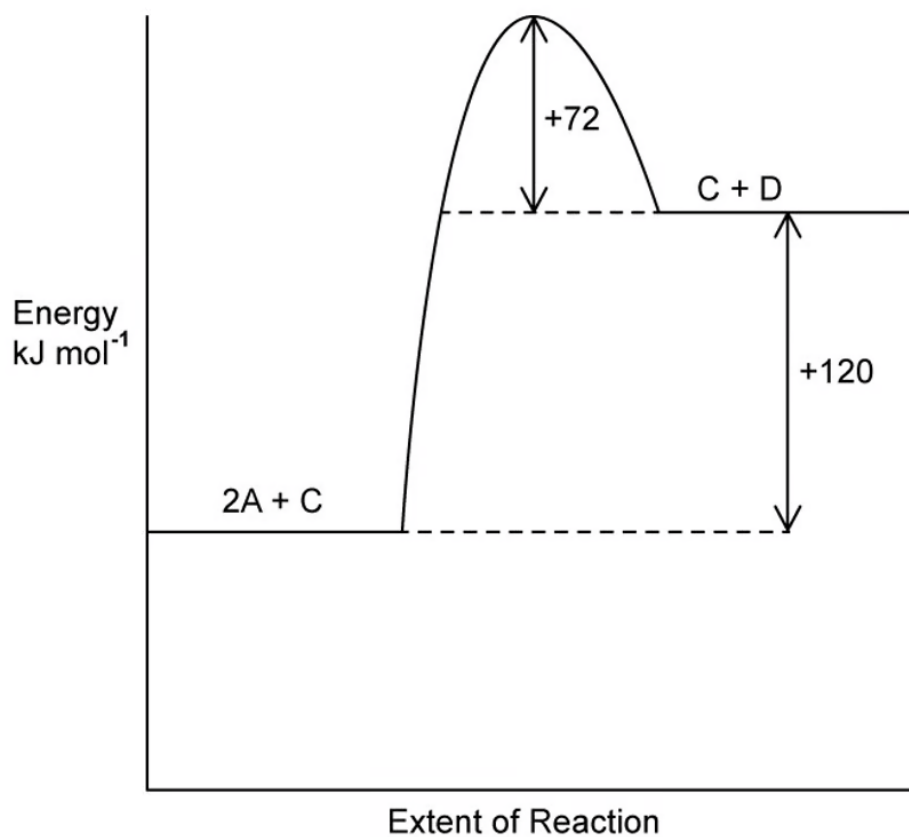
- d) In the absence of sufficient oxygen, butane will undergo incomplete combustion. Write an equation for the incomplete combustion of butane.

[1 mark]

Question 4a

- a) Use the energy level diagram to determine the activation energy, E_a , for the given reaction in **Figure 1**.

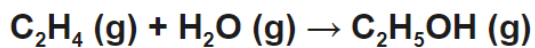
Figure 1



[1 mark]

Question 4b

- b) Ethene can be hydrated via the following reaction:

**Table 1**

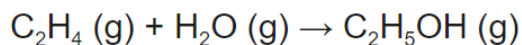
Bond	C-C	C=C	C-H	C-O	O-H
Mean bond enthalpy (kJ mol^{-1})	346	614	414	358	463

Use the data in **Table 1** to calculate the enthalpy change for the hydration of ethene.

[3 marks]

Question 4c

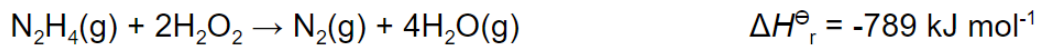
- c) Explain why the value to your answer to part (b) is different from the data book value for the hydration of ethene.



[2 marks]

Question 4d

- d) **Table 2** below has some enthalpy data for a different chemical reaction. Hydrazine, N_2H_4 can react with hydrogen peroxide in an exothermic reaction, as shown below.



The structure of hydrazine is shown in **Figure 1**.

Figure 1

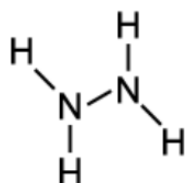


Table 2

Bond	Mean Bond Enthalpy ΔH^\ominus (kJ mol^{-1})
N-N	+158
$\text{N}\equiv\text{N}$	+945
O-H	+463
O-O	+144

Using the reaction equation and the data in the table above, calculate the value of the N-H bond in hydrazine.

[3 marks]

Question 5a

- a) The bond enthalpies, in kJmol^{-1} , of oxygen-oxygen single and double bonds are shown below in **Table 1**.

Table 1

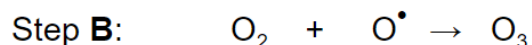
O=O	O-O
498	144

Predict, with a reason, the bond enthalpy of the oxygen-oxygen bond in ozone, O_3 .

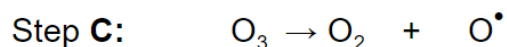
[2 marks]

Question 5b

- b) Ozone is formed in the upper atmosphere in a two-step process as shown below:



Ozone is naturally lost through the decomposition of ozone:



- i) Identify, with a reason, which of the three steps is exothermic.
- ii) Identify which of the steps is endothermic. Explain with reference to the bonding present.

[2 marks]

Question 5c

- c) Draw an enthalpy level diagram to represent the three steps **A**, **B** and **C** shown in part (b). Clearly label the position of oxygen, ozone, and the oxygen radical.

[2 marks]

Question 5d

- d) What can be deduced from the fact that ozone absorbs UV radiation in the region of 340 nm and molecular oxygen in the region of 242 nm?

[2 marks]