CfE HIGHER
CHEMISTRY
Chemistry In Society

Topic 4.1 Test

Enthalpy & Moles

Time allocation: 45 minutes

Reference can be made to the Data Booklet

Section A *Multiple Choice Questions* ***(12 marks)***

Section B *Written Questions* ***(20 marks)***

Section A - MULTIPLE CHOICE QUESTIONS

Q1.

Excess iron was added to 100 cm^3 of 1·0 mol l^{-1} copper(II) sulfate solution releasing 3·1 kJ of energy.

$$Fe_{(s)} + CuSO_{4(aq)} \rightarrow Cu_{(s)} + FeSO_{4(aq)}$$

What is the enthalpy change, in kJ mol^{-1} for the above reaction?

A –0·31
B –3·1
C –31
D –310

Q2.

The enthalpy of combustion of an alcohol is always the enthalpy change for

A the alcohol burning in 1 mole of oxygen
B the alcohol burning to produce 1 mole of water
C 1 mole of the alcohol burning completely in oxygen
D 1 mole of the alcohol burning to produce 1 mole of carbon dioxide.

Q3.

$$C_{(graphite)} + O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta H = -394 \text{ kJ mol}^{-1}$$

$$C_{(diamond)} + O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta H = -395 \text{ kJ mol}^{-1}$$

What is the enthalpy change, in kJ mol^{-1}, for the conversion of one mole of graphite into one mole of diamond?

A +789
B +1
C –1
D –789

Q4.

Which of the following gases has the same volume as 128·2 g of sulfur dioxide?

(All volumes are measured under the same conditions of temperature and pressure)

A 2·0 g hydrogen
B 8·0 g helium
C 32·0 g oxygen
D 80·8 g of neon

Q5.

$$2C_2H_{2(g)} + 5O_{2(g)} \rightarrow 4CO_{2(g)} + 2H_2O_{(l)}$$
ethyne

What volume of gas would be produced by the complete combustion of 100 cm^3 of ethyne gas?

All volumes were measured at atmospheric pressure and room temperature.

A 200 cm^3
B 300 cm^3
C 400 cm^3
D 800 cm^3

Q6.

A mixture of magnesium bromide and magnesium sulfate is known to contain 3 mol of magnesium and 4 mol of bromide ions.

How many moles of sulfate ions are present?

A 1
B 2
C 3
D 4

Q7.

$$C_{(s)} + H_{2(g)} + O_{2(g)} \rightarrow HCOOH_{(l)} \quad \Delta H = a$$
$$HCOOH_{(l)} + \tfrac{1}{2}O_{2(g)} \rightarrow CO_{2(g)} + H_2O_{(l)} \quad \Delta H = b$$
$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \quad \Delta H = c$$
$$H_{2(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} \quad \Delta H = d$$

What is the relationship between a, b, c and d?

A a = c + d – b

B a = b – c – d

C a = –b – c – d

D a = c + b + d

Q8.

Calcium carbonate reacts with nitric acid as shown.

$$CaCO_{3(s)} + 2HNO_{3(aq)} \rightarrow Ca(NO_3)_{2(aq)} + H_2O_{(l)} + CO_{2(g)}$$

0·05 mol of calcium carbonate was added to a solution containing 0·08 mol of nitric acid.

Which of the following statements is true?

A 0·05 mol of carbon dioxide is produced.

B 0·08 mol of calcium nitrate is produced

C Calcium carbonate is in excess by 0·01 mol.

D Nitric acid is in excess by 0·03 mol.

Q9.

$$5N_2O_{4(l)} + 4CH_3NHNH_{2(l)} \rightarrow 4CO_{2(g)} + 12H_2O_{(l)} + 9N_{2(g)} \quad \Delta H = -5116 \text{ kJ}$$

The energy released when 2 moles of each reactant are mixed and ignited is

A 2046 kJ

B 2558 kJ

C 4093 kJ

D 5116 kJ

Q10.

The enthalpy of combustion of methanol is –727 kJ mol^{-1}.

What mass of methanol has to be burned to produce 72·7 kJ?

A 3·2 g

B 32·0 g

C 72·7 g

D 727·0 g

Q11.

Aluminium reacts with oxygen to form aluminium oxide.

$$2Al_{(s)} + 1\tfrac{1}{2}O_{2(g)} \rightarrow Al_2O_{3(s)} \quad \Delta H = -1670 \text{ kJ mol}^{-1}$$

What is the enthalpy of combustion of aluminium in kJ mol^{-1}?

A –835

B –1113

C –1670

D +1670

Q12.

In the presence of bright light, hydrogen and chlorine react explosively. One step in the reaction is shown below.

$$H_{2(g)} + Cl_{(g)} \rightarrow HCl_{(g)} + H_{(g)}$$

The enthalpy change for this step can be represented as

A (H-H bond enthalpy) + (Cl-Cl bond enthalpy)

B (H-H bond enthalpy) – (Cl-Cl bond enthalpy)

C (H-H bond enthalpy) + (H-Cl bond enthalpy)

D (H-H bond enthalpy) – (H-Cl bond enthalpy)

Section B - WRITTEN QUESTIONS

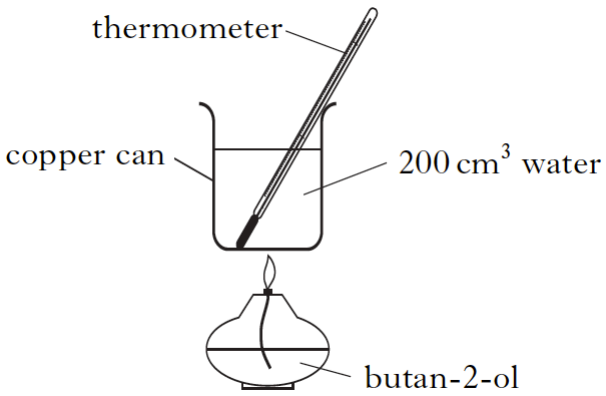
Q1 The enthalpies of combustion of some alcohols are shown in the table.

Name of alcohol	Enthalpy of combustion/kJ mol^{-1}
methanol	–727
ethanol	–1367
propan-1-ol	–2020

a) Using this data, predict the enthalpy of combustion of butan-1-ol, in kJ mol^{-1}.

1

b) A value for the enthalpy of combustion of butan-2-ol, C_4H_9OH, can be determined experimentally using the apparatus shown.



Mass of butan-2-ol burned = 1·0 g
Temperature rise of water = 40 °C

Use these results to calculate the enthalpy of combustion of butan-2-ol, in kJ mol^{-1}.

3

Q1 contd ***b)*** Enthalpy changes can also be calculated using Hess's Law.

The enthalpy of combustion of pentan-1-ol is

$$C_5H_{11}OH_{(l)} + {}^{17}/_{2}\,O_{2(g)} \rightarrow 5CO_{2(g)} + 6H_2O_{(l)}$$

Using the following data, calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)} \qquad \Delta H = -394 \text{ kJ mol}^{-1}$$

$$H_{2(g)} + \tfrac{1}{2}O_{2(g)} \rightarrow H_2O_{(l)} \qquad \Delta H = -286 \text{ kJ mol}^{-1}$$

$$5C_{(s)} + \tfrac{1}{2}O_{2(g)} + 6H_{2(g)} \rightarrow C_5H_{11}OH_{(l)} \qquad \Delta H = -354 \text{ kJ mol}^{-1}$$

Show your working clearly

2

Q2 Hydrogen and fluorine can react explosively to form hydrogen fluoride gas.

The equation for the reaction is shown. $H_{2(g)} + F_{2(g)} \rightarrow 2HF_{(g)}$

Using bond enthalpy values from the data booklet, calculate the enthalpy change for this reaction.

2

Q3 A student bubbled 240 cm^3 of carbon dioxide into 400cm^3 of 0·10 mol l^{-1} lithium hydroxide solution. The equation for the reaction is:

$$2LiOH_{(aq)} + CO_{2(g)} \longrightarrow Li_2CO_{3(aq)} + H_2O_{(l)}$$

Calculate the number of moles of lithium hydroxide that would not have reacted. (Take the molar volume of carbon dioxide to be 24 litres mol^{-1}.)

Show your working clearly.

2

Q4 Hydrogen sulfide is a toxic gas with the smell of rotten eggs. It can be prepared by the reaction of iron(II) sulfide with excess dilute hydrochloric acid:

$$FeS_{(s)} + 2HCl_{(aq)} \rightarrow FeCl_{2(aq)} + H_2S_{(g)}$$

Calculate the mass, in g, of iron(II) sulfide required to produce 79 cm^3 of hydrogen sulfide gas. (Take the molar volume of hydrogen sulfide to be 24 litres mol^{-1}.)

Show your working clearly.

3

Q5 A student prepared a sample of methyl cinnamate from cinnamic acid and methanol.

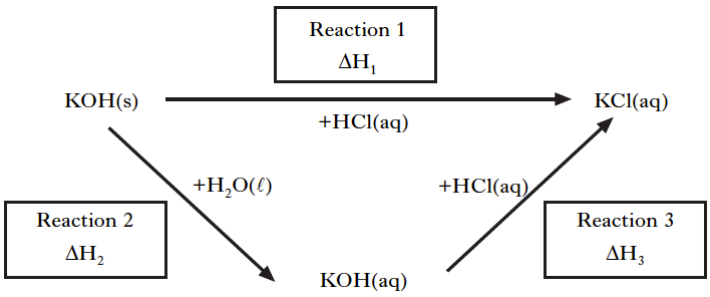
$$\underset{\text{mass of one mole} = 148\text{ g}}{\text{cinnamic acid}} + \underset{\text{mass of one mole} = 32\text{ g}}{\text{methanol}} \longrightarrow \text{methyl cinnamate} + \text{water}$$

6·5 g of cinnamic acid was reacted with 2·0 g of methanol.

Show, by calculation, that cinnamic acid is the limiting reactant. (One mole of cinnamic acid reacts with one mole of methanol.)
Show your working clearly.

2

Q6 a) Hess's Law can be verified using the reactions summarised below.



i) What is the mathematical relationship between ΔH_1 , ΔH_2 & ΔH_3 .

1

ii) Complete the list of measurements that would have to be carried out in order to determine the enthalpy change for Reaction 2.

Reaction 2

1. Using a measuring cylinder, measure out 25 cm^3 of water into a polystyrene cup.
2.
3. Weigh out accurately about 1·2 g of potassium hydroxide and add it to the water, with stirring, until all the solid dissolves.
4.

1

iii) Why was the reaction carried out in a polystyrene cup?

1

iv) Suggest an improvement to the procedure outlined above.

1

b) A student found that 1·08kJ of energy was released when 1·2 g of potassium hydroxide was dissolved completely in water.

Calculate the enthalpy of solution of potassium hydroxide.

1