

## Introduction

All chemical reactions are accompanied by energy changes which are observed in temperature changes.

The substances involved may lose energy to the surrounding and the reaction is said to be exothermic or

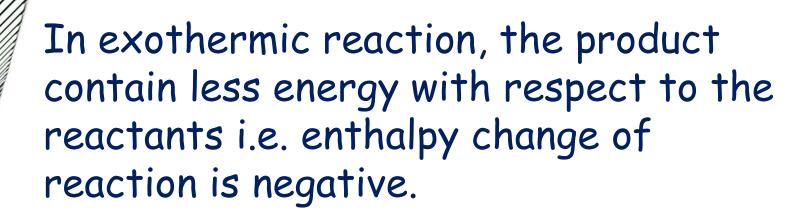


The heat given out or absorbed when a chemical reaction takes place is called enthalpy change/heat change,  $\Delta H$ 

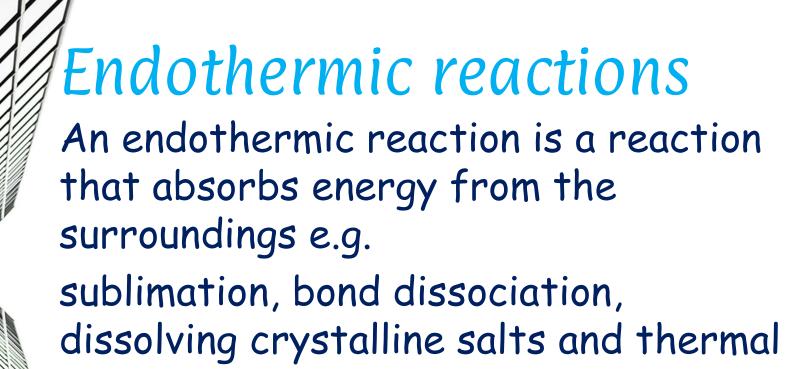


An exothermic reaction is a reaction that releases energy to the surroundings e.g.

neutralization, combustion, dissolving anhydrous salts, displacement reaction, bond formation.



Thus the temperature of the surrounding increases.



decomposition.

In endothermic reaction, the products contain more energy with respect to the reactants i.e. enthalpy change of reaction is positive.

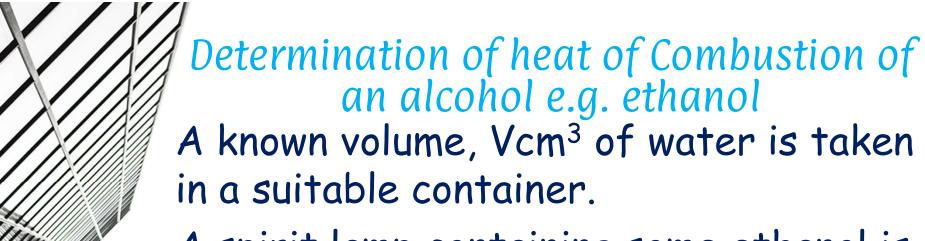
Thus the temperature of the surrounding decreases.

# Heat of combustion

Heat (Enthalpy) of combustion is the heat evolved when **one mole** of a substance is completely burnt in oxygen.

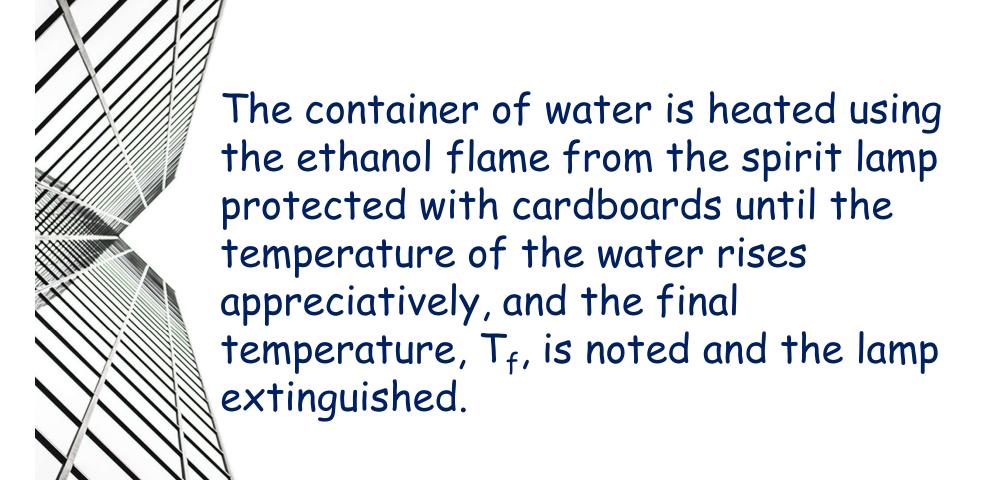
$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(1)$$

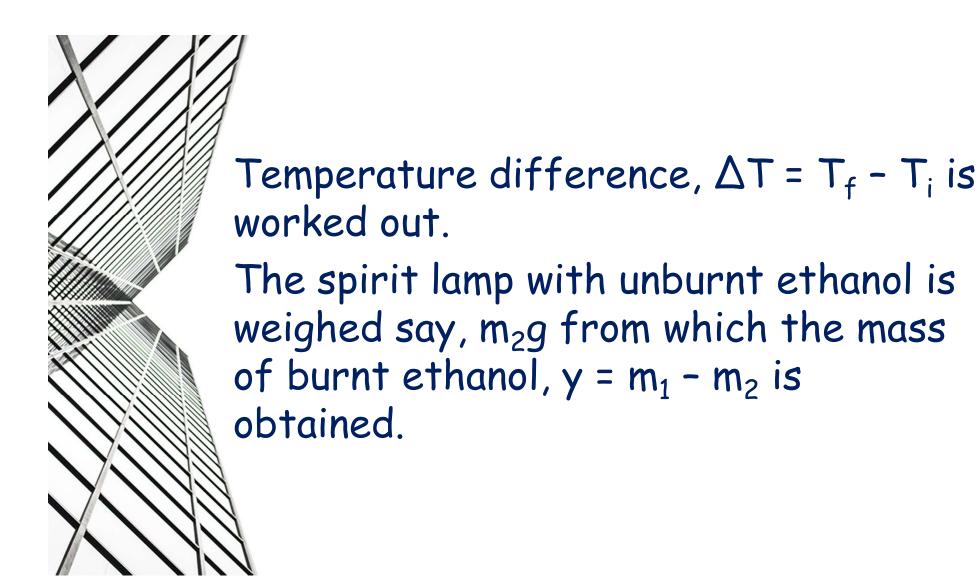
$$C_2H_6(g) + \frac{7}{2}O_2(g) \longrightarrow 2CO_2(g)$$

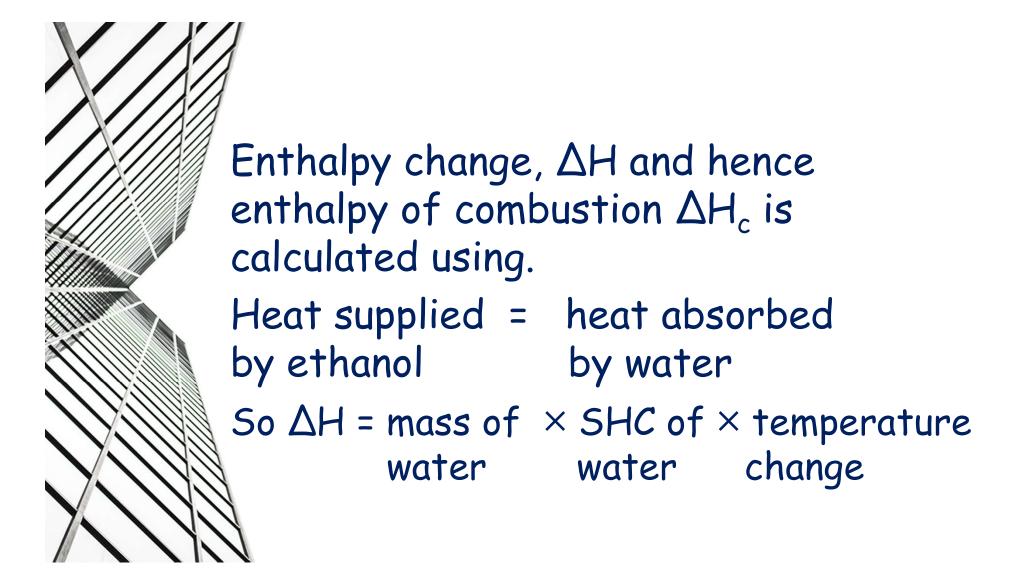


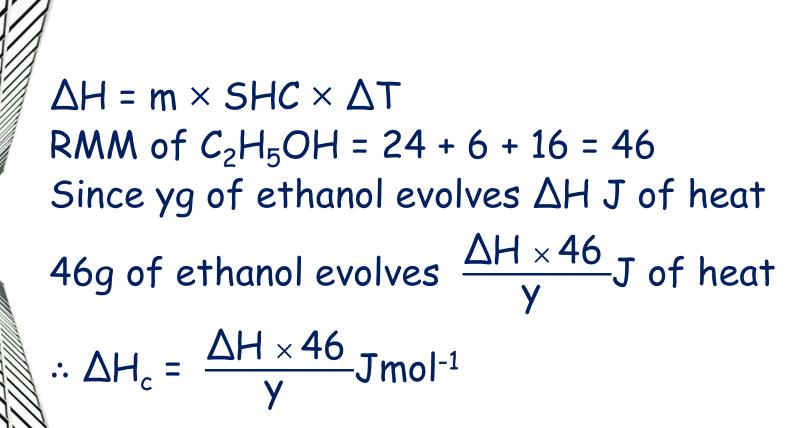
A spirit lamp containing some ethanol is weighed say,  $m_1g$ .

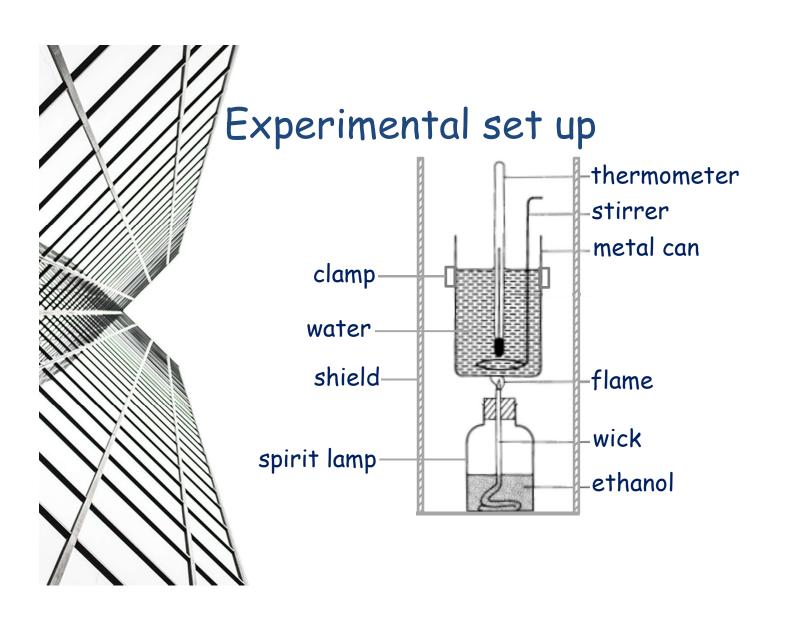
Initial temperature,  $T_i$ , of water in the container is noted.

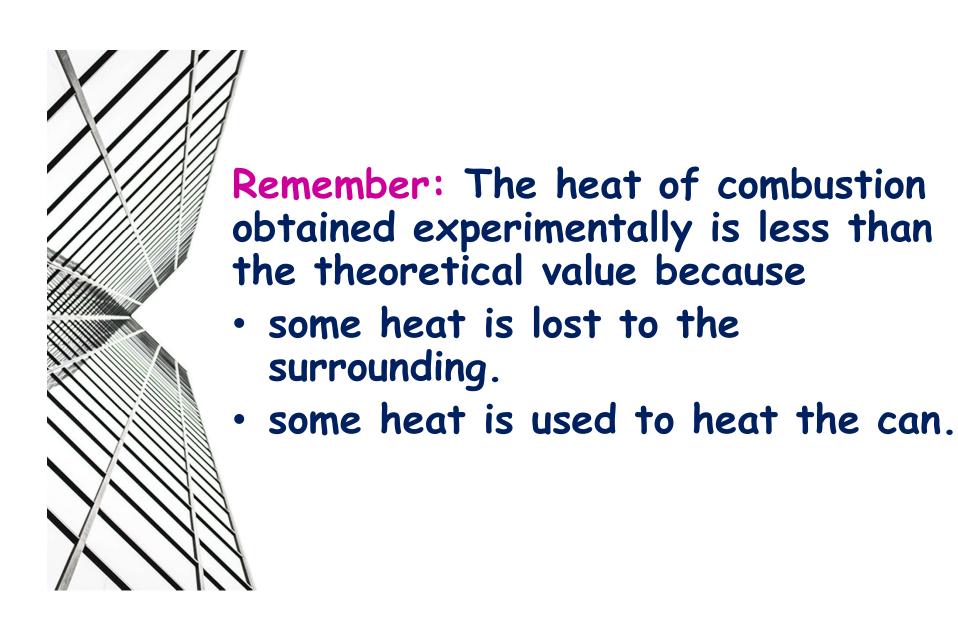


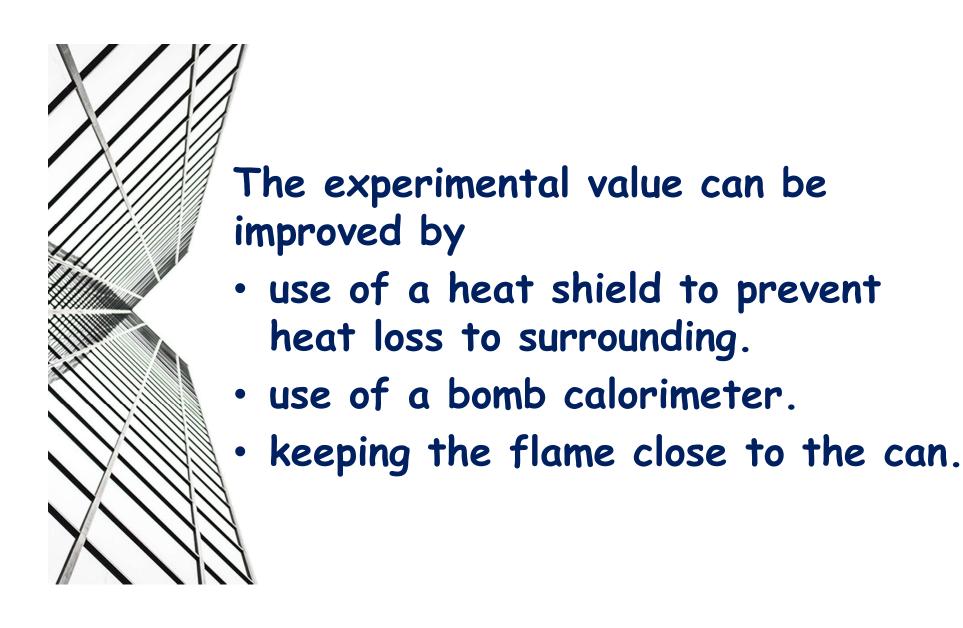


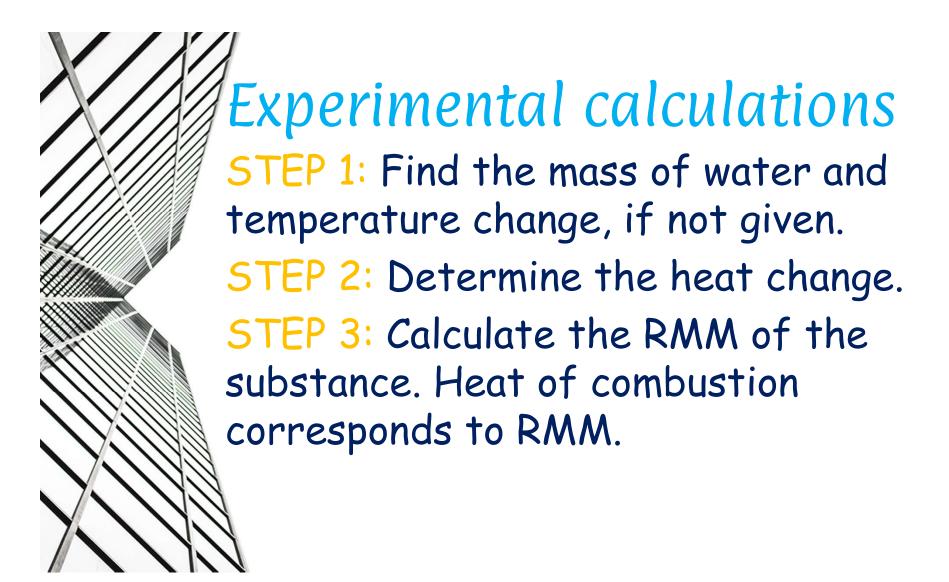






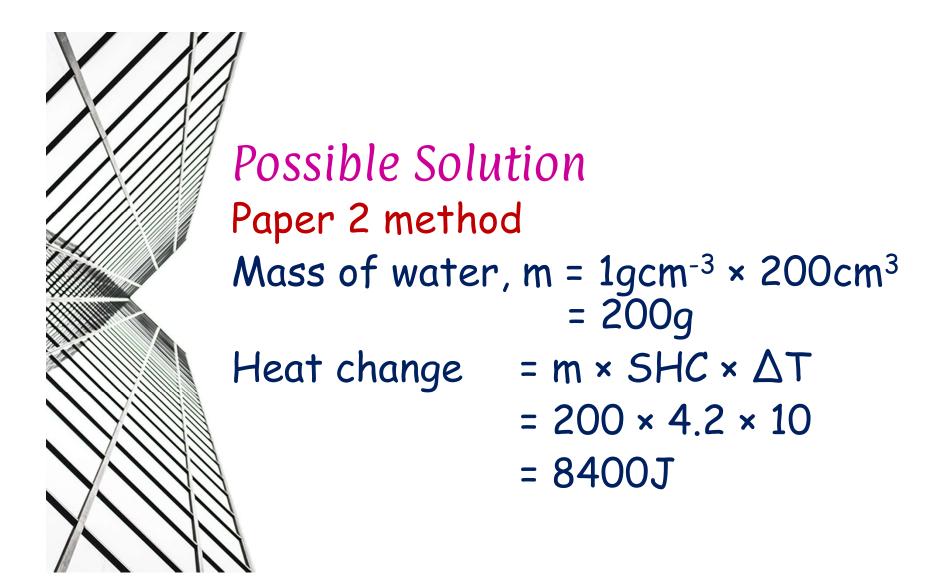


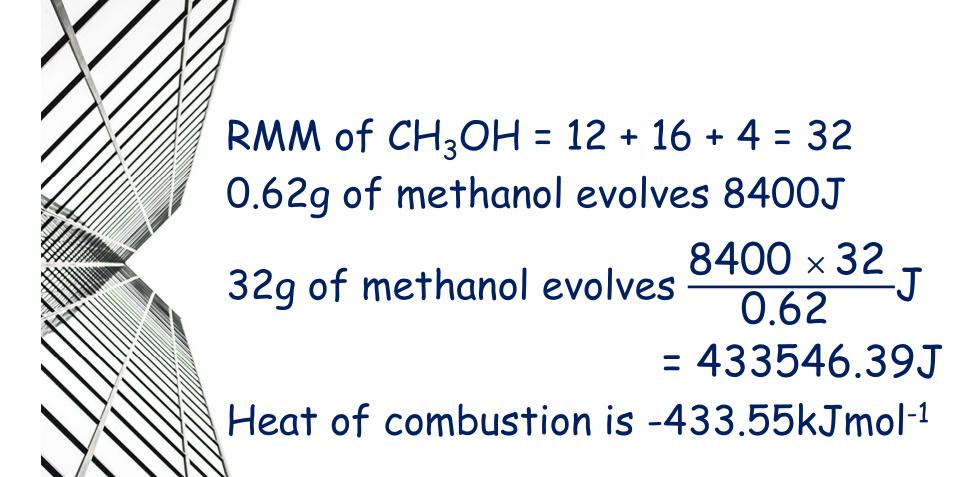


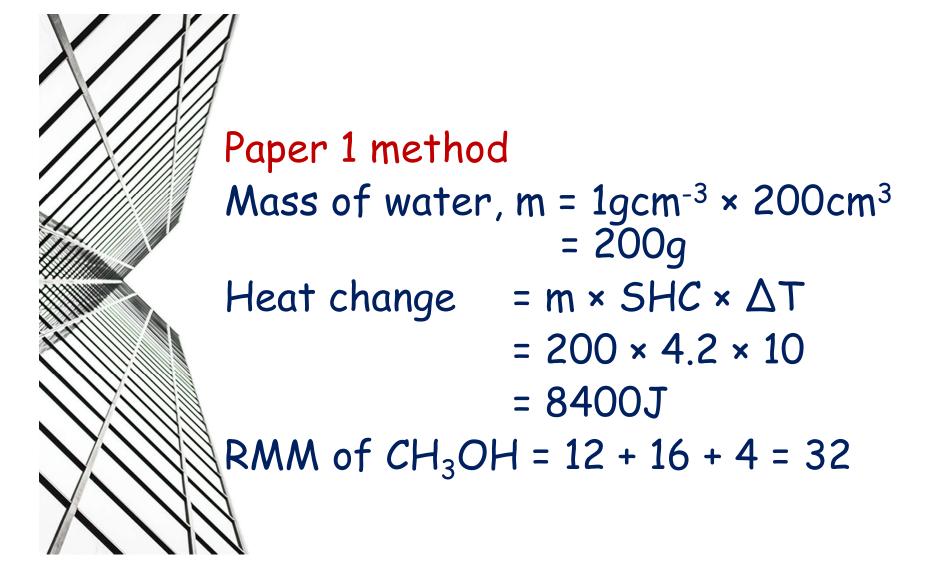


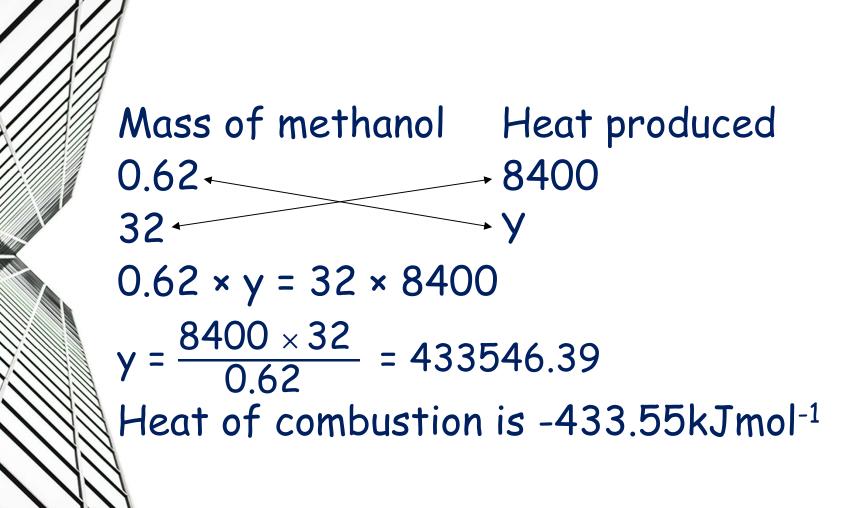
## Follow-up Question 1

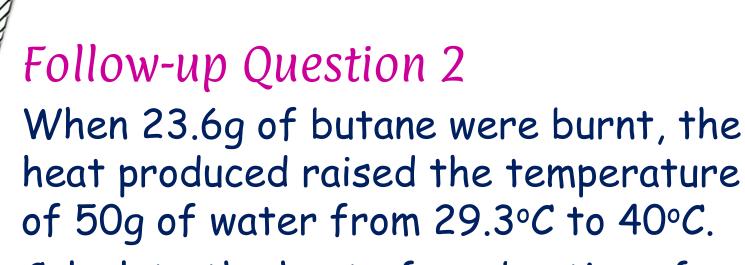
When 0.62g of methanol was completely burnt, the temperature rise of  $200 \text{cm}^3$  of water was found to be  $10^{\circ}C$ . Calculate the heat of combustion of methanol. (Specific heat capacity is  $4.2 \text{Jg}^{-10}C^{-1}$ , density of water is  $1 \text{gcm}^{-3}$ , H = 1, C = 12, O = 16)











Calculate the heat of combustion of butane. (H = 1, C = 12)

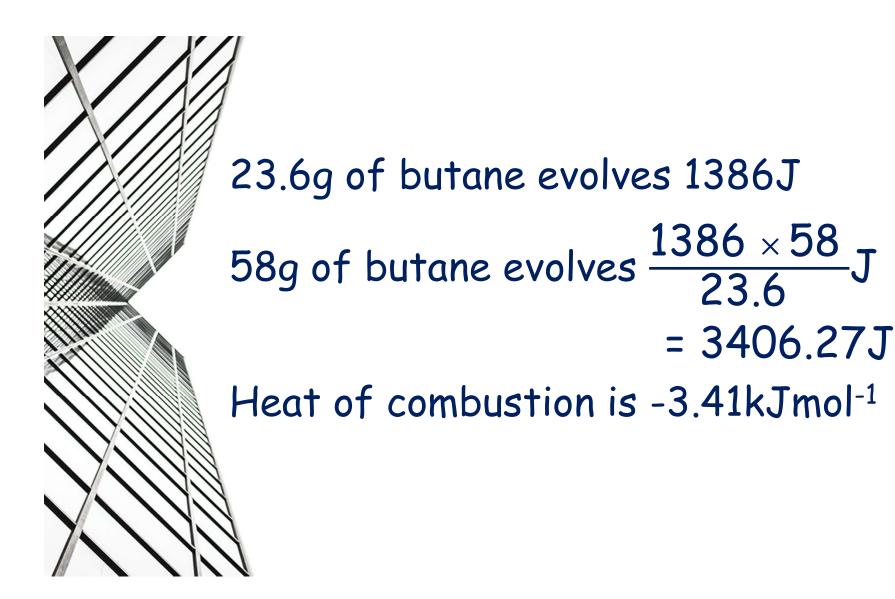


Temperature rise, 
$$\Delta T = 40 - 33.4$$
  
= 6.6°C

Heat change = 
$$m \times SHC \times \Delta T$$

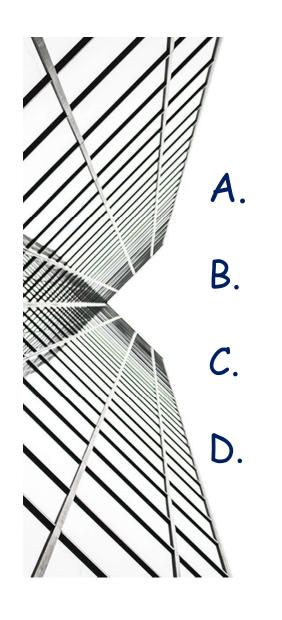
$$= 50 \times 4.2 \times 6.6$$

RMM of  $C_4H_{10} = 12 \times 4 + 10 = 58$ 

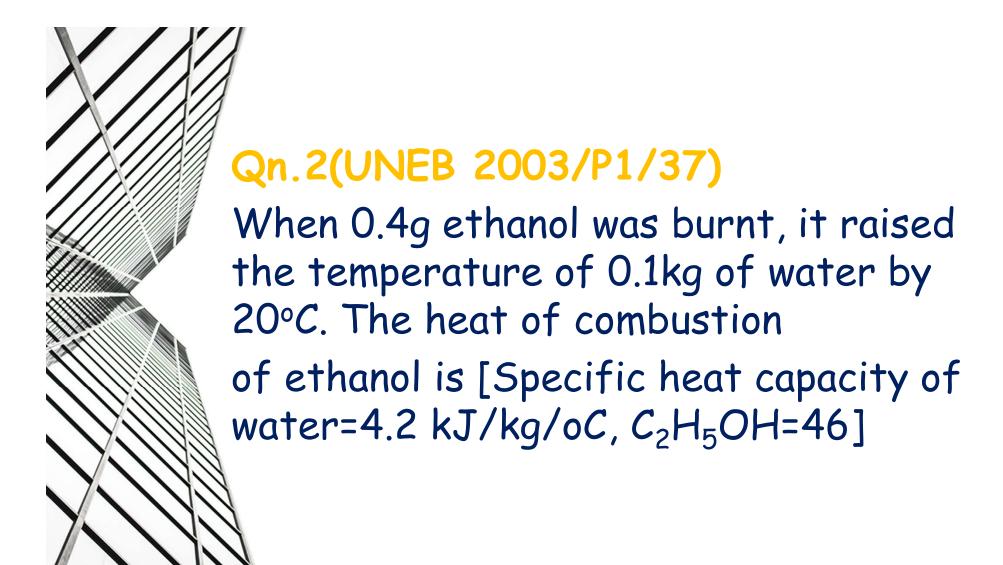


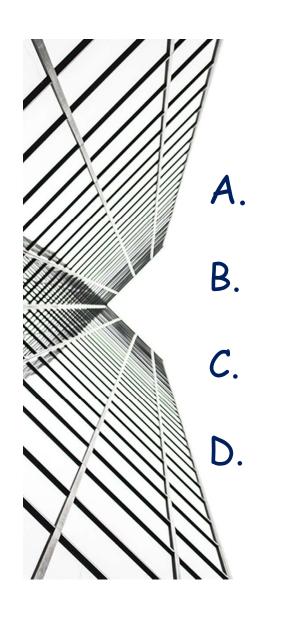


When 2.0g of substance X were burnt the heat produced raised the temperature of 1000g of water by  $15.6^{\circ}C$ . The molar heat of combustion of X in joules is (The specific heat capacity of water is  $4.2Jg^{-1\circ}C^{-1}$ ; relative molecular mass of X is 60).



$$\frac{1000 \times 4.2 \times 15.6 \times 2.0}{60} \\
\underline{1000 \times 15.6 \times 60} \\
2.0 \times 4.2 \\
\underline{1000 \times 15.6 \times 2.0} \\
60 \times 4.2 \\
\underline{60 \times 15.6 \times 4.2} \\
1000 \times 2.0$$





$$\frac{4.2\times46\times20}{0.4\times0.1}\text{kJmol}^{-1}$$

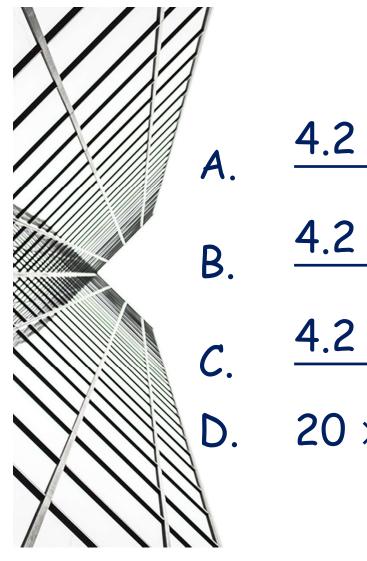
$$\frac{4.2 \times 0.4 \times 20}{46 \times 0.1} \text{kJmol}^{-1}$$

$$\frac{0.1\times4.2\times20\times46}{0.42}\text{kJmol}^{\text{-}1}$$

$$\frac{0.1\times4.2\times20}{0.4\times46}\text{kJmol}^{\text{-}1}$$



When 2.3g of ethanol was completely burnt in oxygen, the heat evolved raised the temperature of 100g of water by 30°C. The molar heat of combustion of ethanol in joules is [The molar mass of ethanol is 46 and the specific heat capacity of water is 4.2Jg<sup>-1</sup>K<sup>-1</sup>].

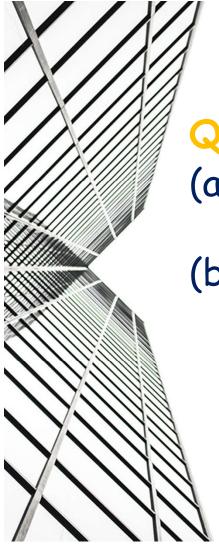


$$\frac{4.2\times30\times100\times46}{2.3}$$

$$\frac{4.2\times30\times100\times2.3}{46}$$

$$\frac{4.2\times20\times100\times2.3}{46}$$

$$20 \times 4.2 \times 46 \times 100$$

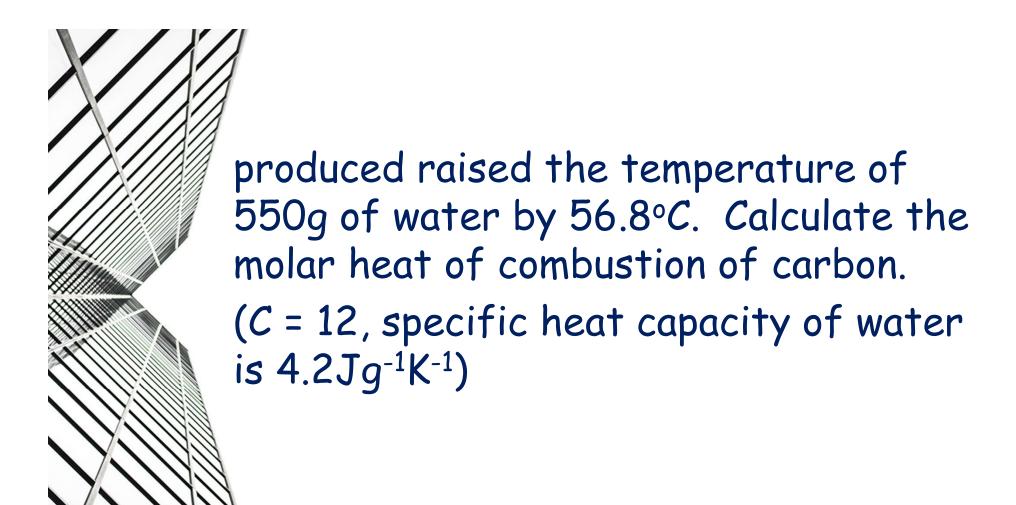


### Qn.4(UNEB 2018/P2/10)

- (a) State the difference between endothermic and exothermic reaction.
- (b) Carbon burns in air according to the following equation

  (c) (c) (c) (c) (d) (d)

 $C(s) + O_2(g) \longrightarrow CO_2(g) + \text{heat}$ When 4.00g of carbon was burnt in air, the heat

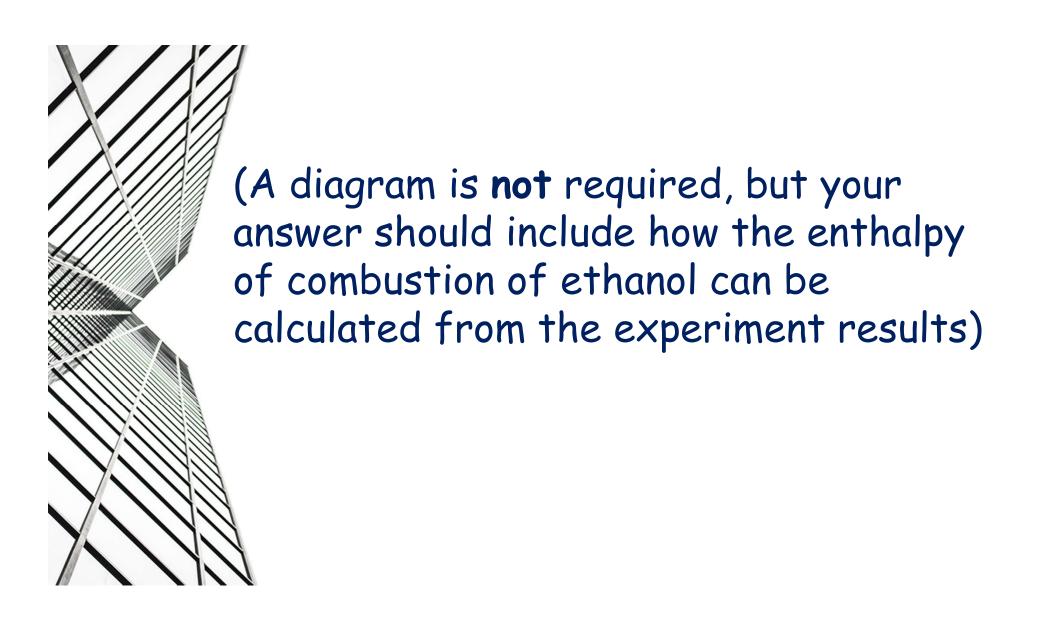


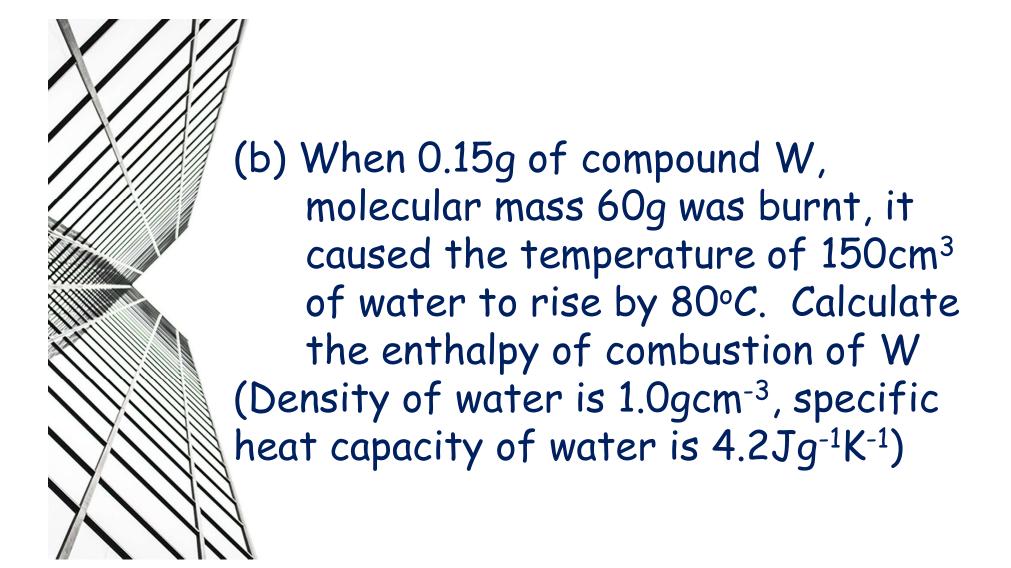


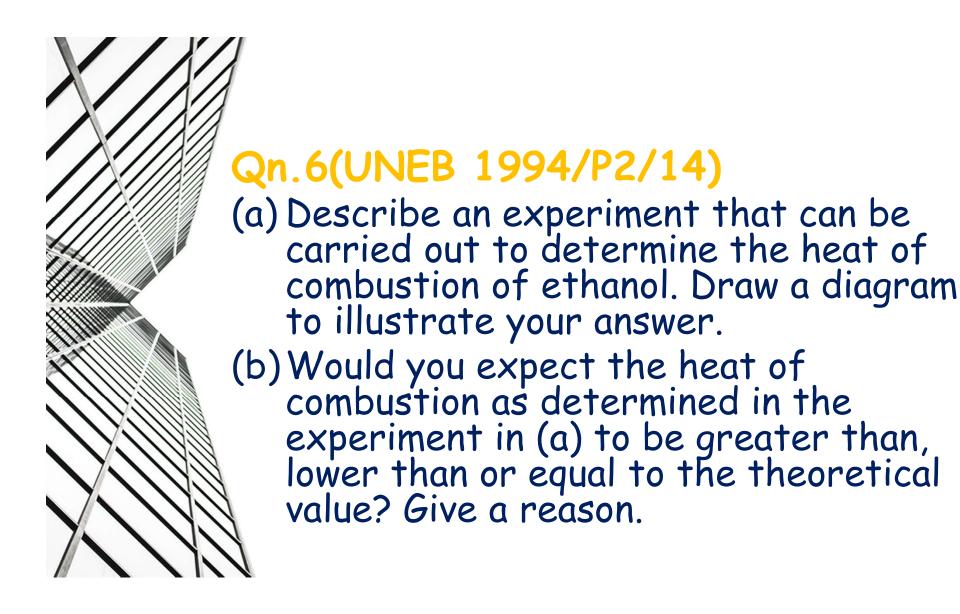
### Qn.5(UNEB 2017/P2/14)

(a)(i) Write the equation for the complete combustion of ethanol.

(ii) Outline an experiment that can be carried out in the laboratory to determine the enthalpy of combustion of ethanol.

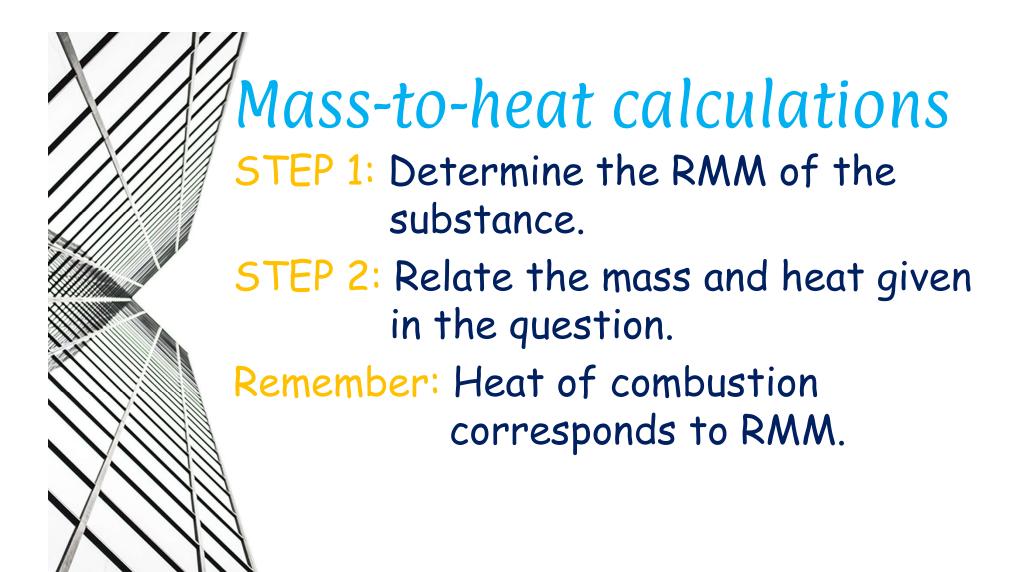


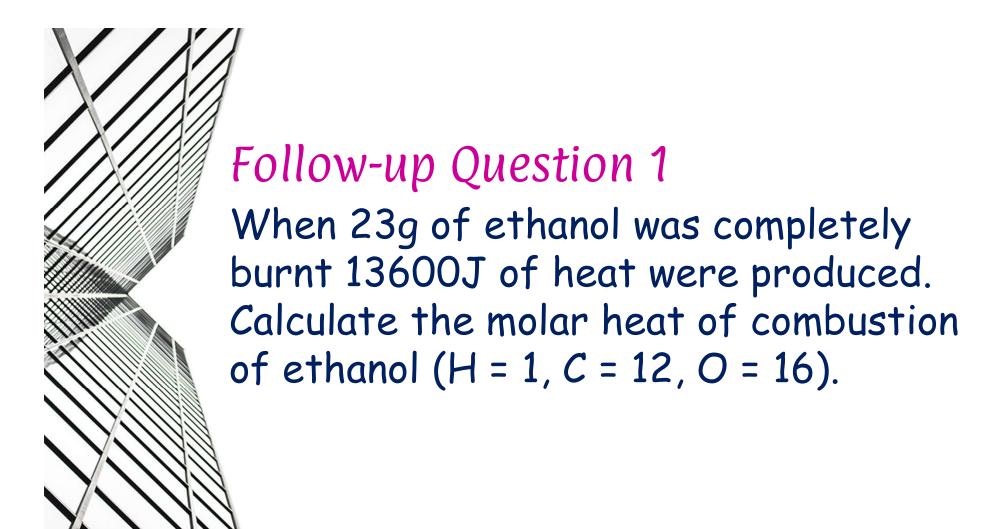


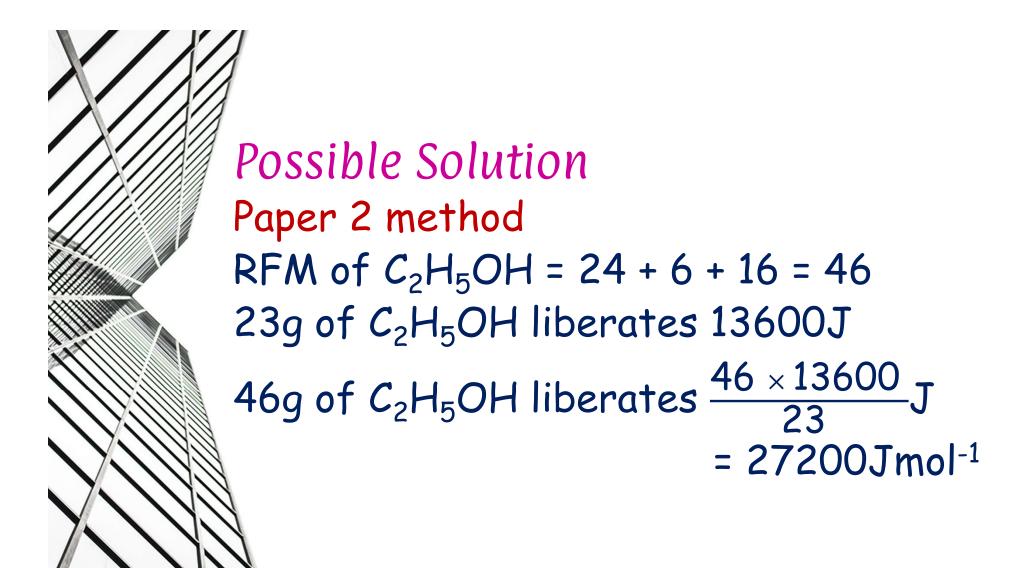


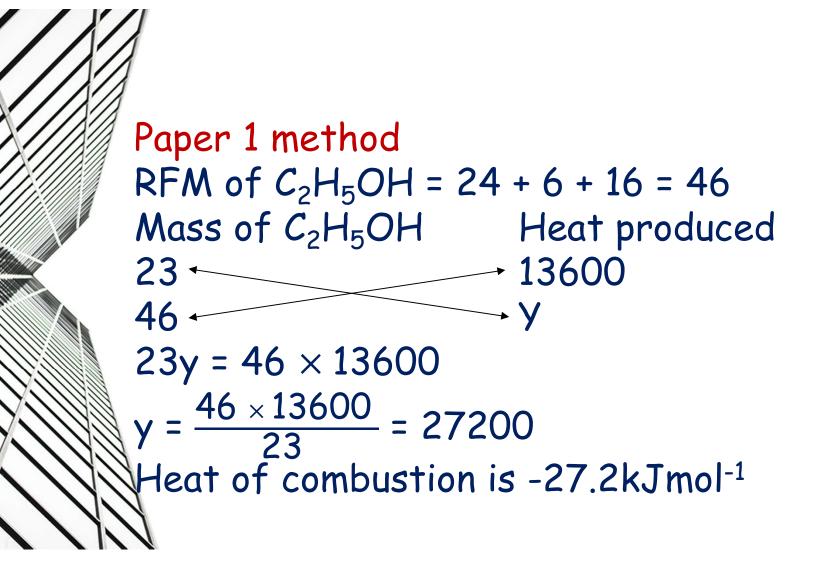


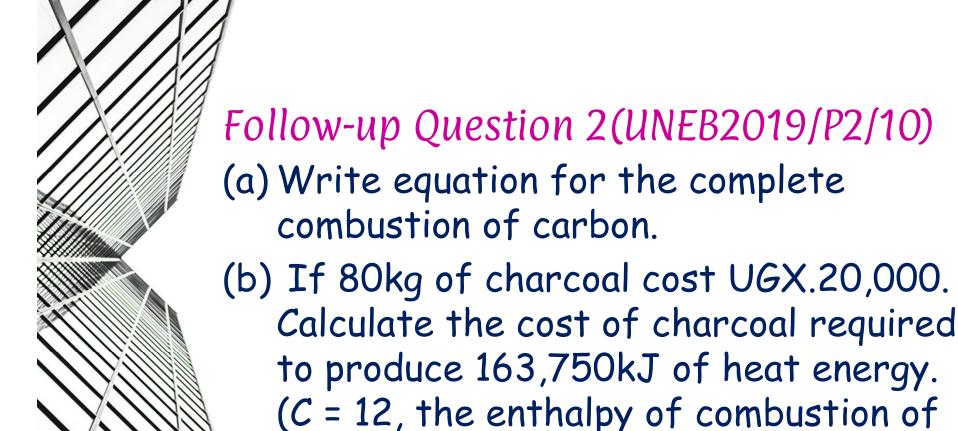
(c) When 0.382g of ethanol was burnt, the heat evolved raised the temperature of 100 g of water from  $16.5^{\circ}C$  to  $43.5^{\circ}C$ . Calculate the heat of combustion of ethanol. (Heat capacity of water is  $4.2Jg^{-10}C^{-1}$ )











carbon =  $-393kJmol^{-1}$ )



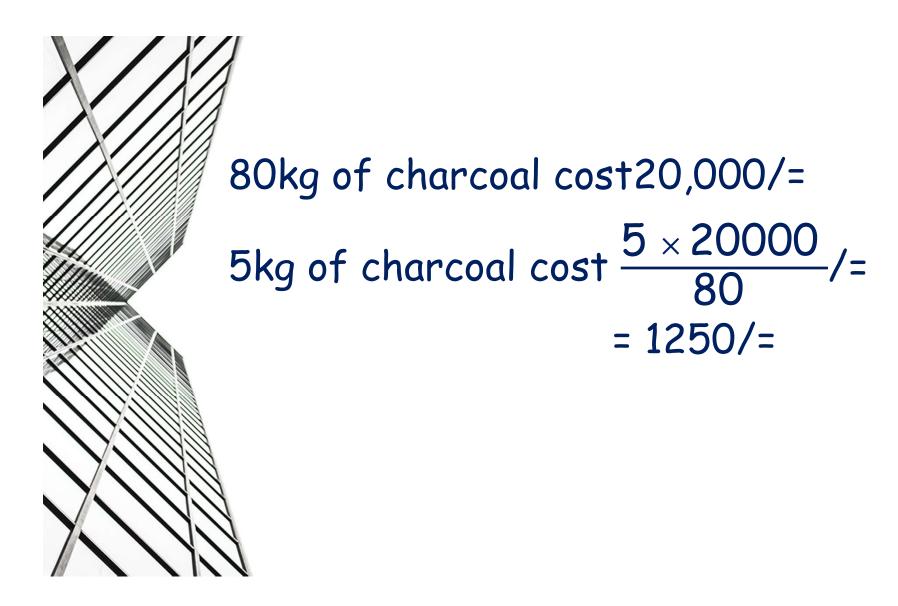
#### Possible Solution

(a) 
$$C(s) + O_2(g) \rightarrow CO_2(g)$$

(b) 393kJ of heat are produced by 12g of C

163,750kJ of heat are produced by

$$\frac{12 \times 163750}{393}$$
 g of C = 5000g of C



## Follow-up Question 3 (UNEB 1996/P1/8)

Methane burns in air according to the equation:

 $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g) + Heat (H=890kJmol^{-1})$ 

The energy liberated when 4g of methane is burnt in air(C=12, H=1).

A. 222.5 kJ

C. 1780.0 kJ

**B**. 445.0 kJ

**D**. 3560.0 kJ



RMM of 
$$CH_4 = 12 + 4 = 16$$
  
Mass of  $CH_4$  Heat evolved  
 $16 \xrightarrow{} 890$   
 $4 \xrightarrow{} y$   
 $16y = 4 \times 890$   
 $y = \frac{4 \times 890}{16} = 222.5$ 

correct option is A

# Volume-to-heat calculations

Heat of combustion of a gaseous sample corresponds to the heat produced by burning 22.4dm<sup>3</sup> at s.t.p or 24dm<sup>3</sup> at r.t.p of the substance.

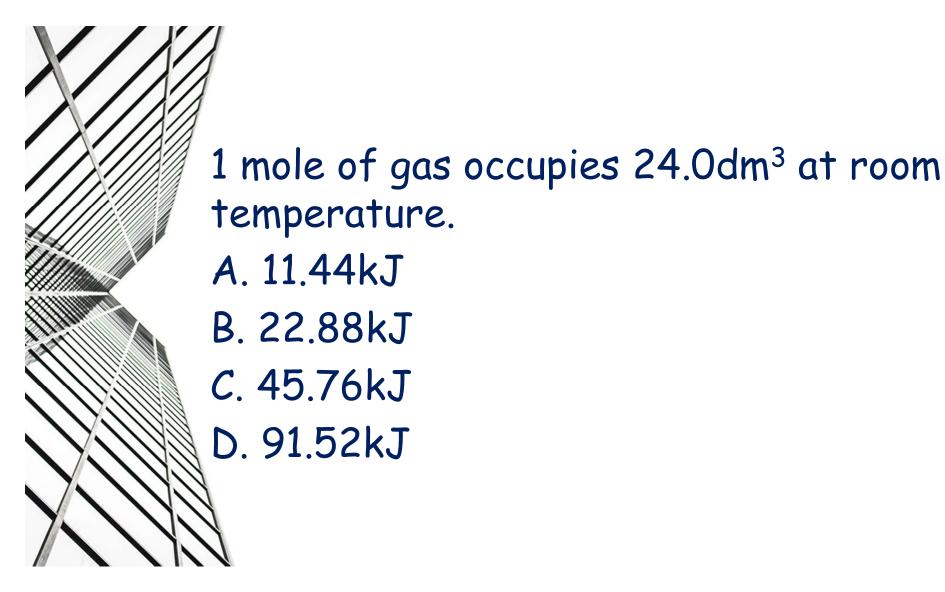
In the calculations, relate the volume and heat given in the question.

## Follow-up Question 1(UNEB 2013/P1/15)

Hydrogen burns in air according to the following equation

$$H_2(g) + \frac{1}{2}O_2(g) \longrightarrow H_2O(I) \Delta H_c = -286 \text{kJmol}^{-1}$$

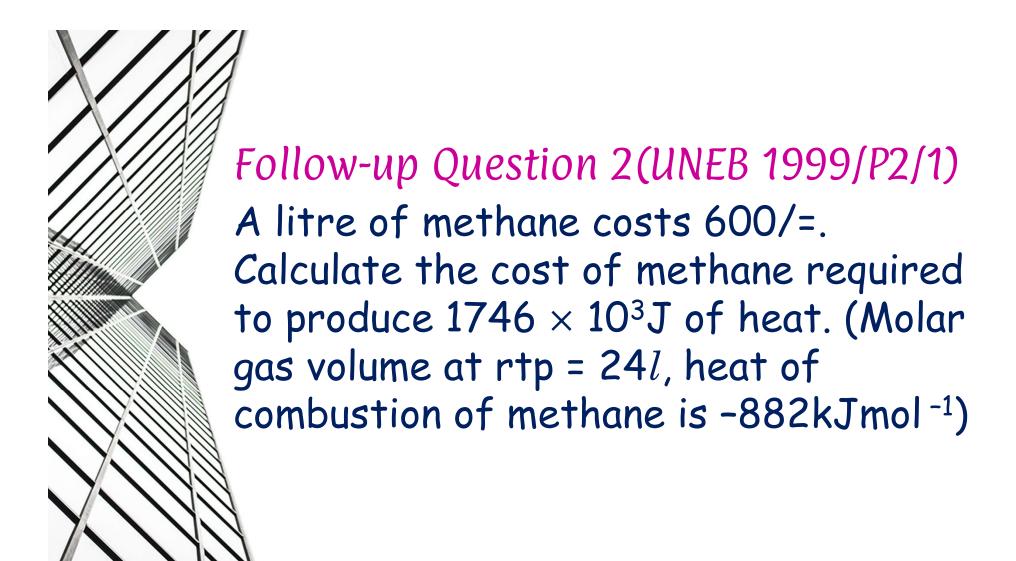
The quantity of heat liberated when 3.84dm<sup>3</sup> of hydrogen was completely burnt in air at room temperature is

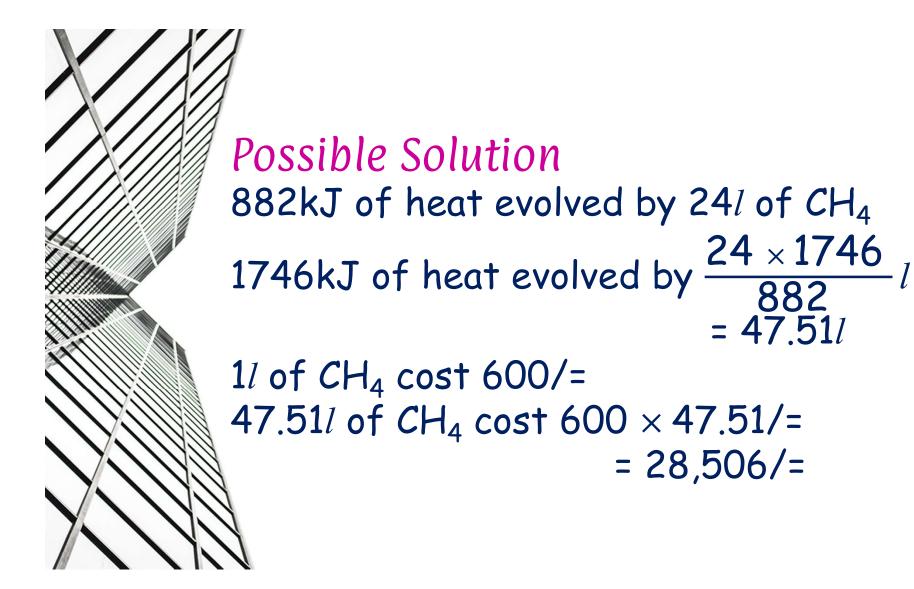




Volume of 
$$H_2$$
 Heat evolved  
24 286  
3.84  $y$   
24y = 286  $\times$  3.84  
 $y = \frac{3.84 \times 286}{24} = 45.76$ 

correct option is C





## Mole-to-heat calculations

Heat of combustion corresponds to the heat produced by burning one mole of a substance.

In the calculations, relate the number of moles and heat given in the question.



Ethanol burns in oxygen according to the equation:

 $C_2H_5OH + \frac{7}{2}O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(g) \Delta H = -1185kJmol^{-1}$ 

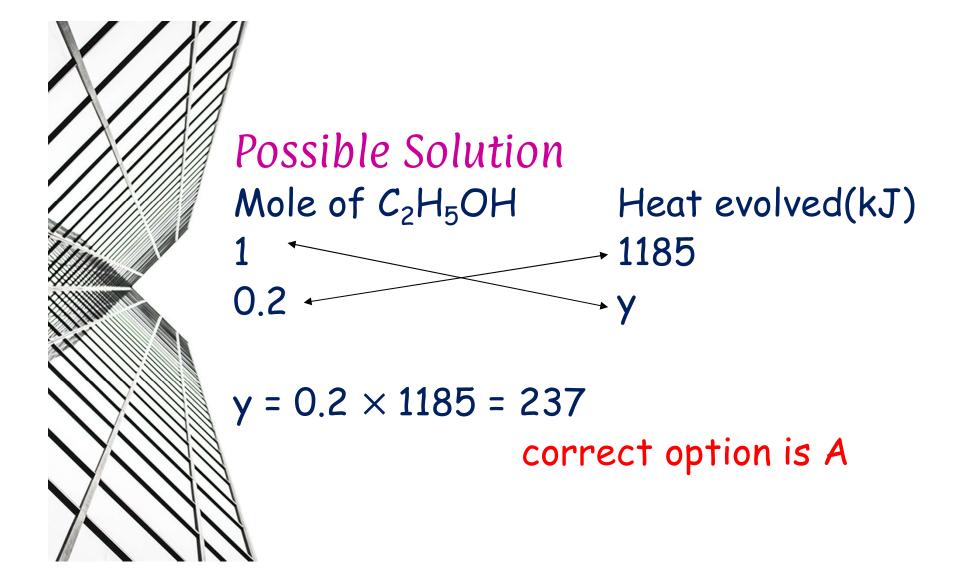
Calculate the amount of heat given out when 0.2 moles of ethanol is burned completely.

**A**. -237kJ

**C**. -1185kJ

B. -592.5kJ

D. -2370kJ

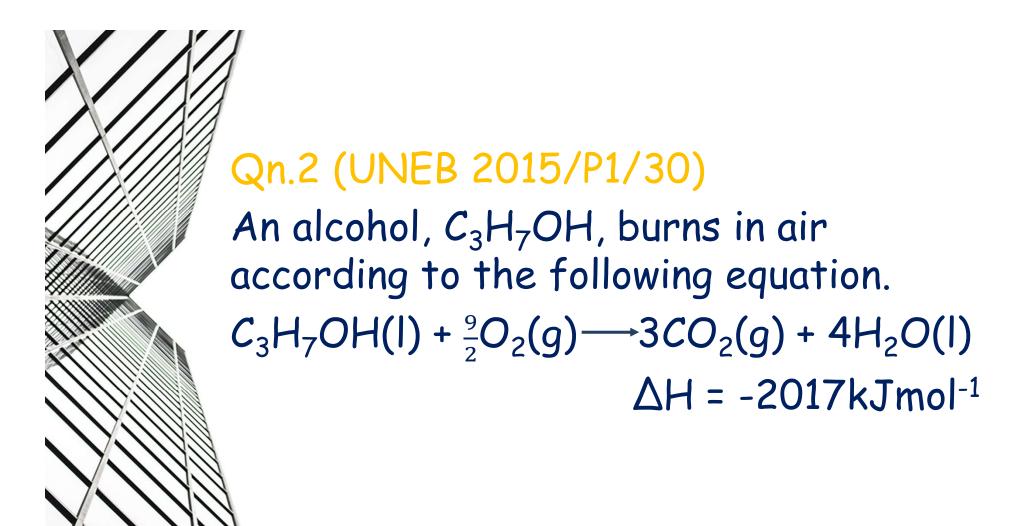


# Knowledge Check 2 Qn.1 (UNEB 2015/P1/14)

Which one of the following volumes of butane would produce 1500kJ of heat at s.t.p on combustion? (Molar heat of combustion of butane is 2880kJmol<sup>-1</sup>)

A. 
$$\left(\frac{1500 \times 22.4}{2880}\right) dm^3$$
 B.  $\left(\frac{2280 \times 22.4}{1500}\right) dm^3$ 

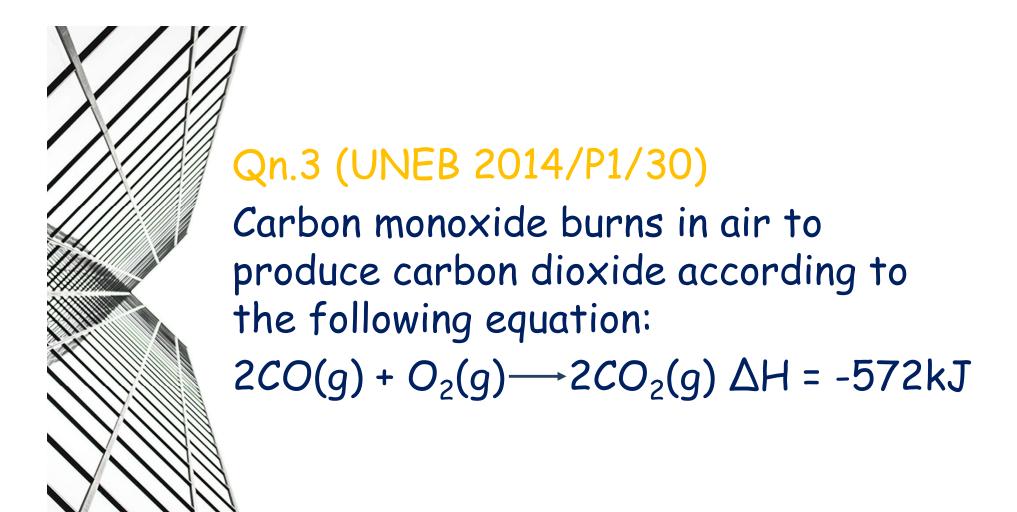
C. 
$$\left(\frac{1500 \times 2880}{22.4}\right)$$
 dm<sup>3</sup> D.  $(1500 \times 2880 \times 22.4)$  dm<sup>3</sup>

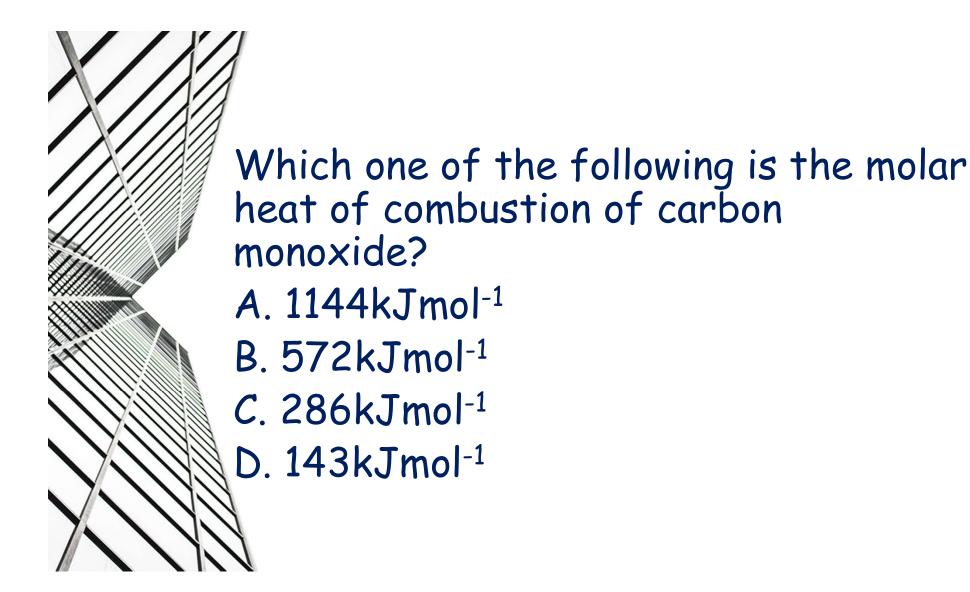




A. 
$$\left(\frac{2\times60\times200}{4034}\right)g$$
 B.  $\left(\frac{60\times200}{2\times4034}\right)g$ 

C. 
$$\left(\frac{60\times4034}{200}\right)g$$
 D.  $\left(\frac{60\times4034}{2\times200}\right)g$ 







Graphite burns in oxygen according to the equation:

$$C(s) + O_2(g) \longrightarrow CO_2(g)$$
  $\Delta H = -390kJ$ 

When 48g of graphite is burnt in excess oxygen the heat produced is



Carbon reacts with sulphur according to the following equation

$$C(s)+2S(s) \longrightarrow CS_2(I) \Delta H = 117kJmol^{-1}$$

The amount of heat absorbed when 16g of sulphur reacts with excess carbon is

$$(C=12, S=32)$$

A. 7kJ

C. 58kJ

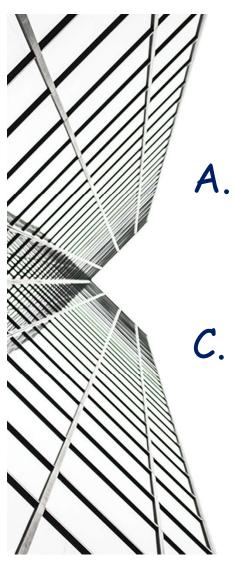
B. 29kJ

D. 116kJ

### Qn.6 (UNEB 2002/P1/30)

Glucose bums in oxygen at 25°C according to the equation below, giving out 2802kJmol<sup>-1</sup> of heat energy.

 $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow CO_2(g) + 6H_2O(g)$ The amount of heat produced when 18.0g of glucose is burnt in oxygen at the same temperature is (H = 1, C = 12, O = 16).



A. 
$$\frac{2802 \times 18.0}{180 \times 25}$$

B. 
$$\frac{180}{2802 \times 18.0}$$

D. 
$$\frac{2802 \times 18.0}{180}$$

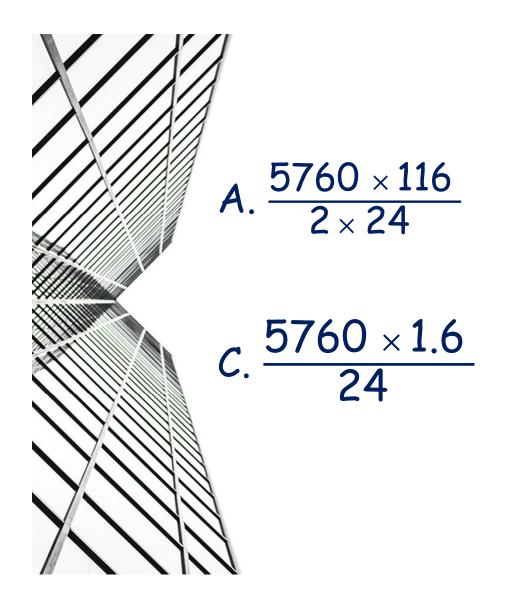
### Qn.7 (UNEB 2005/P1/12)

Butane burns in excess air according to the following equation:

$$2C_4H_{10}(g) + 13O_2(g) \longrightarrow 8CO_2(g) + 10H_2O(g)$$

 $\Delta H = -5760kJ$ 

The quantity of heat evolved when 1.6dm<sup>3</sup> of butane is burnt at room temperature is [1mole of a gas occupies 24dm<sup>3</sup> at room temperature].



$$\mathsf{B.} \; \frac{5760 \times 1.6}{2 \times 24}$$

D. 
$$\frac{5760 \times 116}{24}$$



10g of methanol,  $CH_3OH$ , 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]

A. 
$$\frac{32 \times 226}{10}$$

C. 
$$\frac{10}{32 \times 226}$$

B. 
$$\frac{10 \times 32}{226}$$

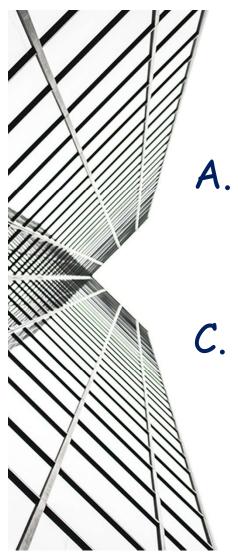
D. 
$$\frac{10 \times 226}{32}$$



Butane undergoes combustion according to the following equation:

 $2C_4H_{10}(g) + 3O_2(g) \longrightarrow 8CO_2(g) + 10H_2O(I) + Heat$ 

The mass of butane required to produce 950 kJ of heat is [H = 1, C = 12; 1 mole of butane produces 287kJ of heat]



A. 
$$\frac{950 \times 58}{2 \times 2877}$$
 g

B. 
$$\frac{950 \times 58}{2877}$$
 g

*c.* 
$$\frac{950 \times 58 \times 2}{2877}$$
 *b.*  $\frac{2877 \times 58}{950}$  *g*

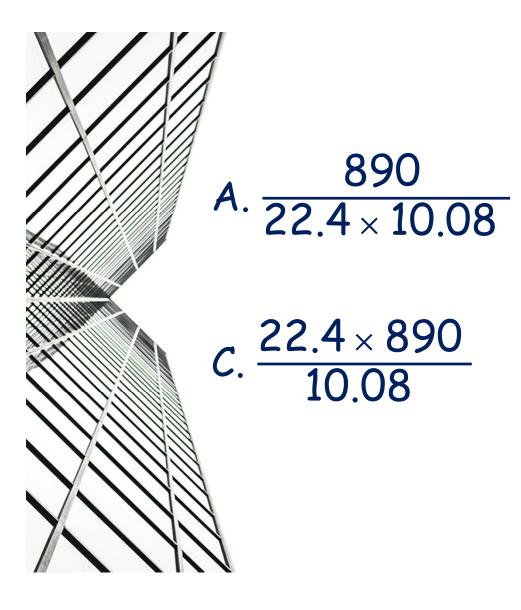
D. 
$$\frac{2877 \times 58}{950}$$
 g



Methane burns according to the following equation:

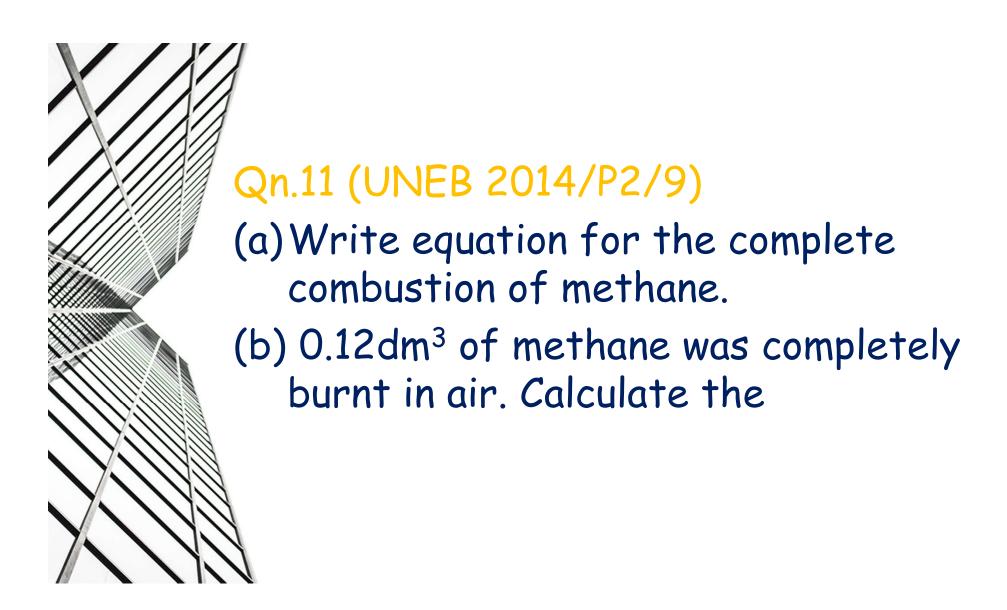
 $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g), \Delta H = -890kJ$ 

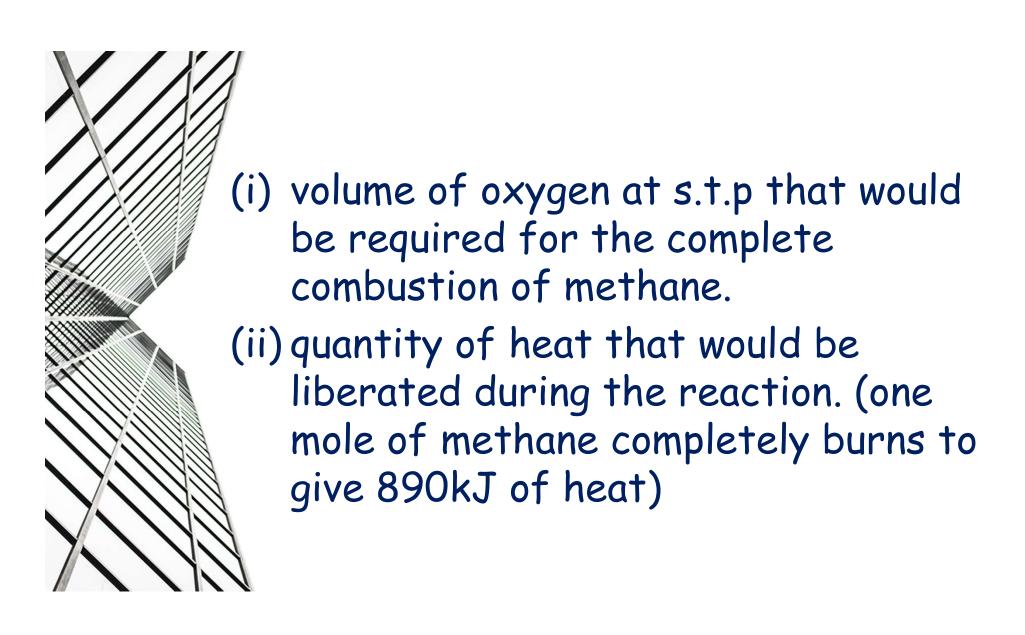
The volume of methane gas which when burnt will raise the temperature of 160g of water by  $15^{\circ}C$  is [1 mole of gas occupies  $22.4 \, \mathrm{dm}^3$  at s.t.p; Specific heat capacity of water is  $4.2 \, \mathrm{Jg}^{-1} \, \mathrm{o}C^{-1}$ ]



B. 
$$\frac{22.4 \times 10.08}{890}$$

D. 
$$\frac{10.08 \times 890}{22.4}$$



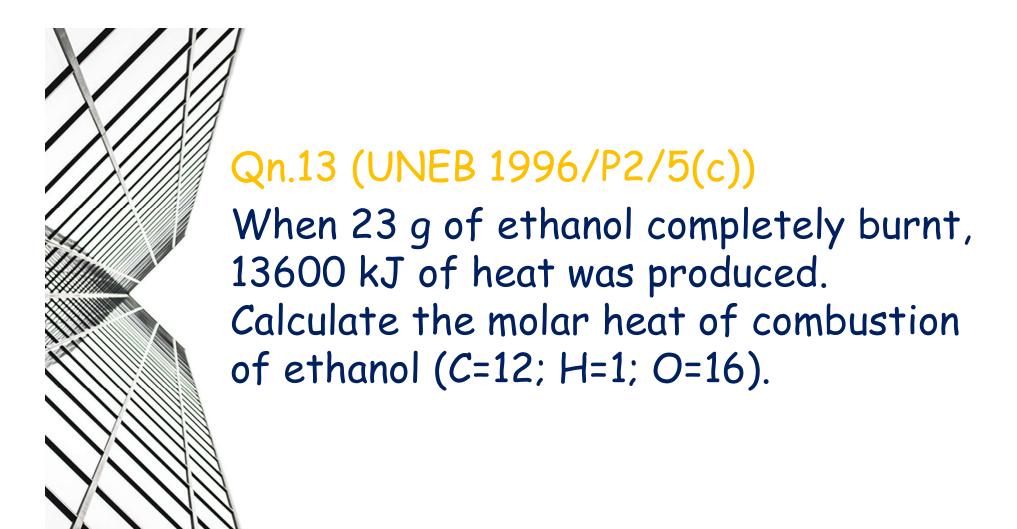




### Qn.12 (UNEB 1993/P2/10)

The enthalpy of combustion of carbon is -398kJmol<sup>-1</sup>.

- (a) Write an equation for the complete combustion of carbon.
- (b)80g of charcoal costs 4000/=. Calculate the cost of charcoal required to produce 16375kJ.



### Qn.14 (UNEB 2006/P2/6)

Ethane burns in oxygen according to the following equation:

 $2C_2H_6(g) + 7O_2(g) \longrightarrow 4CO_2(g) + 6H_2O(1)$ 

When 2.0g of ethane was burnt in excess oxygen, 104kJ of heat was produced. Calculate the:

(a) mass of water formed

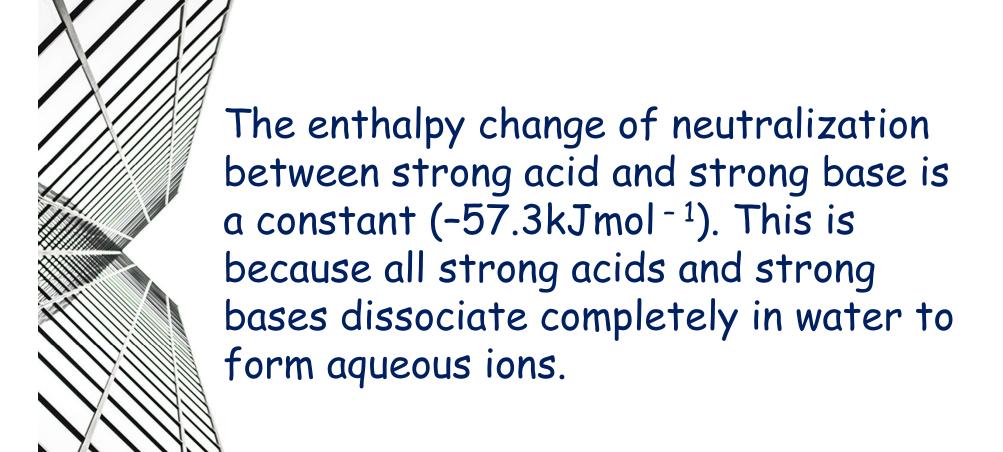
(b) molar heat of combustion of ethane.

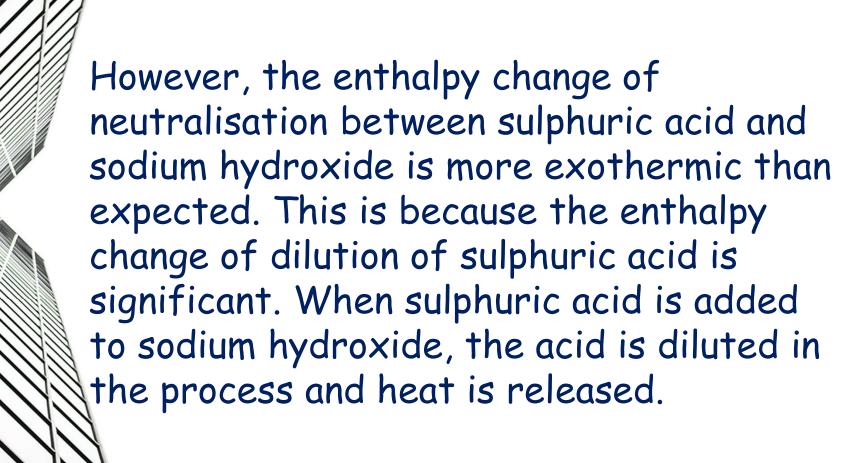


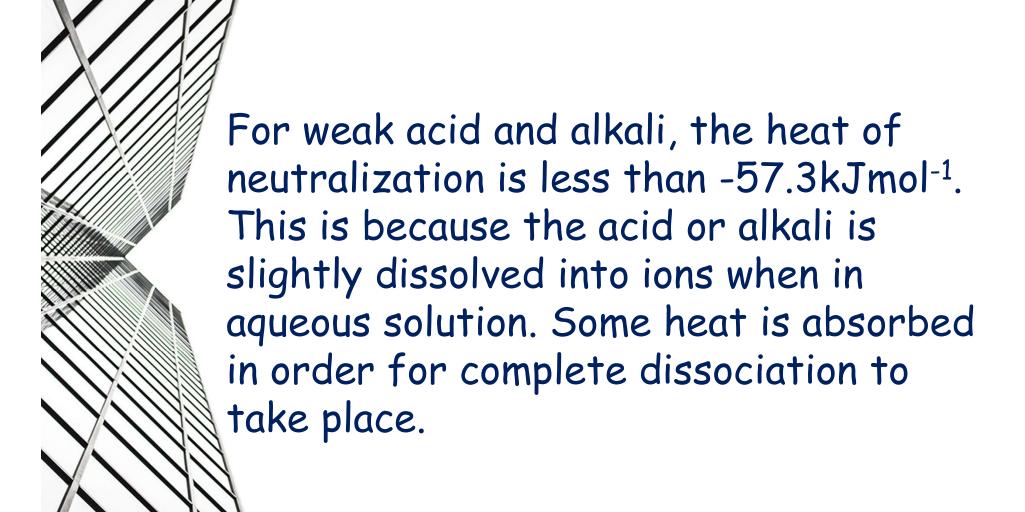
Heat of neutralization is the heat change that occurs when one mole of an acid reacts with one mole of an alkali to produce one mole of water.

 $HCI(aq) + NaOH(aq) \longrightarrow NaCI(aq) + H_2O(I)$ For any acid-alkali reaction, the ionic equation is:

 $H^+(aq) + OH^-(aq) \longrightarrow H_2O(1)$ 



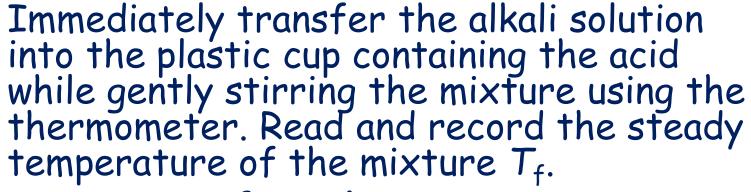




## Determination of heat of Neutralisation

Place acid of known volume  $(V_1)$  and molarity into the plastic cup. Read and record the initial temperature  $T_1$ , of the acid.

Transfer alkali solution of the same volume and molarity as for the acid into another plastic cup. Read and record the initial temperature  $T_2$ , of the alkali.



Treatment of results

Volume of mixture =  $2V_1$ 

Initial temperature of mixture  $T_i = \frac{T_1 + T_2}{2}$ 



Temperature change  $\Delta T = T_f - T_i$ 

Thus heat given on mixing = heat gained

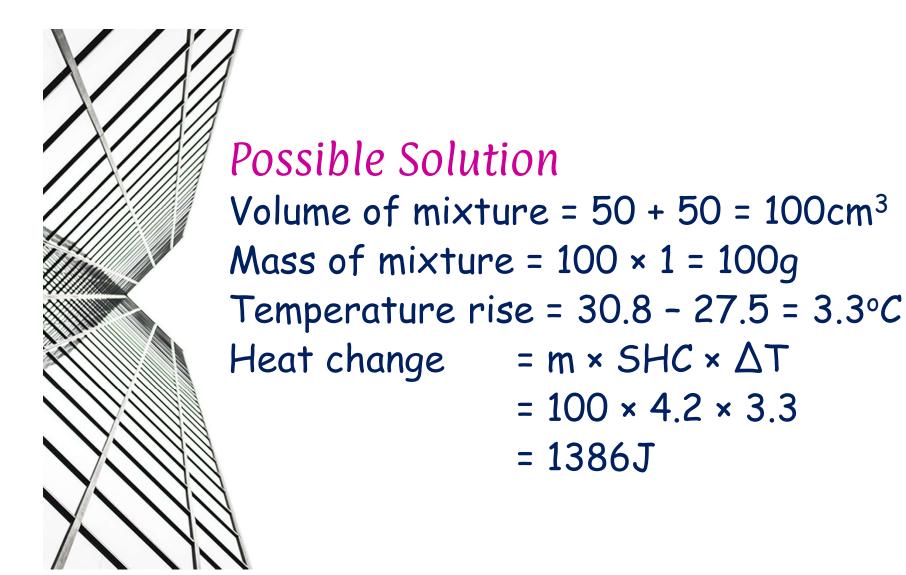
$$= m \times SHC \times \Delta T$$

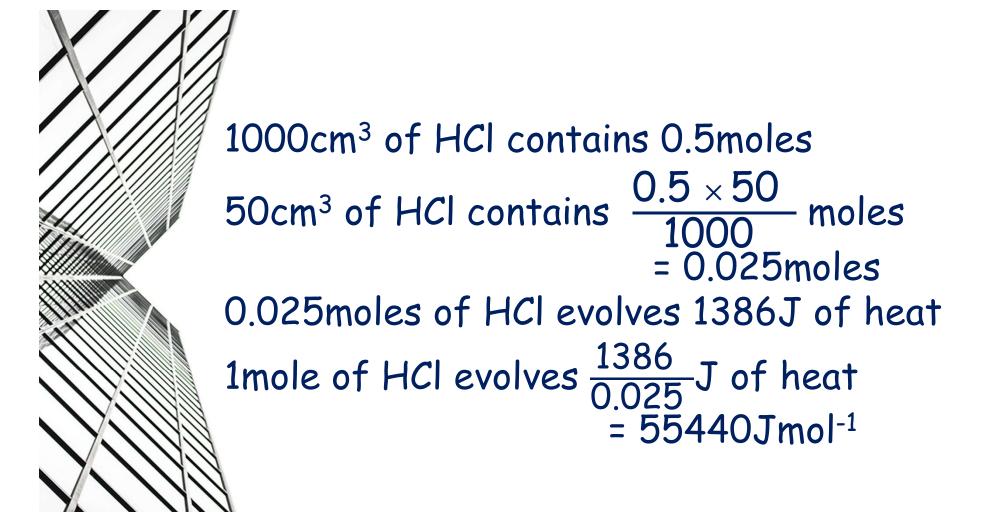
Moles of acid is n moles

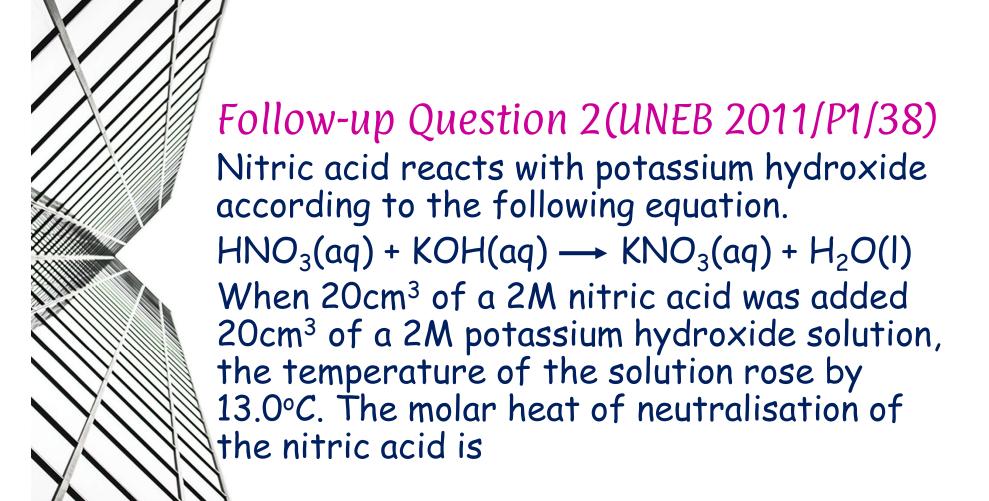
Heat of neutralization = 
$$-\frac{m \times c \times \Delta T}{n}$$
 Jmol<sup>-1</sup>

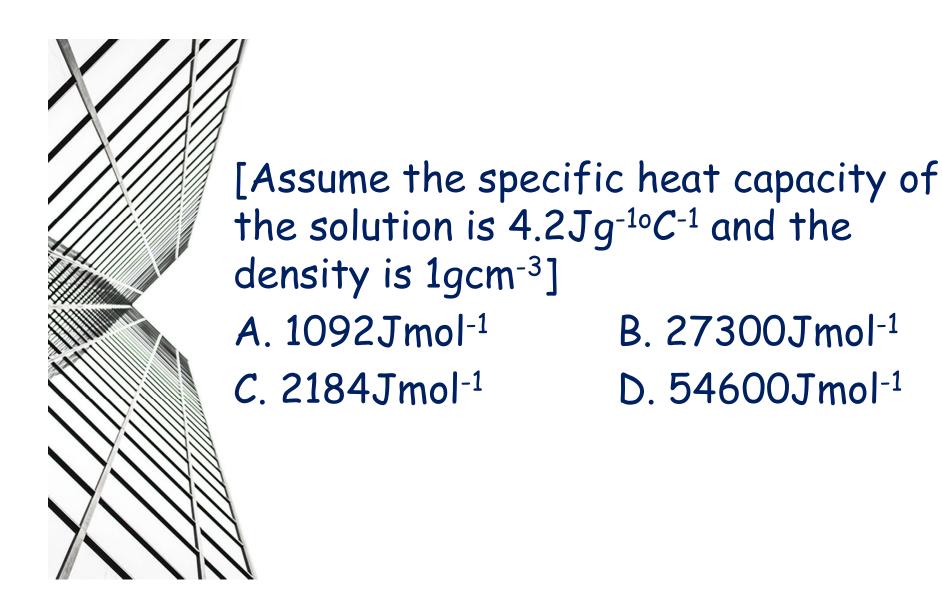
### Follow-up Question 1(UNEB 2001/P2/8(b))

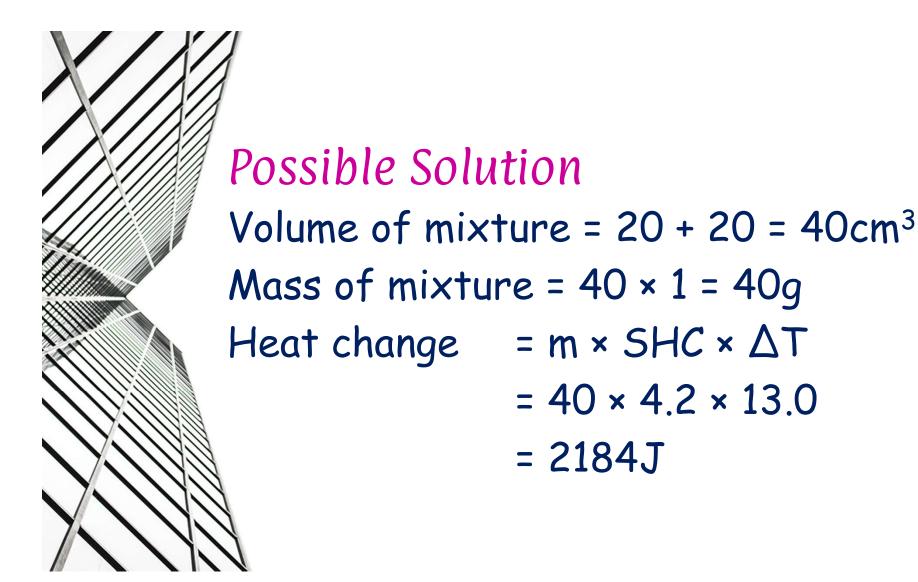
When  $50\text{cm}^3$  of a 0.5M hydrochloric acid was added to  $50\text{cm}^3$  of a 0.5M potassium hydroxide in a calorimeter, there was a temperature rise from  $27.5^{\circ}C$  to  $30.8^{\circ}C$ . Calculate the enthalpy of the reaction. (specific heat capacity of mixture is  $4.2Jg^{-10}C^{-1}$ , density of mixture is  $1g\text{cm}^{-3}$ )

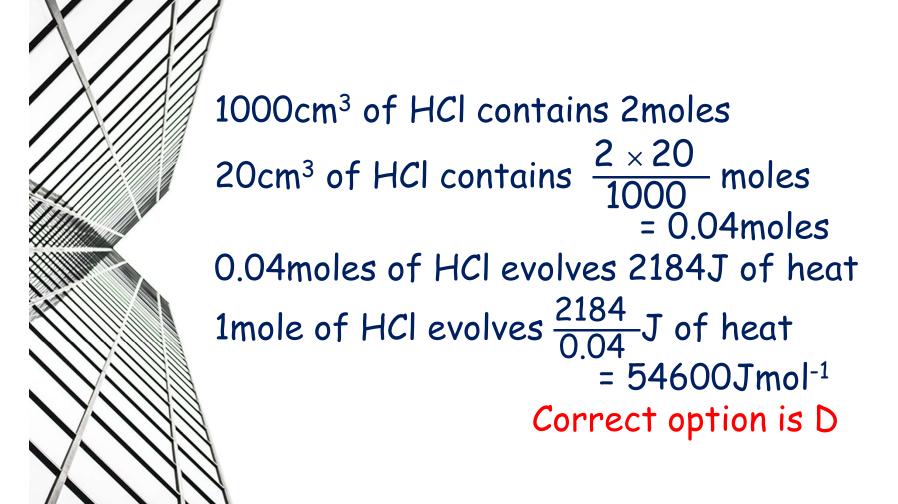






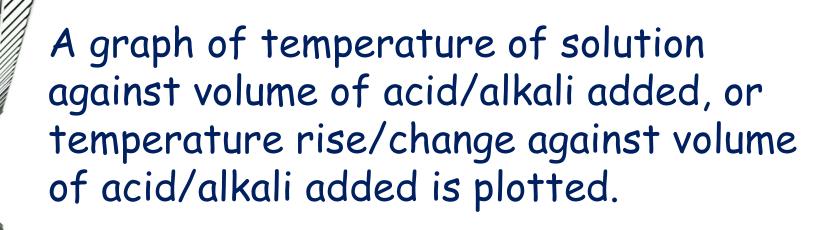




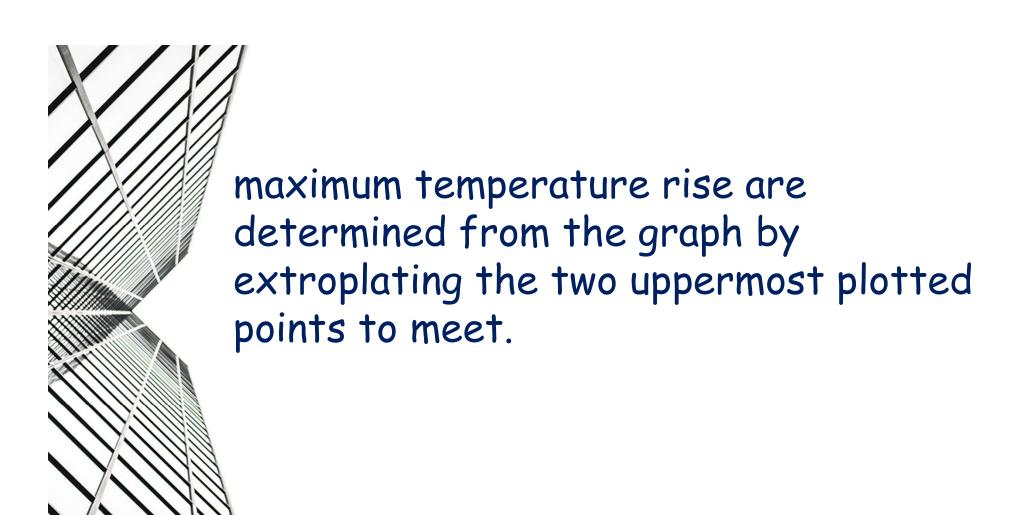


# Thermometric titrations

In thermometric titration, small quantity of acid from burette is added to alkali in a plastic beaker/cup (or alkali to acid) and the temperature of the mixture at each stage of the addition of the acid (or alkali) is noted and recorded.



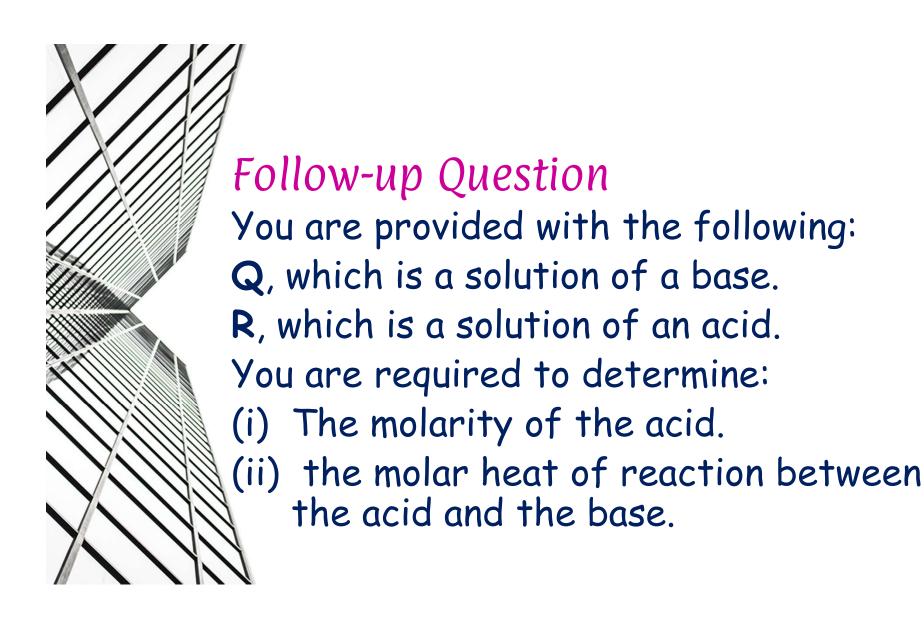
Volume of acid needed to reach the end-point and maximum temperature/

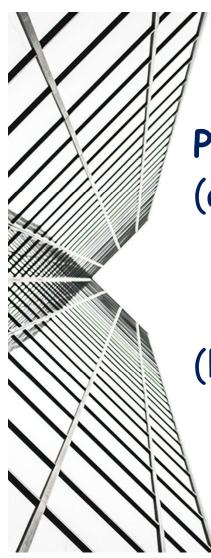




### Remember

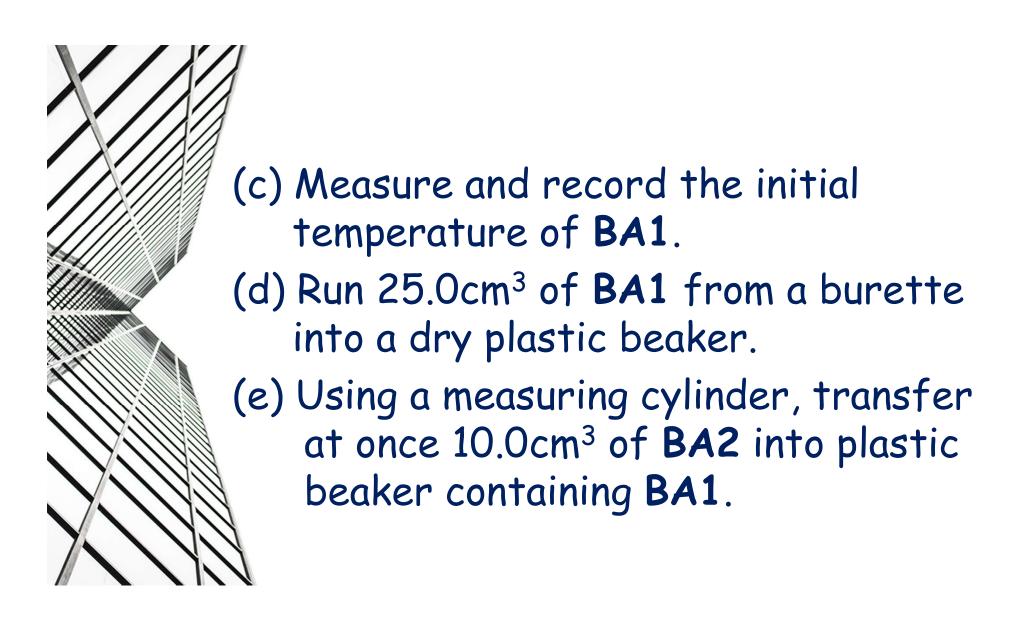
- Label axes with their units in bracket along each axis.
- Join the plotted points using free hand.
- Show evidence of value obtained from the graph using dotted lines.

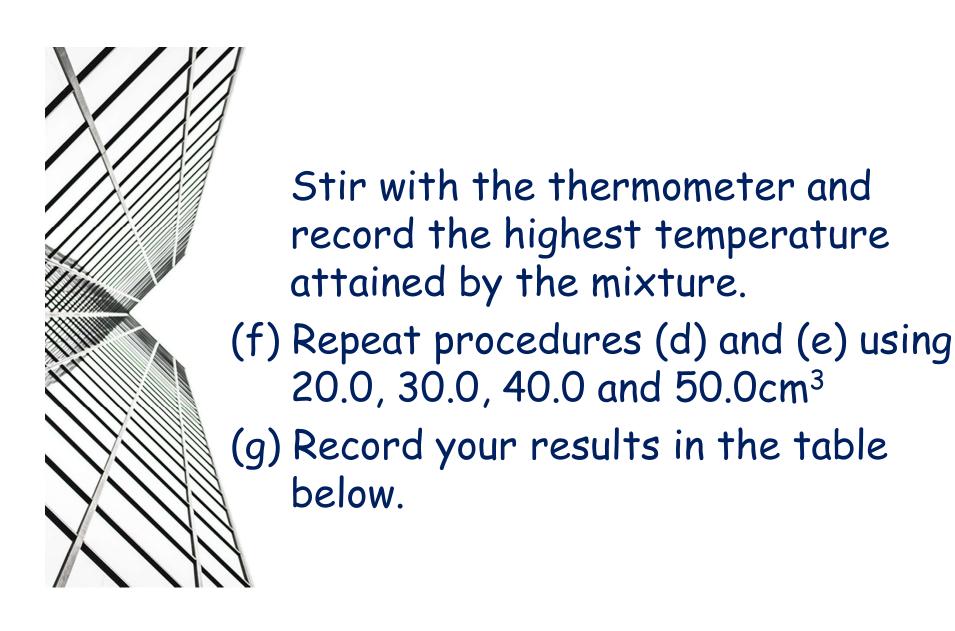




#### **PROCEDURE**

- (a) Using a measuring cylinder, measure 150.0cm<sup>3</sup> of **Q** and transfer into a 250cm<sup>3</sup> beaker. Add 50cm<sup>3</sup> of distilled water, mix and label it **BA1**.
- (b) transfer 100.0cm<sup>3</sup> of **R** into another 250cm<sup>3</sup> beaker. Add 100cm<sup>3</sup> of distilled water, mix and label it **BA2**.



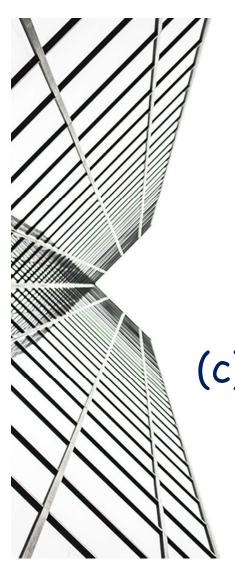


# Initial temperature of BA1 22.0°C

Volume of BA2 used(cm <sup>3</sup> )	10.0	20.0	30.0	40.0	50.0
Highest temperature attained by the mixture(°C)	27.0	35.0	36.0	33.0	30.0

(a) Plot a graph of highest temperature attained by the mixture against volume of **BA2** used.

(b) From the graph, determine:



- (i) the volume of **BA2** required to neutralize 25.0cm<sup>3</sup> of **BA1**.
- (ii) the maximum temperature change for the reaction.
- (c) Calculate the molarity of BA2.
  [1mole of base reacts with 1mole of acid; molarity of BA1 = 1.5M]

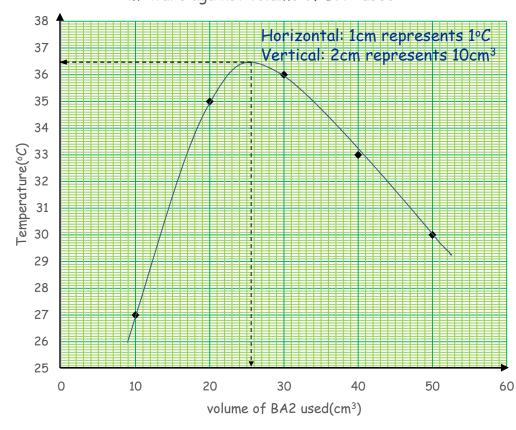


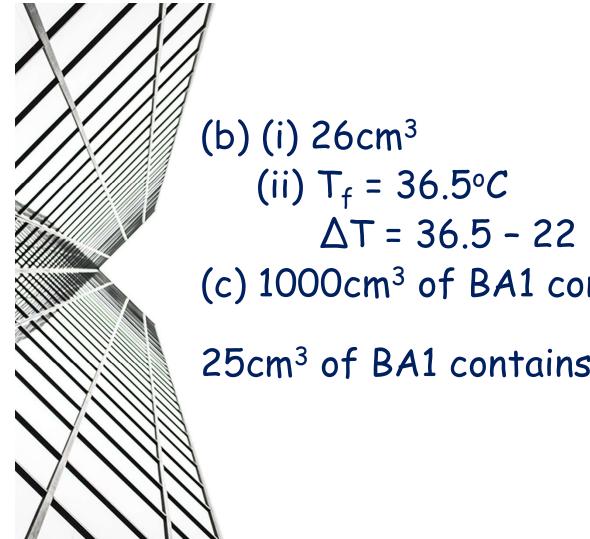
(d) Determine the:

- (i) maximum heat evolved during the reaction. [specific heat capacity of mixture =  $4.2Jg^{-1}K^{-1}$ , density of mixture =  $1gcm^{-3}$ ]
- (ii) molar heat of reaction between the acid and the base.



A graph of highest temperature attained by the mixture against volume of **BA2** used

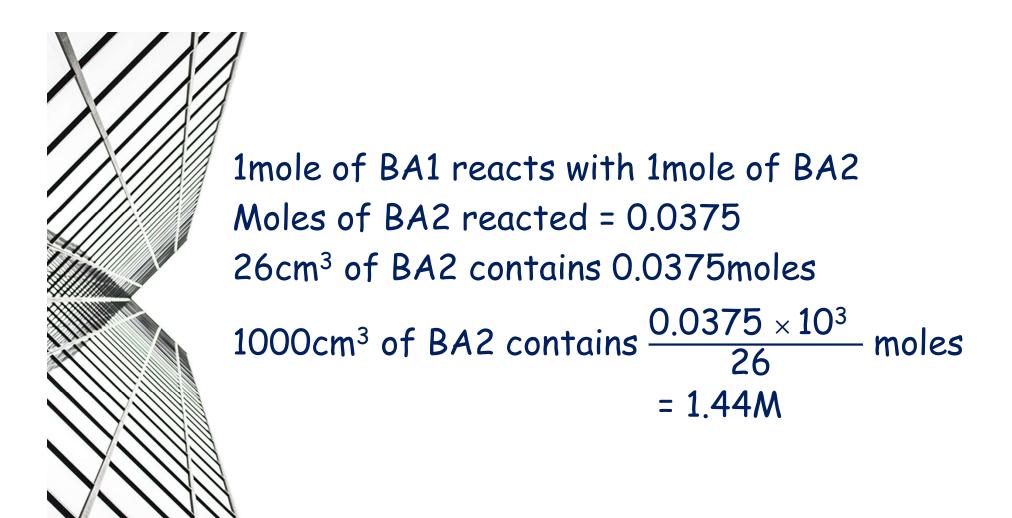


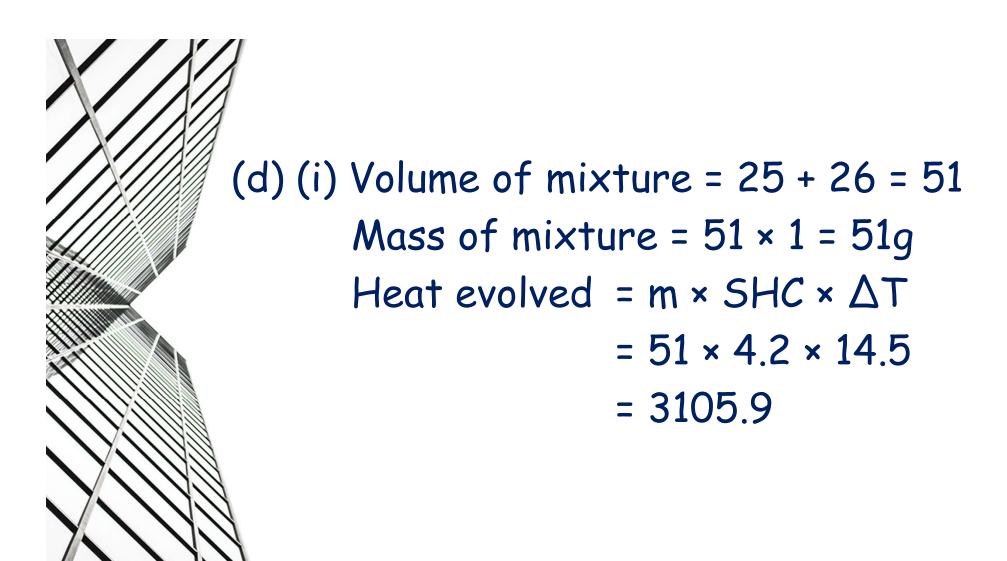


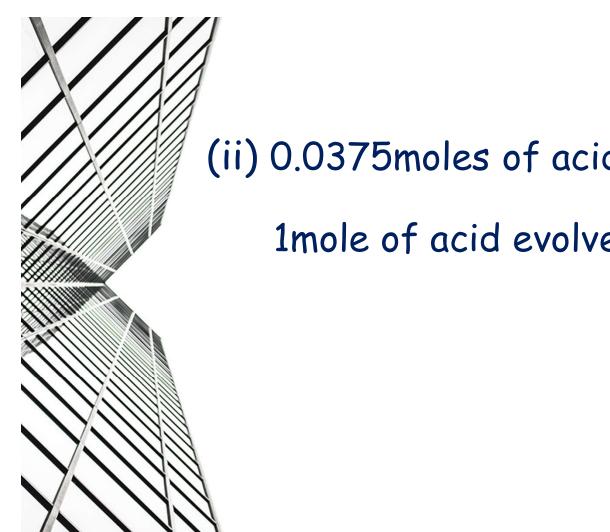
(ii) 
$$I_f = 36.5^{\circ}C$$
  
 $\Delta T = 36.5 - 22 = 14.5^{\circ}C$ 

(c) 1000cm<sup>3</sup> of BA1 contains 1.5moles

25cm<sup>3</sup> of BA1 contains  $\frac{1.5 \times 25}{1000}$ - moles = 0.0375 moles







(ii) 0.0375 moles of acid evolves 3105.9 J

1 mole of acid evolves  $\frac{3105.9}{0.0375}$  J

 $= 82824 \text{Jmol}^{-1}$ 

# Knowledge Check 3

Qn. 1

When 500cm<sup>3</sup> of 2M nitric acid reacts with 500cm<sup>3</sup> of 2M sodium hydroxide, the temperature rise is 12°C. Calculate heat change when one mole of acid is neutralized by one mole of alkali.

(specific heat capacity of mixture is  $4.2Jg^{-10}C^{-1}$ , density of mixture is  $1gcm^{-3}$ )



When  $50\text{cm}^3$  of 1M sulphuric acid was added to  $50\text{cm}^3$  of 2M sodium hydroxide, the temperature of the resultant solution rose by  $13.6^{\circ}C$ .

- (i) Write an ionic equation for the reaction that took place.
- (ii) Calculate the heat of neutralization of sodium hydroxide.



In a thermometric titration, 50cm<sup>3</sup> of 1M sodium hydroxide was placed in a plastic beaker and 5cm<sup>3</sup> portions of hydrochloric acid were added.

The mixture was stirred after addition and the temperature measured. Both solution were initially at 20°C.

Volume of HCI (cm <sup>3</sup> )	5	10	15	20	25	30	35	40	45	50
Temperature(°C)	22.8	23.8	24.8	25.8	26.8	27.8	28.1	27.7	27.3	26.8

(a)Plot a graph of temperature rise against volume of HCl.

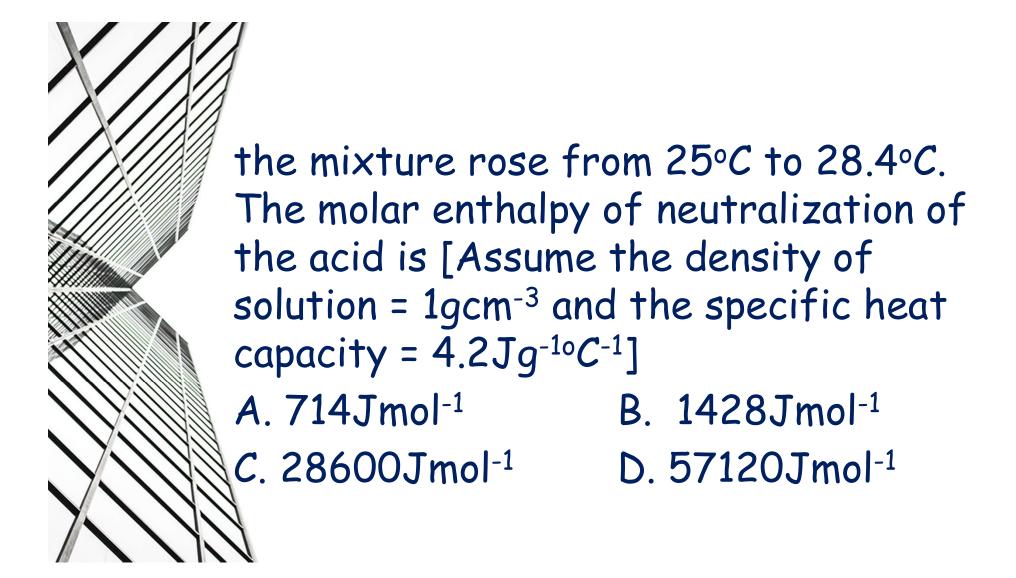
(b) Determine the molarity of HCl.

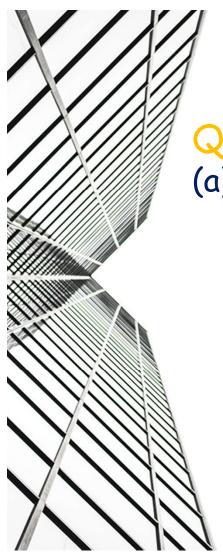
(c)Calculate the heat of neutralization.

#### Qn.4(UNEB 2012/P1/38)

Hydrochloric acid reacts with sodium hydroxide according to the following equation:

 $HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$ When 25cm<sup>3</sup> of a 0.5M hydrochloric acd was added to 25cm<sup>3</sup> of a 0.5M sodium hydroxide solution, the temperature of





Qn.4(UNEB 1995/P2/2)

(a)  $50\text{cm}^3$  of 2M hydrochloric acid and  $50\text{ cm}^3$  of 2M sodium hydroxide, both at  $22^{\circ}C$ , were mixed in a plastic beaker. The mixture was stirred and its maximum temperature was  $35^{\circ}C$  (Specific heat capacity of the solution =  $4.2\text{kJg}^{-1}/^{\circ}C$ ; density of the solution =  $1\text{gcm}^{-3}$ )

- (i) Write an ionic equation for the reaction which took place.
- (ii) Calculate the heat of the reaction.



(b) 50cm³ of 2M ammonia solution was used instead of the sodium hydroxide in (a). State whether the heat of the reaction was greater than, smaller than or equal to the value you have calculated in (a)(ii). Give a reason for your answer.



# Heat of Displacement

Heat of displacement is the heat change when one mole of a metal is displaced from its salt solution by a more reactive metal.

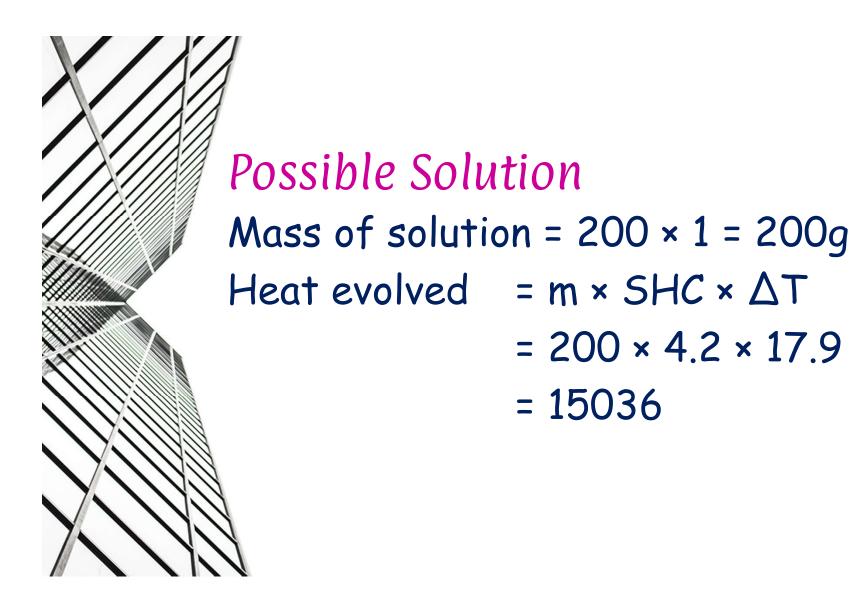
$$Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$$

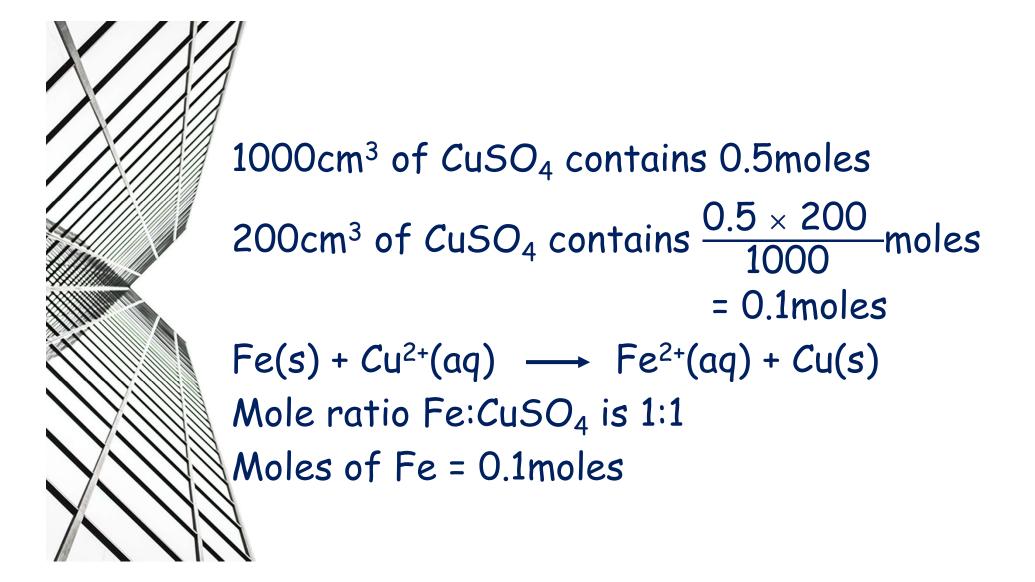
$$Fe(s) + Cu^{2+}(aq) \longrightarrow Fe^{2+}(aq) + Cu(s)$$

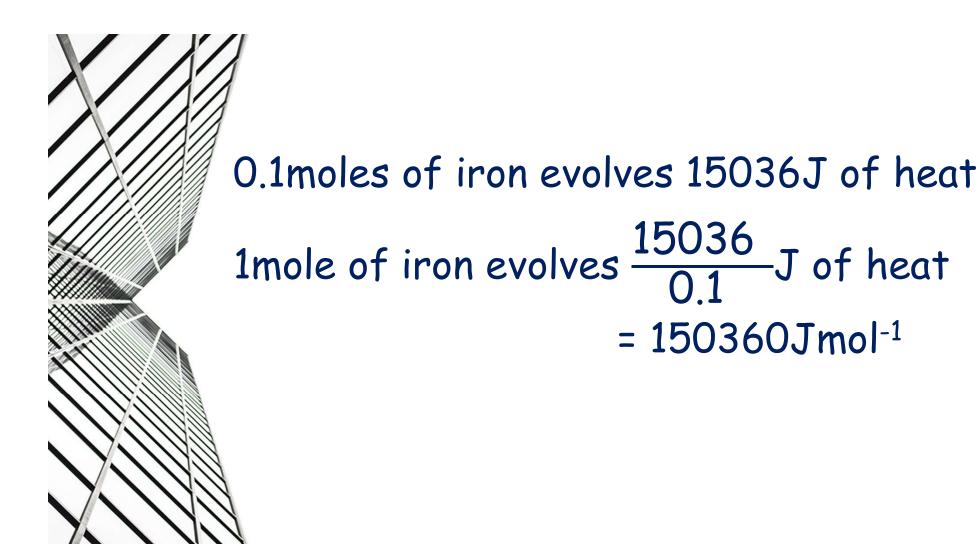
## Follow-up Question 1

When excess iron fillings were added to 200cm<sup>3</sup> of a 0.5M copper(II) sulphate solution in a plastic cup, the temperature of the solution rose by 17.9°C.

Calculate the enthalpy of displacement for the reaction [Assume the density of solution =  $1\text{gcm}^{-3}$  and the specific heat capacity =  $4.2Jg^{-10}C^{-1}$ ].







## Follow-up Question 2(UNEB 2000/P1/32)

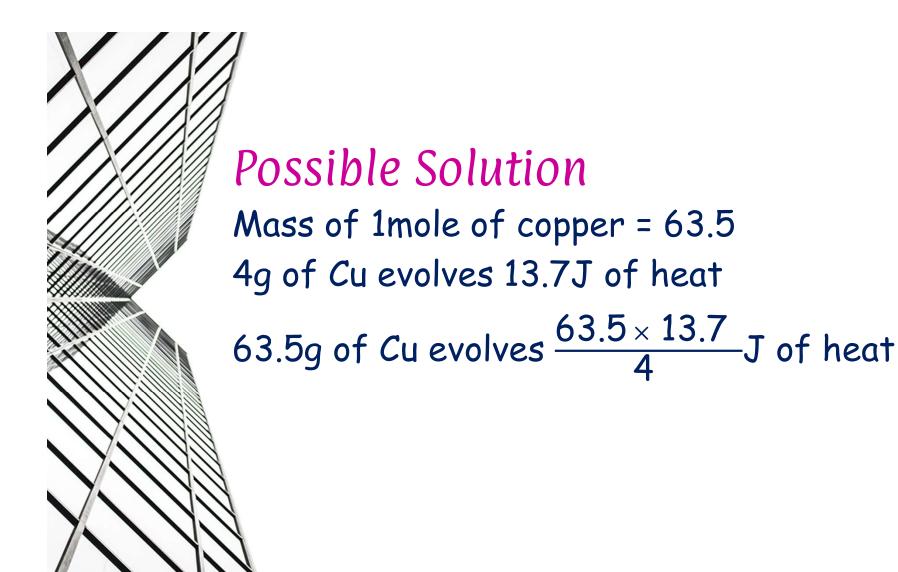
13.70kJ of heat was evolved when 4.0g of copper was displaced from copper(II) sulphate solution by zinc. The amount of heat evolved when one mole of copper was displaced is

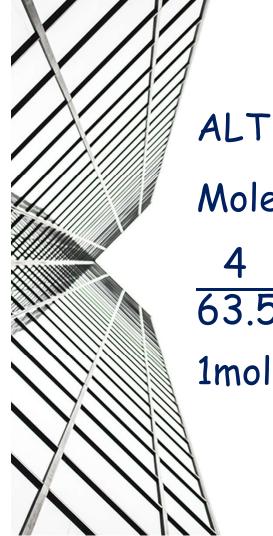
A. 
$$\frac{63.5 \times 4}{13.7}$$

$$\frac{13.7\times4}{63.5}$$

B. 
$$\frac{63.5 \times 13.7}{4}$$

D. 
$$\frac{63.5}{13.7 \times 4}$$





Moles of Cu displaced =  $\frac{4}{63.5}$ 

 $\frac{4}{63.5}$  moles of Cu evolves 13.7J of heat

1mole of Cu evolves  $\frac{63.5 \times 13.7}{4}$  J of heat

Correct option is B

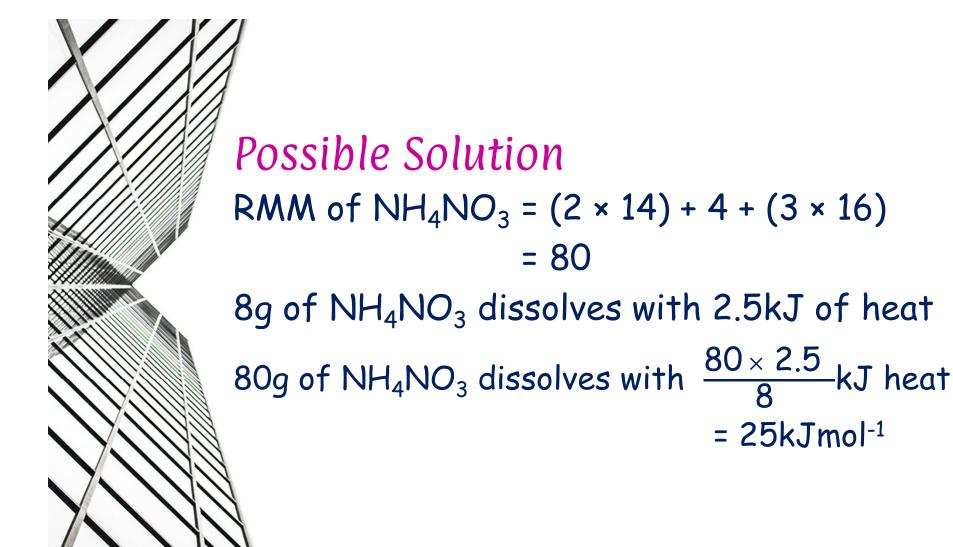


Heat of solution is the heat change that occurs when one mole of a compound is completely dissolved in water to form an infinitely dilute solution.

# Follow-up Question

When 8g of ammonium nitrate are dissolved in water, 2.5kJ are absorbed from the surroundings. Calculate the heat of solution of ammonium nitrate.

(H = 1, N = 14, O = 16)

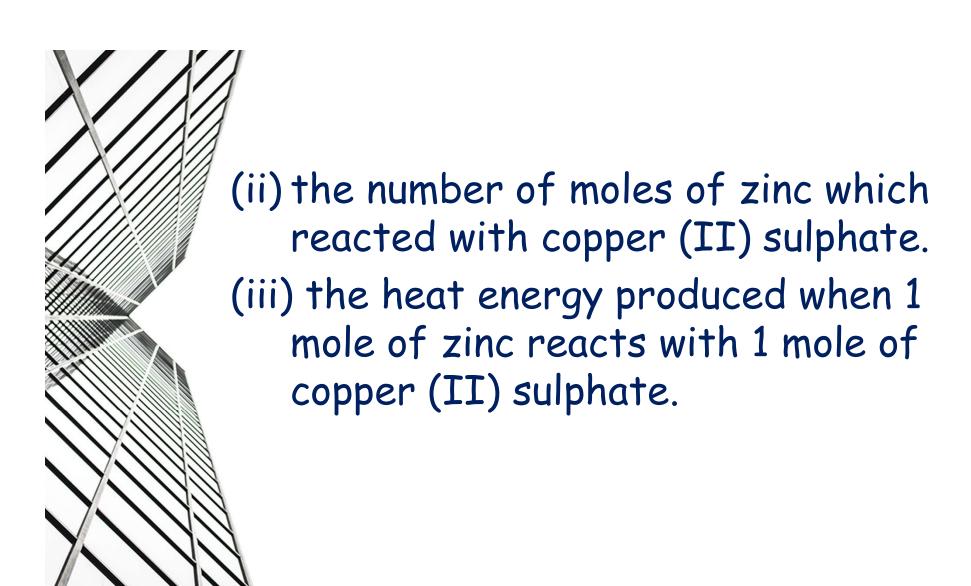




Qn. 1(UNEB 1989/P2/5)

When 6.5g of zinc powder were added to 250cm<sup>3</sup> of a 0.1M copper (II) sulphate solution in a plastic cup, 5.45kJ of heat was liberated.

- (a) Explain why a plastic cup was used instead of a metallic cup.
- (b) Write an equation for the reaction between zinc powder and copper (II) sulphate.
- (c) Calculate
  - (i) the number of moles of zinc in 6.5g of zinc powder.





When one mole of ammonium chloride was dissolved in a certain volume of water, 2.94kJ of heat was absorbed. The amount of heat absorbed when 5.35g of ammonium chloride is dissolved in the same volume of water is

A. 
$$\frac{53.5}{2.94 \times 5.35}$$

$$\begin{array}{c} 2.94\times53.5\\ \hline 5.35\end{array}$$

B. 
$$\frac{2.94 \times 5.35}{53.5}$$

D. 
$$\frac{53.5 \times 5.35}{2.94}$$

### Qn.3(UNEB 2002/P1/13)

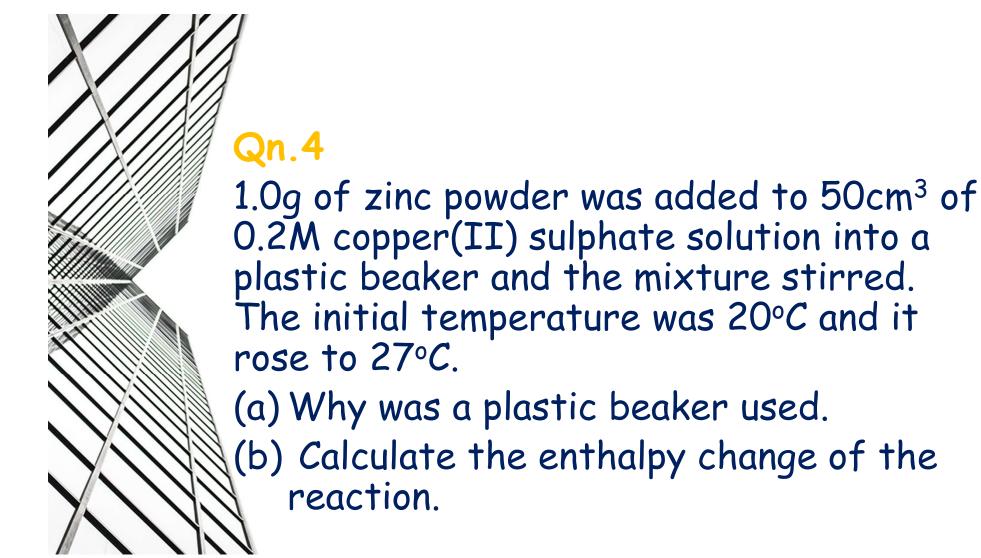
The amount of heat evolved when 6.0g of metal, M was displaced from a solution was 28.8kJ. The amount of heat produced when 0.5mole of M was displaced is

$$A. \ \frac{28.8 \times 0.5 \times 54.9}{6.0}$$

B. 
$$\frac{28.8 \times 6.0}{28.8 \times 0.5}$$

C. 
$$\frac{28.8 \times 54.9}{6.0 \times 0.5}$$

D. 
$$28.8 \times 54.9 \times 6.0 \times 0.5$$





5.3kJ of heat energy are required to vaporise 13g of liquid of relative molecular mass 78.

The heat of vaporisation of the liquid in kJmol<sup>-1</sup> is

**A**. 78.0

C. 31.8

**B**. 68.9

D. 11.3



When 2.4g of magnesium was reacted with  $200\text{cm}^3$  of 2M hydrochloric acid, 13.6kJ of heat was evolved. The molar heat of reaction of magnesium with the acid is [Mg = 24]

A. 
$$\frac{13.6 \times 200}{24 \times 2.4}$$

C. 
$$\frac{2.4 \times 24}{13.6}$$

B. 
$$\frac{13.6 \times 24}{200 \times 2.4}$$

D. 
$$\frac{13.6 \times 24}{2.4}$$

