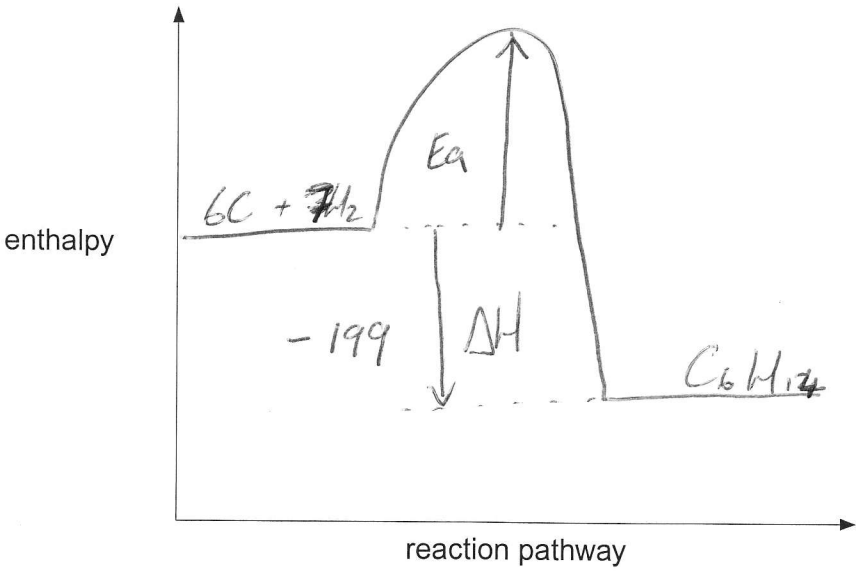
2.3.1 Enthalpy Changes Exam Questions

1. The standard enthalpy change of formation of hexane is –199 kJ mol^{-1}.

Using the axes below, show the enthalpy profile diagram for the formation of hexane.

On your diagram label the enthalpy change of reaction, ΔH, and the activation energy, E_a.



[Total 3 marks]

2. Alkanes are important hydrocarbons since they are used as fuels in homes and in industry. It is important that the enthalpy changes involved in alkane reactions are known.

(i) Define the term *enthalpy change of formation of a compound.*

ENTHALPY CHANGE WHEN 1 MOLE OF SUBSTANCE IS FORMED FROM ITS ELEMENTS IN THEIR STANDARD STATES UNDER STANDARD CONDITIONS

[2]

(ii) Write the equation, including state symbols, that accompanies the enthalpy change of formation of hexane, $C_6H_{14}(l)$.

$6C_{(s)} + 7H_{2(g)} \longrightarrow C_6H_{14}$

[2]

(iii) What conditions of temperature and pressure are used when measuring the **standard** enthalpy change of formation?

temperature ..... 298K .....

pressure ..... 1 ATMOSPHERE .....

[1]

[Total 5 marks]

3. The combustion of butane is shown in the equation below.

$$C_4H_{10}(g) + 6\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

(i) The standard enthalpy change of combustion of butane is –2877 kJ mol^{-1}. What does *standard* mean in this context?

298K, 1 ATMOSPHERE

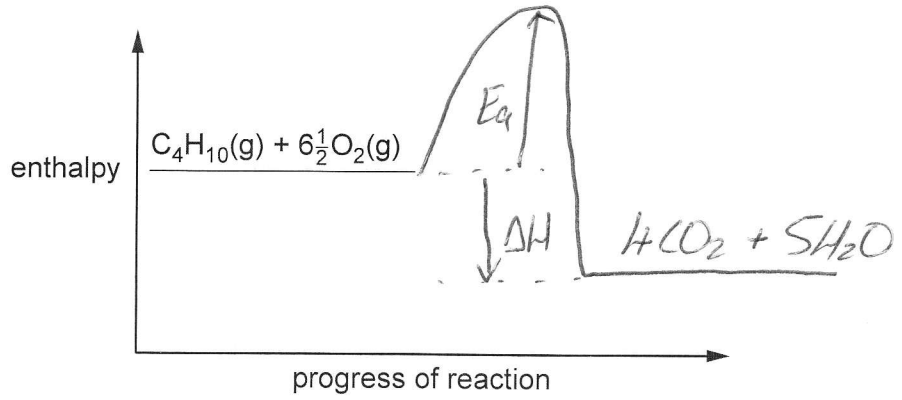
[1]

(ii) Define the term *enthalpy change of combustion*.

ENTHALPY CHANGE WHEN 1 MOLE OF SUBSTANCE UNDERGOES COMPLETE COMBUSTION IN O_2 IN THEIR STANDARD STATES UNDER STANDARD CONDITIONS

[2]

(iii) Complete the enthalpy profile diagram for the combustion of butane. Label the activation energy, E_a, and the enthalpy change, ΔH.

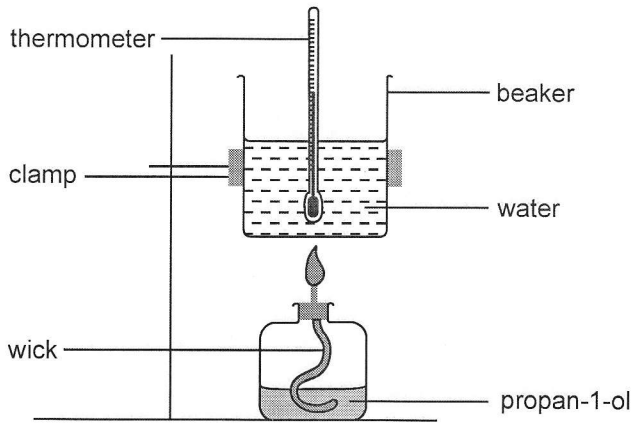


[3]

[Total 6 marks]

4. In an experiment to determine the standard enthalpy change of combustion of propan-

1-ol, C_3H_7OH, a student used the apparatus shown below.



(a) Define the term *enthalpy change of combustion*.

AS Qu 3 PART (ii)

[2]

(b) Write the equation for the standard enthalpy change of combustion of propan-1-ol, C_3H_7OH.

$C_3H_7OH_{(l)} + 5O_2 \longrightarrow 3CO_2 + 4H_2O$ [2]

(c) The student measured 50.0 cm^3 of water into the beaker and lit the burner. When the temperature of the water had gone up by 12.8 °C, he found that 0.100 g of propan-1-ol had been burnt.

(i) Calculate the energy, in kJ, produced by burning 0.100 g of propan-1-ol. The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.

$Q = \frac{M \times C \times \Delta T}{1000} \Rightarrow \frac{50 \times 4.18 \times 12.8}{1000}$ energy = 2.68 kJ

[2]

(ii) Calculate the number of moles of propan-1-ol in 0.100 g.

$MOLES = \frac{0.1}{60}$ number of moles = 0.00167

[2]

(iii) Calculate the enthalpy change of combustion, in kJ mol^{-1}, of propan-1-ol.

$\frac{2.68}{0.00167}$ -1605

enthalpy change ..... kJ mol^{-1}

[1]

(d) The student then calculated the error of the 50cm^3 measuring cylinder used. The

maximum error of the measuring cylinder was +- 1cm^3. Calculate the % error in this piece of apparatus. [1]

% error = $\frac{1}{50} \times 100 = 2\%$

(e) The student looked in a text book and found that the actual value for the standard enthalpy change of combustion of propan-1-ol was more exothermic than the experimental value.

Suggest **two** reasons for the difference between this value and the one he obtained experimentally.

1 HEAT LOSS TO THE SURROUNDINGS

2 EVAPORATION OF PROPANOL (OR WATER)

[2]

(f) The student told one of her friends and she suggested using a 10cm^3 measuring cylinder 5 times as its maximum error was +- 0.5cm^3

State and explain whether this method would reduce the error in measuring 50cm^3 of water. [1]

MULTIPLE USES i.e 5 TIMES

∴ ERROR WILL BE MULTIPLIED 5 TIMES

$\% = \frac{0.5}{10} \times 5 \times 100 = 25\%$ ∴ SMALLER THAN (d)

(g) The student repeated the experiment using the same apparatus. The water started at 60°C. The student was surprised to find the value was less exothermic. Explain why. [1]

THE WATER IS AT A HIGHER TEMPERATURE

∴ MORE HEAT WILL BE LOST TO THE SURROUNDINGS

OR SOME ENERGY WILL HAVE EVAPORATED SOME OF THE WATER

(h) Other students in the class got very similar enthalpy changes of combustion even though their temperature changes and masses of propan – 1 – ol burnt were different. Explain this in terms of energy and moles. [1]

ENTHALPY CHANGES ARE DEPENDANT UPON AMOUNT OF MOLES OF PROPANOL BURNT AND TEMPERATURE CHANGE.

[Total 15 marks]

THE ~~AMOUNT~~ TEMPERATURE CHANGE IS DEPENDANT UPON THE Nº OF MOLES OF PROPAN-1-OL BURNT ∴ ΔH's WILL BE SIMILAR

5. A student carries out an experiment to determine the enthalpy change of combustion of glucose. / $C_6H_{12}O_6$

In the experiment, 0.831 g of glucose is burned. The energy released is used to heat 100 cm^3 of water from 23.7 °C to 41.0 °C.

(i) Calculate the energy released, in kJ, during combustion of 0.831 g glucose.

The specific heat capacity of water = 4.18 J g^{-1} K^{-1}.
Density of water = 1.00 g cm^{-3}.

$Q = \frac{m \times C \times \Delta T}{1000}$ $\frac{100 \times 4.18 \times 17.3}{1000}$

energy = 7.23 kJ

[2]

(ii) Calculate the amount, in moles, of glucose that is burned.

MOLES = $\frac{0.831}{180}$

amount = 0.00462 mol

[2]

(iii) Calculate the enthalpy change of combustion of glucose.
Give your answer to **three** significant figures.

$\Delta H = \frac{7.23}{0.00462} = -1564.9 \Rightarrow -157$

ΔH_C = ... kJ mol^{-1}

[2]

[Total 6 marks]

6. Some reactions of H_2O_2 are exothermic. Use ideas about the enthalpy changes that take place during bond breaking and bond making to explain why some reactions are exothermic.

MORE ENERGY IS RELEASED WHEN NEW BONDS FORM THAN THE ENERGY REQUIRED TO BREAK THE INITIAL BONDS

[Total 2 marks]

7. The equations for the combination of gaseous atoms of carbon and hydrogen to form methane, CH_4, and ethane, C_2H_6, are shown below.

$C(g) + 4H(g) \rightarrow CH_4(g)$ $\quad \Delta H = -1652$ kJ mol^{-1}

$2C(g) + 6H(g) \rightarrow C_2H_6(g)$ $\quad \Delta H = -2825$ kJ mol^{-1}

REVERSE REACTIONS WILL BE ENDOTHERMIC AS BONDS ARE BROKEN (+)VE VALUES

Use this data to calculate:

(i) the bond enthalpy of a C–H bond,

bond enthalpy = ... kJ mol^{-1}

$\frac{1652}{4} = 413$ kJ mol^{-1} [1]

(ii) the bond enthalpy of a C–C bond.

bond enthalpy = ... kJ mol^{-1}

$(6 \times C\text{-}H) + (1 C\text{-}C) = 2825$

$2478 + (C\text{-}C) = 2825$

$C\text{-}C = 2825 - 2478$

$= 347$ kJ mol^{-1} [2]

[Total 3 marks]

8. Enthalpy changes can be calculated using enthalpy changes of combustion. The table below shows some values for standard enthalpy changes of combustion.

substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	−394
$H_2(g)$	−286
$CH_4(g)$	−890

COMBUSTION ∴ ARROWS DOWN

Use these values to calculate the standard enthalpy change of the reaction below.

(E) (F)

$C(s) + 2H_2(g) \rightarrow CH_4(g)$

-394

2×-286

-966

(-890)

$+890$

$CO_2 + 2H_2O$

$\Delta H = -966 + 890$

-76

standard enthalpy change = ... kJ mol^{-1}

[Total 3 marks]

9. Enthalpy changes of combustion can be used to determine enthalpy changes of formation.

(i) Write the equation for the standard enthalpy change of formation of butane, C_4H_{10}. Include state symbols in your answer.

$4C_{(s)} + 5H_{2(g)} \rightarrow C_4H_{10(l)}$

[2]

(ii) Use the following data to calculate the standard enthalpy change of formation of butane.

	standard enthalpy change of combustion / kJ mol^{-1}
carbon	–394
hydrogen	–286
butane	–2877

∴ ARROWS DOWN

(S) (F)

$4C_{(s)} + 5H_{2(g)} \rightarrow C_4H_{10(l)}$

$4 \times -394 = -1576$

$5 \times -286 = -1430$

-3006

(−2877) +2877

$4CO_2 + 5H_2O$

answer ..... kJ mol^{-1}

[3]

$-3006 + 2877 = -129$ kJ/mol

[Total 5 marks]

10. The standard enthalpy change of combustion of glucose can also be determined indirectly.

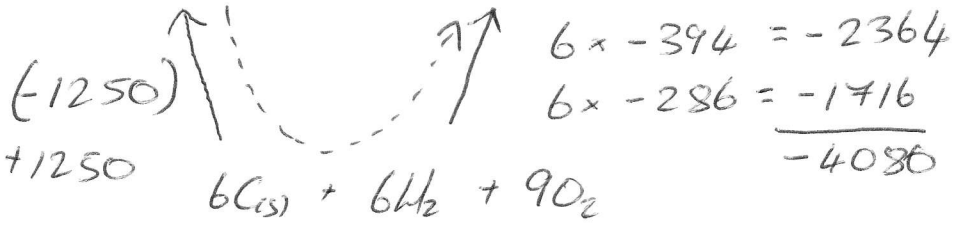
Calculate the standard enthalpy change of combustion of glucose using the standard enthalpy changes of formation below.

substance	$H_f^{\ominus}$ / kJ mol^{-1}
$C_6H_{12}O_6(s)$	–1250
$CO_2(g)$	–394
$H_2O(l)$	–286

FORMATION ∴ ARROWS UP.

S F

$C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$



+1250 + -4080

answer = −2830 kJ mol^{-1}

[Total 3 marks]