

## O-level chemistry

### Calculations involving heat in reactions

Reaction involve energy change; exothermic reactions such as burning fire woods produce heat while endothermic reactions such as dissolution of ammonium chloride in water absorb heat.

The amount of heat absorbed or released in a reaction depend on

- Amounts of the reactants
- Temperature and
- Pressure at which a reaction is carried out.

When molar quantities are involved at 298K and 1 atmosphere, the resultant heat changes are referred to as standard heat/enthalpy changes given a symbol a symbol  $\Delta H$  (delta H).

Enthalpy changes ( $\Delta H$ ) (for exothermic reactions carry a negative sign because heat is lost from the system while enthalpy changes ( $\Delta H$ ) for endothermic reaction carry a positive sign because heat is gained by the system.

Heat is measured in joules ( J )

Each heat change is identified by names; the common ones are:

1. **Heat of combustion or enthalpy of combustion** of a substance is the heat change when 1 mole of substance is burnt completely in oxygen.

#### Experiment to determine enthalpy of combustion

A given mass ( $M_1$ g) of a substance of molecular mass,  $M_r$ , is burnt completely in excess oxygen. Heat liberated raises the temperature of ( $M_w$  g) of water through a temperature change of  $\theta^\circ$ .

Assumption

Heat liberated by a burning substance = heat absorbed by water  
=  $M_w C \theta$  (where C = specific heat capacity of water)

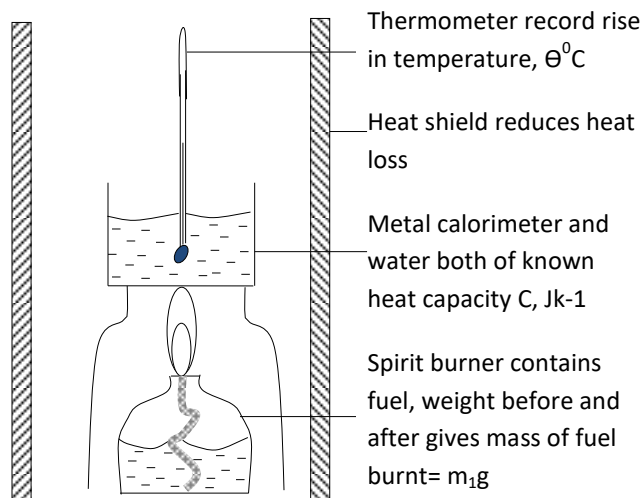
$$\begin{aligned} \Rightarrow M_1 \text{ g of the substance produce} & \quad M_w C \theta \text{ J} \\ \Rightarrow M_r \text{ g of substance produce} & \quad \frac{M_w C \theta \times M_r}{M_1} \text{ Jmol}^{-1}. \end{aligned}$$

Therefore, enthalpy of combustion of the substance =  $\frac{M_w C \theta \times M_r}{M_1} \text{ Jmol}^{-1}$

Experimental depends on whether a fuel is a liquid or a solid.

## Experimental method for finding enthalpy of combustion a liquid fuel

The figure below shows a simple method for obtaining approximate value for the enthalpy of combustion of a fuel.



### Calculations

#### Assumption

Heat produced by combusting fuel = Heat gained by calorimeter and water

Heat gained by calorimeter and water =  $C\theta$  joules

It implies that

$m_1\text{g}$  of fuel produce =  $C\theta$  joules

Mr (mass equivalent to 1 mole of fuel) produces =  $\frac{MrC\theta}{m_1}$  joulesmol<sup>-1</sup>

### Example 1

When 23g of ethanol completely burnt, 13600KJ of heat was produced.

Calculate the molar heat of combustion of ethanol (C = 12, H = 1, O = 16)

#### solution

Formula mass of ethanol ( $\text{CH}_3\text{CH}_2\text{OH}$ ) =  $12 \times 2 + 6 + 16 = 46$

23g of ethanol liberate 13600KJ

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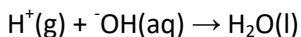
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Then, 46g of ethanol liberate  $\frac{13600 \times 46}{23} = 27200 \text{kJ}$

Therefore, the enthalpy of combustion of ethanol =  $27200 \text{kJmol}^{-1}$ .

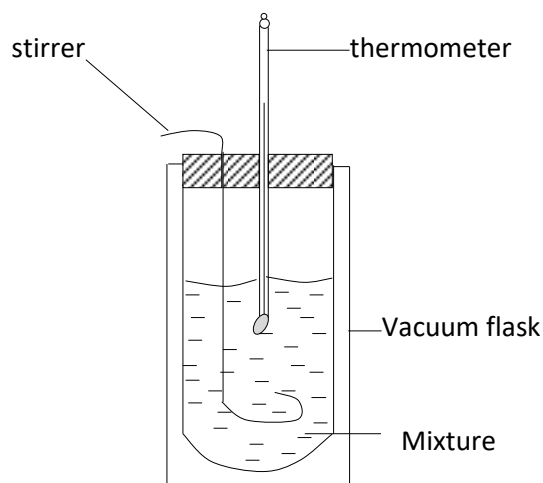
## 2. Enthalpy of neutralization

This refers to enthalpy change for the formation 1 mole of water from hydrogen and hydroxide ions



### Measurement of standard enthalpy of neutralization

The heat released when a known amount of water is formed is found by measuring the temperature produced in a calorimeter and its contents.



NB. A vacuum flask is used to minimize heat losses

Known volume of standard acid ( $V_1$ ) and alkali ( $V_2$ ) are added to calorimeter, and temperature change  $\theta^\circ\text{C}$  is noted. The number of moles of water formed,  $M_w$ , is calculated

### Calculations

Heat given out = Heat received by  
By water calorimeter of capacity, C.

$$\text{Total volume} = (V_1 + V_2) \text{cm}^3$$

Given that the density of solution = density of water (or  $1 \text{gcm}^{-3}$ )

$$\text{Mass of water, } m = (V_1 + V_2) \text{g}$$

Heat =  $mc\theta$  J (where c is the specific heat capacity)

Amount of water formed =  $m_w$  moles

The standard enthalpy of neutralization is  $(mc\theta)/m_w \text{Jmol}^{-1}$ .

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### Example 2

250 cm<sup>3</sup> of 0.40M NaOH were added to 250cm<sup>3</sup> of 0.40M HCl in the calorimeter. The temperature of the two solutions was 17.5°C and rose to 20.1°C

Calculate the enthalpy of neutralization assuming that the specific heat capacities of solution are the same as that of water = 4180J kg<sup>-1</sup> K<sup>-1</sup>.

Solution

$$\text{Temperature rise} = 20.1 - 17.5 = 2.6^{\circ}\text{C}$$

$$\begin{aligned}\text{Mass of solution} &= \text{total volume of solution} \\ &= (250 + 250) = 500\text{g}\end{aligned}$$

$$\begin{aligned}\text{Heat liberated} &= mc\theta \\ &= 500 \times 4.180 \times 2.6 \\ &= 5434\text{J}\end{aligned}$$

Mole of water produced = moles of NaOH or moles of HCl

$$= \frac{250 \times 0.4}{1000} = 0.1\text{mole}$$

0.1mole of water require = 5434J

$$1 \text{ mole of water require} = \frac{5434 \times 1}{0.1} = 54340 \text{ J}$$

Therefore, enthalpy of neutralization of water = 54340Jmol<sup>-1</sup>

### Exercise

1	When 1 gram of methanol is burnt in excess air 22.6kJ of heat was liberated. What is the quantity of heat in kJ liberated when 1 mole of methanol was burnt under similar conditions A. 22.6      B. 32      C. 723.2      D. 777.8
2	5.3kJ of energy are required to vaporize 13g of a liquid X (molecular mass of X = 78) The molar heat of vaporization of X in kJ/mole is A. $\frac{5.3 \times 78}{13}$ B. $\frac{13 \times 78}{5.3}$ C. $\frac{5.3 \times 13}{78}$ D. 5.3 x 13 x 78
3	When 0.4g of ethanol was burnt, it raised the temperature of 0.1kg of water by 20°C. the heat of combustion of ethanol is (specific heat capacity of water = 4.2kJ/kg/°C, C <sub>2</sub> H <sub>5</sub> OH = 46) A. $\frac{4.2 \times 20 \times 46}{0.1 \times 0.4} \text{ kJmol}^{-1}$ B. $\frac{0.14 \times 4.2 \times 20}{46 \times 0.1} \text{ kJmol}^{-1}$ C. $\frac{0.1 \times 4.2 \times 20 \times 46}{0.4} \text{ kJmol}^{-1}$ D. $\frac{0.1 \times 20 \times 46}{46 \times 0.4} \text{ kJmol}^{-1}$

4	<p>Glucose burn according to the following equation below giving out <math>2802\text{kJmol}^{-1}</math> of heat energy.</p> $\text{C}_6\text{H}_{12}\text{O}_6(\text{s}) + 6\text{O}_2(\text{g}) \longrightarrow 6\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$ <p>The amount of heat produced when 18g of glucose is burnt in oxygen at the same temperature is (H = 1, C = 12, O =16)</p> <p>A. <math>\frac{2802 \times 18}{180 \times 25}</math>    B. <math>\frac{180}{2802 \times 18}</math>    C. <math>\frac{180 \times 25 \times 18}{2802}</math>    D. <math>\frac{2802 \times 18}{180}</math></p>
5	<p>Graphite burns in oxygen according to he following equation</p> $\text{C}(\text{s}) + \text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) \quad \Delta\text{H} = -390\text{kJmol}^{-1}$ <p>When 48g of graphite is burnt in oxygen the heat produced is</p> <p>A. -97.5kJ    B. -195kJ    C. -780kJ    D. -1560kJ</p> <p>(C = 12, O = 16, H = 1)</p>
6	<p>The formation of methanol from hydrogen and carbon monoxide is represented by equation</p> $2\text{H}_2(\text{g}) + \text{CO}(\text{g}) \longrightarrow \text{CH}_3\text{OH}(\text{g}) \quad \Delta\text{H} = -92\text{kJmol}^{-1}$ <p>What would be the energy released, in kJ, when 3.2g of methanol is formed?</p> <p>A. 2.9    B. 3.6    C. 9.2    D. 10.2</p>
7	<p>When 2.0g of substance X were burnt the heat produced raised the temperature of 1000g of water by <math>15.6^\circ\text{C}</math>. The molar heat of combustion of X in joules is (the specific heat capacity of water is <math>4.2\text{Jg}^{-1}\text{C}^{-1}</math>, relative molecular mass of X is 60)</p> <p>A. <math>\frac{1000 \times 4.2 \times 15.6 \times 20}{60}</math>    B. <math>\frac{15.6 \times 60 \times 1000}{2.0 \times 4.2}</math>    C. <math>\frac{15.6 \times 2.0 \times 1000}{4.2 \times 60}</math>    D. <math>\frac{4.2 \times 15.6 \times 60}{2}</math></p>
8	<p>Methanol burns in excess air according to the equation</p> $2\text{CH}_3\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g}) + 4\text{H}_2\text{O}(\text{l}) \quad \Delta\text{H} = -730\text{kJmol}$ <p>The amount of heat liberated when 3.2g of methanol (Mr = 32) is burnt completely is</p> <p>A. 73kJ    B. 730kJ    C. 1416kJ    D. 2929kJ</p>
9	<p>Carbon reacts with sulphur according to the following equation</p> $\text{C}(\text{s}) + 2\text{S}(\text{s}) \longrightarrow \text{CS}_2(\text{s}) \quad \Delta\text{H} = 116\text{kJ}$ <p>The amount of heat absorbed when 16g of sulphur reacts with excess carbon is (C = 12, S = 32)</p> <p>A. 7kJ    B. 29kJ    C. 58kJ    D. 116kJ</p>

10	<p>When 8g of salt was dissolved in 100g of water the temperature decreased by 10<sup>0</sup>C. The drop in temperature when 2g of the salt is dissolved in 100g of water would be ( H = 1, O = 16)</p> <p>A. 10<sup>0</sup>C      B. 8.5<sup>0</sup>C      C. 5.0<sup>0</sup>C      D. 2.5<sup>0</sup>C</p>
11	<p>Ethanol burns in oxygen according to the following equation</p> $C_2H_5OH(l) + \frac{7}{2} O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(l) \quad \Delta H = -1185kJ$ <p>Calculate heat given out when 0.2moles of ethanol is burnt completely</p> <p>A. -237kJ      B. -592kJ      C. -1185kJ      D. -2370kJ</p>
12	<p>Carbon monoxide reacts with hydrogen according to the equation</p> $CO(g) + 2H_2(g) \longrightarrow CH_3OH(l) \quad \Delta H = +91kJmol^{-1}$ <p>What mass of carbon monoxide would cause heat change of +188.2kJ (H = 1, C =12, O = 16)</p> <p>A. 2g      B. 28g      C. 58g      D. 273g</p>
13	<p>13.7kJ of heat was evolved when 4.0g of copper was displaced from copper (II) sulphate solution by zinc. The amount heat evolved when one mole of copper was displaced is</p> <p>A. <math>\frac{63.5 \times 4}{13.7}</math>      B. <math>\frac{13.7 \times 63.5}{4}</math>      C. <math>\frac{13.7 \times 4}{63.5}</math>      D. <math>\frac{63.5}{13.7 \times 4}</math></p>
14	<p>Carbon burns in excess oxygen according to the equation</p> $C(s) + O_2(g) \longrightarrow CO_2(g) \quad \Delta H = -393kJ$ <p>What mass of carbon in grams would produce 750kJ of energy</p> <p>A. <math>\frac{393 \times 12}{750}</math>      B. <math>\frac{750 \times 12}{393000}</math>      C. <math>\frac{750 \times 12}{393}</math>      D. <math>\frac{750 \times 393}{12}</math></p>
15	<p>10g of methanol, CH<sub>3</sub>OH, burns in air to liberate 226kJ of heat. The amount of heat liberated when 1 mole of methanol is burnt in air is (H=1, C = 12)</p> <p>A. <math>\frac{32 \times 226}{10}</math>      B. <math>\frac{10 \times 32}{226}</math>      C. <math>\frac{10}{32 \times 226}</math>      D. <math>\frac{10 \times 226}{32}</math></p>
16	<p>When 1.0g of carbon is burnt in excess oxygen, the heat produced raises the temperature of 400g of water by 19<sup>0</sup>C. the heat of combustion of carbon is (C =12, specific heat capacity of water is 4.2kJkg<sup>-1</sup>K<sup>-1</sup>)</p> <p>A. 0.4 x 4.2 x 19 x 12kJmol<sup>-1</sup></p> <p>B. <math>\frac{0.4 \times 4.2}{12 \times 19} kJmol^{-1}</math></p> <p>C. 400 x 4.2 x 19 x 12kJmol<sup>-1</sup></p>

	D. $\frac{12 \ 19 \times 19}{0.4 \times 4.2} \text{kJmol}^{-1}$
17	<p>Ethanol burns in oxygen according to the following equation</p> $\text{CH}_3\text{CH}_2\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$ <p>Calculate the amount of heat evolved when 45g of oxygen is used for complete combustion of ethanol. (C= 12, H = 1, O = 16, the molar heat of combustion of ethanol is 1370.0kJmol<sup>-1</sup>)</p> <p>A. 642.2kJ      B. 1284.4kJ      C. 1340.2kJ      D. 1926.6kJ</p>
18	<p>When 1 mole of ammonium chloride was dissolved in a certain volume of water, 2.94kJ of heat was absorbed. The amount heat absorbed when 5.35g of ammonium chloride is dissolved in the same volume of water is (NH<sub>4</sub>Cl = 53.5)</p> <p>A. <math>\frac{53.5}{2.94 \times 5.53} \text{kJ}</math>      B. <math>\frac{2.94 \times 5.35}{53.5} \text{kJ}</math>      C. <math>\frac{29.4 \times 53.5}{5.35}</math>      D. <math>\frac{53.5 \times 5.35}{2.94}</math></p>
19	<p>When 2.3g of ethanol was completely burnt in oxygen, heat evolved raised the temperature of 100g of water by 30°C. the molar heat of combustion of ethanol is [The molar heat of combustion of ethanol in joule is (the molar mass of ethanol = 46 and the specific heat capacity of water = 4.2Jg<sup>-1</sup>K<sup>-1</sup>)</p> <p>A. <math>\frac{100 \times 4.2 \times 30 \times 46}{2.3}</math>      B. <math>\frac{30 \times 4.2 \times 2.3 \times 100}{46}</math>      C. <math>\frac{20 \times 4.2 \times 2.3 \times 100}{46}</math>      D. <math>\frac{20 \times 4.2 \times 46 \times 100}{2.3}</math></p>
20	<p>When 2.4g of magnesium was reacted with 200cm<sup>3</sup> of 2M hydrochloric acid, 13.6kJ of heat was evolved. The molar heat of reaction of magnesium with the acid is (Mg = 24)</p> <p>A. <math>\frac{13.6 \times 200}{24 \times 2.4} \text{kJ}</math>      B. <math>\frac{13.6 \times 24}{2.4 \times 200}</math>      C. <math>\frac{2.4 \times 24}{13.6} \text{kJ}</math>      D. <math>\frac{24 \times 13.6}{2.4} \text{kJ}</math></p>
21	<p>Butane undergoes combustion according to the following equation:</p> $2\text{C}_4\text{H}_{10}(\text{g}) + 13\text{O}_2(\text{g}) \longrightarrow 8\text{CO}_2(\text{g}) + 10\text{H}_2\text{O}(\text{l}) + \text{heat}$ <p>The mass of butane required to produce 950kJ of heat is</p> <p>(H = 1, C = 12, 1 mole of butane produces 2877kJ of heat)</p> <p>A. <math>\frac{950 \times 58}{2 \times 2877} \text{g}</math>      B. <math>\frac{950 \times 58}{2877}</math>      C. <math>\frac{950 \times 52 \times 2}{2877}</math>      D. <math>\frac{2877 \times 58}{950}</math></p>

## Section B

22.	(a)	What is meant by enthalpy of neutralization? (02marks)
	(b)	When 50.0cm <sup>3</sup> of 1M sulphuric acid was added to 50cm <sup>3</sup> of 2M sodium hydroxide, the temperature rose by 13.6 <sup>o</sup> C.  (i) Write ionic equation for the reaction that took place (01 mark) (ii) Calculate the enthalpy of neutralization of sodium hydroxide. (specific heat capacity of water = 4.2Jmol <sup>-1</sup> , density of water 1g/cm <sup>3</sup> (3marks)
23		Biogas contain mainly methane.
	(a)	Name two raw materials that can be used to produce biogas
	(b)	Methane burns in oxygen according to the following equation  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \quad \Delta H = -890\text{kJmol}^{-1}$ Calculate the volume of methane at s.t.p that will produce 2670kJ.
24	(a)	50cm <sup>3</sup> of 2M HCl and 50cm <sup>3</sup> of 2M NaOH each at 22 <sup>o</sup> C were mixed in a plastic beaker. The mixture was stirred and its maximum temperature was 35 <sup>o</sup> C. [heat capacity of solution is 4.2kJkg <sup>-1</sup> <sup>o</sup> C, density of water = 1gcm <sup>-3</sup> ]  (i) Write ionic equation for the reaction. (ii) Calculate the heat of reaction
	(b)	50cm <sup>3</sup> of 2M ammonia was used instead of 2M NaOH in (a). State whether the heat of the reaction was greater than, equal to or less than the value obtained in (a)(ii) above. Explain your answer.
25	(a)	Write equation for complete combustion of methane
	(b)	A litre of methane gas costs 600/=. Calculate the cost of methane required to produce 1746 x 10 <sup>3</sup> J of heat. ( 1mole of a gas occupies 24dm <sup>3</sup> at room temperature, heat of combustion of methane is -882kJmol <sup>-1</sup> )
26	(a)	Define the term enthalpy of combustion (02marks)
	(b)	With the aid of a diagram describe an experiment you would carry out in a laboratory to determine the enthalpy of combustion of propanol (9marks)
	(c)	In an experiment to determine the enthalpy of combustion of propanol, 0.54g of propanol was burnt and the heat evolved caused the temperature of 150cm <sup>3</sup> of water to rise by 21.5 <sup>o</sup> C ( molar mass of propanol = 60, density of water is 1gcm <sup>-3</sup> , specific heat capacity of



		<p>water = <math>4.1\text{Jg}^{-1}</math>)</p> <p>Calculate heat capacity experiment value of enthalpy of combustion of propanol (3 ½ marks)</p>
27		<p>Ethane burns in oxygen according to the following equation</p> $2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g}) \longrightarrow 4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{l})$ <p>When 2.0g of ethane was burnt in excess oxygen, 104kJ of heat was produced.</p> <p>Calculate</p>
	(a)	Mass of water formed (03marks)
	(b)	Molar heat of combustion of ethane (02marks)
28	(a)	What is meant by the term enthalpy of combustion? (02mark)
	(b)	<p>Ethanol burns in oxygen according to the following equation</p> $\text{C}_2\text{H}_5\text{OH}(\text{l}) + 3\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l}) \quad \Delta H = -1360\text{kJmol}^{-1}$ <p>Calculate the mass of ethanol that is required to raise the temperature of <math>1000\text{cm}^3</math> of water by <math>10.0^\circ\text{C}</math> (03marks) (specific heat capacity of water = <math>4.2\text{Jg}^{-1}\text{K}^{-1}</math>)</p>

Answers

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1	C	<p>Formula mass of methanol, <math>\text{CH}_3\text{OH} = 12+3+16 +1 = 32</math></p> <p>1g of methanol produce 22.6kJ</p> <p>32g (1mole) produce <math>22.6 \times 32 = 723.2\text{kJ}</math></p>
2	B	<p>5.3g of X require 5.3kJ</p> <p>78g of X require <math>\frac{5,3 \times 78}{13} \text{ kJ}</math></p>
3	C	<p>Heat = <math>mc\theta = (0.1 \times 4.2 \times 20)\text{kJ}</math></p> <p>0.4g of ethanol produce <math>(0.1 \times 4.2 \times 20)\text{kJ}</math></p> <p>46g of ethanol produce <math>\frac{0.1 \times 4.2 \times 20 \times 46}{0.4}</math></p>
4	D	<p>Formula mass <math>\text{C}_6\text{H}_{12}\text{O}_6</math> weigh <math>6 \times 12 + 12 \times 1 + 16 \times 6 = 180</math></p> <p>180g glucose produce 2802 kJ</p> <p>18g of glucose produce <math>\frac{2802 \times 18}{180} \text{ kJ}</math></p>
5	D	<p>12g produce 390kJ</p> <p>48g produce <math>\frac{390 \times 48}{12} = 1560\text{kJ}</math></p>
6	C	<p>Formula mass of methanol, <math>\text{CH}_3\text{OH} = 32</math></p> <p>32g of <math>\text{CH}_3\text{OH}</math> produce 92kJ</p> <p>3.2g of <math>\text{CH}_3\text{OH}</math> produce <math>\frac{92 \times 3.2}{32} = 9.2\text{kJ}</math></p>
7	D	<p>Heat = <math>mc\theta = (1000 \times 4.2 \times 15.6)\text{J}</math></p> <p>2g of X produce <math>(1000 \times 4.2 \times 15.6)\text{J}</math></p> <p>60g of X produce <math>\frac{1000 \times 4.2 \times 15.6 \times 60}{2} \text{ Jmol}^{-1}</math></p>

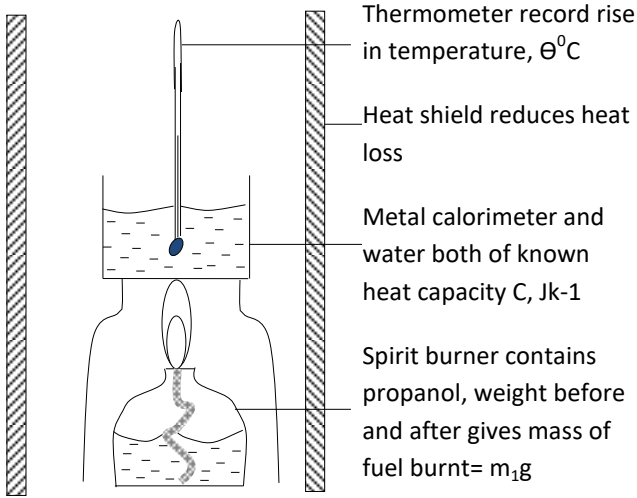
8	A	32g of methanol produce 730kJ 3.2 g of methanol produce $\frac{730 \times 3.2}{32} = 73kJ$
9	B	(2 x 32)g of sulphur produce 116kJ 16g of sulphur produce $\frac{116 \times 16}{64} = 29kJ$
10	D	8g cause a drop in temperature of 10 <sup>0</sup> C 2g will cause a drop in temperature of $\frac{2 \times 10^0}{8} = 2.5^0C$
11	A	1 mole of ethanol produce 1185 kJ 0.2mole produce 0.2 x 1185
12	C	Formula mass of CO = 12 + 16 = 28 91kJ is absorbed by 28g of CO 1882kJ is absorbed by $\frac{1882 \times 28}{91} = 57.9g$
13	B	4.0g of copper produce 13.7kJ 63.5g of copper produce $\frac{63.5 \times 13.7}{4} g$
14	C	393kJ are produced by 12g of carbon 750kJ require $\frac{750 \times 12}{393} g$
15	D	Formula mass of CH <sub>3</sub> OH = 12 + 3 x 1 + 16 + 1 = 32g 10g of methanol produce 226kJ 32g (1mole) produce $\frac{226 \times 32}{10} kJ$
16	A	$400g = \frac{400}{1000} = 0.4kg$ Heat produced = mcθ = (0.4 x 4.2 x 19)kJ 1g of carbon produces (0.4 x 4.2 x 19)kJ 12g produce $\frac{(0.4 \times 4.2 \times 19 \times 12)}{1} kJ$

17	B	<p>Formula mass of <math>O_2 = 16 \times 2 = 32</math></p> <p>(3 x 32) g of oxygen produce 1370kJ</p> <p>45g of oxygen produce = <math>\frac{1370 \times 45}{3 \times 32}</math></p>
18	B	<p>Formula mass of <math>NH_4Cl = 14 + 1 \times 4 + 35.5 = 53.5</math></p> <p>53.5g of <math>NH_4Cl</math> absorb 2.94kJ</p> <p>5.35g of <math>NH_4Cl</math> absorb <math>\frac{5.35 \times 2.94}{53.5}</math></p>
19	A	<p>Formula mass of ethanol, <math>CH_3CH_2OH = 12 + 3 + 12 + 2 + 16 + 1 = 46</math></p> <p>Heat = <math>mc\theta = (100 \times 4.2 \times 30)J</math></p> <p>2.3g of ethanol produce (100 x 4.2 x 30)J</p> <p>46g of ethanol produce <math>\frac{0.1 \times 4.2 \times 30 \times 46}{2.3} J</math></p>
20	D	<p>2.4g of magnesium produce 13.6kJ</p> <p>24g of magnesium produce <math>\frac{24 \times 13.6}{2.4}</math></p>
21	B	<p>Formula mass of butane, <math>C_4H_{10} = 4 \times 12 + 1 \times 10 = 58</math></p> <p>2877kJ is produced by 58g of butane</p> <p>950kg is produced by <math>\frac{58 \times 950}{2877}</math></p>

Section B

22	(a)	Enthalpy of neutralization is enthalpy change when 1 mole of water is formed from aqueous hydrogen and hydroxyl ions.
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	(b)	<p>(i) <math>\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})</math></p> <p>(ii) total volume of water = <math>50 + 50 = 100\text{cm}^3</math></p> <p>Mass of water = <math>100 \times 1 = 100\text{g}</math></p> <p>Heat liberated = <math>mc\theta = 100 \times 4.2 \times 13.6 = 5712\text{J}</math></p> <p>Mole of water formed = moles NaOH = <math>\frac{50 \times 2}{1000} = 0.1 \text{ mole}</math></p> <p>Production of 0.1mole of water produce 5712J</p> <p>1mole of water produced <math>\frac{5712 \times 1}{0.1} 57120\text{J} = 57.12\text{kJmol}^{-1}</math></p>
23	(a)	Cow dung, water, plant remaining
	(b)	<p>Formula mass of <math>\text{CH}_4 = 12 + 4 = 16</math></p> <p>890kJ are produced by 16g of methane</p> <p>2670kJ are produced by <math>\frac{16 \times 2670}{890} = 48\text{g}</math></p>
24	(a)	$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \longrightarrow \text{H}_2\text{O}(\text{l})$
	(b)	<p>total volume of water = <math>50 + 50 = 100\text{cm}^3</math></p> <p>Mass of water = <math>100 \times 1 = 100\text{g}</math></p> <p>Temperature change = <math>35 - 22 = 13^\circ\text{C}</math></p> <p>Heat liberated = <math>mc\theta = 100 \times 4.2 \times 13 = 5460\text{J}</math></p> <p>Mole of water formed = moles NaOH = <math>\frac{50 \times 2}{1000} = 0.1 \text{ mole}</math></p> <p>Production of 0.1mole of water produce 5460J</p> <p>1mole of water produced <math>\frac{5460 \times 1}{0.1} 54600\text{J} = 54.6\text{kJmol}^{-1}</math></p>
	(b)	It would be less because ammonia is a weak base

25	(a) $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$
	(b) Formula mass of $\text{CH}_4 = 12 + 4 = 16$ 882kJ are produce by 24 l 1746kJ require $\frac{1746 \times 24}{882} = 47.5\text{l}$ Cost of 47.5l of methane = $47.5 \times 600 = 28500/=$
26	Ethnalpy of combustion is entalpy change when 1 mole of a substance is completely burnt in oxygen.
	<p><b>Experimental method for finding enthalpy of combustion a liquid fuel</b></p> <p>The figure below shows a simple method for obtaining approximate value for the enthalpy of combustion of a propanol.</p> <div style="display: flex; align-items: center;">  </div> <p>Calculations</p> <p>Assumption</p> <p>Heat produced by combusting fuel = Heat gained by calorimeter and water</p> <p>Heat gained by calorimeter and water = <math>C\Theta</math> joules</p> <p>It implies that</p> <p><math>m_1\text{g}</math> of fuel produce = <math>C\Theta</math> joules</p> <p>Mr (mass equivalent to 1 mole of fuel) produces = <math>\frac{MrC\Theta}{m_1}</math> joulesmol<sup>-1</sup></p>

	(b)	<p>Mass of water = <math>150 \times 1 = 150\text{g}</math>  Heat = <math>mc\theta = 150 \times 4.2 \times 21.5 = 13545\text{J}</math>  0.54g of propanol produce 13545J  60g of propanol produce <math>\frac{13545 \times 60}{0.54} = 1505\text{kJ}</math></p>
27	(a)	<p>Formula mass of ethane <math>\text{C}_2\text{H}_6 = 2 \times 12 + 6 \times 1 = 30</math>  Formula mass of water, <math>\text{H}_2\text{O} = 1 \times 2 + 16 = 18</math>  (2 x 30) g of ethane produce (6 x 18) g of water  2g of ethane produce <math>\frac{2 \times 6 \times 18}{2 \times 30} = 3.6\text{g of water}</math></p>
	(b)	<p>2g of ethane produce 104kJ  30g (1mole) of ethane produce <math>\frac{30 \times 104}{2} = 1560\text{kJ}</math></p>
28	(a)	<p>Enthalpy of combustion is the enthalpy change when 1 mole of a substance is burnt completely in oxygen.</p>
	(b)	<p>Formula mass of ethanol <math>\text{C}_2\text{H}_5\text{OH} = 2 \times 12 + 6 + 16 = 46</math>  Mass of water = volume of water = 1000g  Heat = <math>mc\theta = 1000 \times 4.2 \times 10 = 42000\text{J}</math>  2g of ethanol produce 42000J  30g of ethanol produce <math>\frac{42000 \times 30}{2} = 630\text{kJ}</math></p>