The Mole and Energy

Mole, gas volume and reactions,
Chemical energy and Enthalpy,

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Chemical Energy

Thermochemistry is the study of heat energy taken in or given out in chemical reactions. This heat, absorbed or released, can be related to the internal energy of the substances involved. Such internal energy is called ENTHALPY, symbol H.

As it is only possible to measure the change in enthalpy, the symbol Δ **H**, is used.

$\Delta H = H_p - H_r$ Enthalpy (products) – Enthalpy(reactants)

Units **kJ**, kilojoules

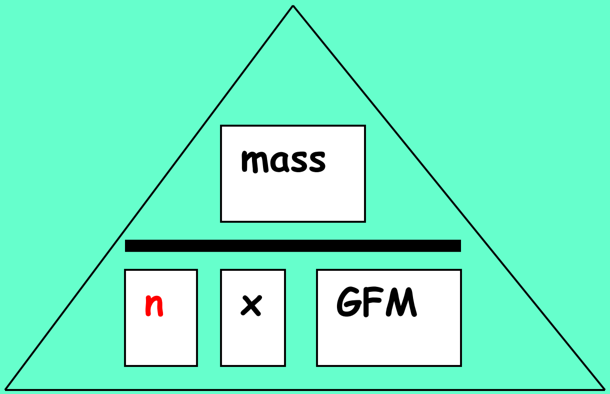
The Mole, the amount of a substance.

One mole of carbon-12 is the amount of carbon-12 which weighs exactly 12.000g.

From the relative atomic mass scale we know that Mg weighs x2 as much as C, 24 amu compared to 12 amu.

It follows that 24g of Mg contains the same number of atoms as 12 g of C.

A mole is that amount of substance which contains as many elementary entities as there are carbon atoms in 0.012 kg of carbon-12.



n = mass/GFM

Molar Quantities

You can calculate the number of moles (n) in a substances by:

1. Given the mass, divide the mass by the gram formula mass
2. Given the number of particles, divide the number of particles by Avogadro's constant.
3. Given the volume and concentration of a solution, multiply the volume by the concentration.
4. Given the volume of a gas, divide the volume by the molar volume.

AVOGADRO'S CONSTANT

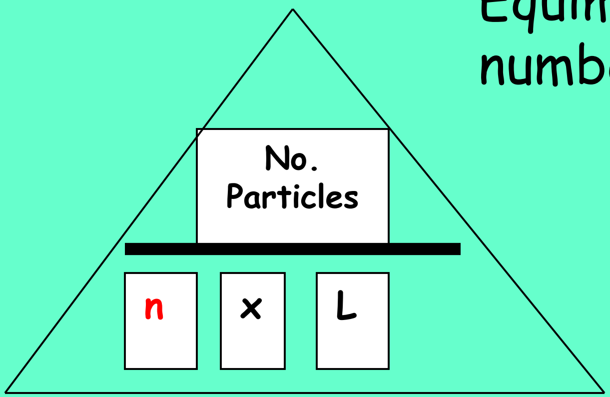
One mole of any substance contains the gram formula mass (GFM), or molar mass, g mol^{-1}.

Avogadro's hypothesis states that equal volumes of different gases, under STP, contain equal numbers of molecules.

Avogadro's constant, L or N_A, is the number of elementary entities (particles) in one mole of any substance

Avogadro's constant = 6.02×10^{23} formula units

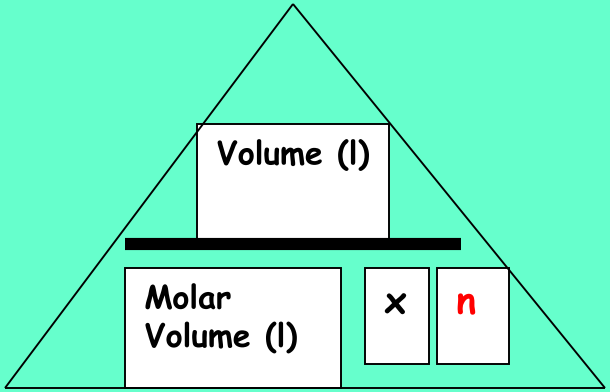
Equimolar amounts of substances contain equal numbers of formula units



Mole and gas volume

The molar volume of a gas is its volume per mole, litre mol^{-1}.
It is the same for all gases at the same temperature and pressure. The value, though, is temperature and pressure dependent.

The molar volume of all gases is approximately
24 litre mol^{-1} at 20°C and **22.4** litre mol^{-1} at 0°C.



Calculations in Higher Chemistry

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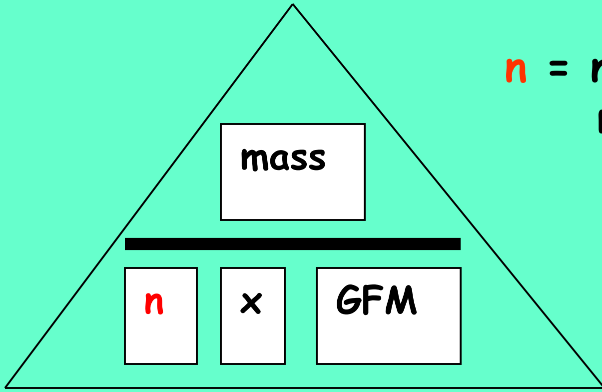
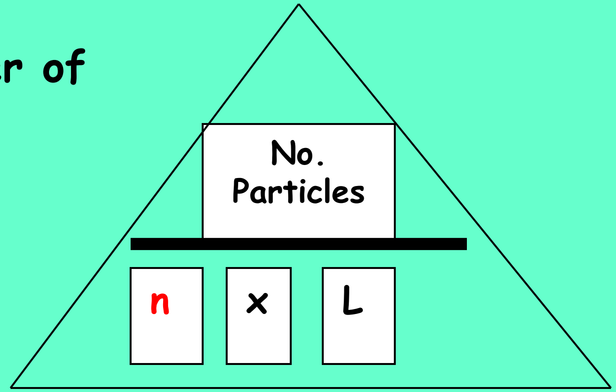
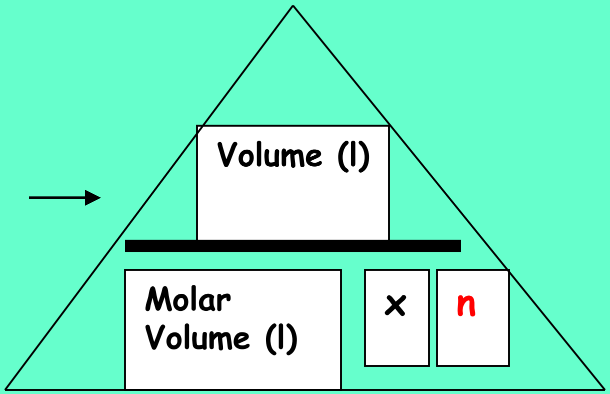
n = number of moles

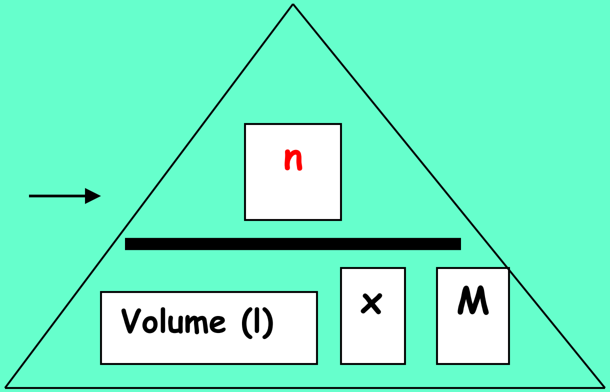




Gases
Units
litres (l)



liquids
Units
mol/l
M (Conc.)



The Mole and Avogadro's constant

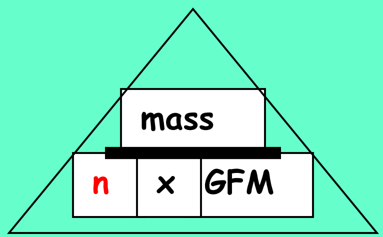
How many molecules are in 6g of water?

1 Mole of water	=	18 g
1 Mole of water	=	Avogadro's constant of molecules
18 g	=	Avogadro's constant of molecules
1 g	=	L/18
6 g	=	(L/18) * 6

Answer: 2×10^{23}

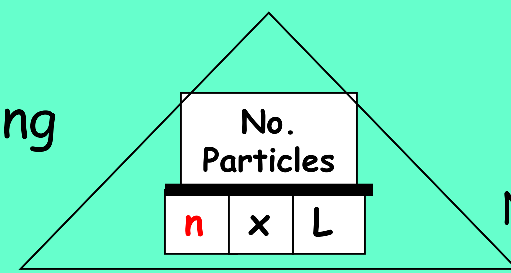
or

1st work out the number of moles (n) of water using



n = 6/18 = 0.33 mol

Then work out the number of molecules (L) of water using



№ molecules = n x L

№ molecules = 0.33 x 6.02 x 10^{23}

Further calculations

The Mole and Avogadro's constant

Avogadro's constant is the number of 'elementary particles' in one mole of a substance. It has the value of 6.02×10^{23} mol^{-1}.

Worked example 1.

Calculate the number of atoms in 4 g of bromine.

Step 1:- Identify the elementary particles present → Br_2 molecules

1 mole → 6.02×10^{23} Br_2 molecules

Step 2:- Change from moles to a mass in grams

160g → 6.02×10^{23} Br_2 molecules

Step 3:- Use proportion.

4 g → $^{4}/_{160} \times 6.02 \times 10^{23}$ Br_2 molecules

→ 0.505×10^{23} Br_2 molecules

Step 4:- Change from number of molecules to number of atoms.

0.505×10^{23} Br_2 molecules → $2 \times 0.505 \times 10^{23}$ Br atoms

→ 1.10×10^{23} Br atoms

Calculations for you to try.

1. How many atoms are there in 0.01 g of carbon?

The elementary particles → C atoms.

1 mole → 6.02×10^{23} C atoms.

12 g → 6.02×10^{23} C atoms.

So 0.01 g → $^{0.01}/_{12} \times 6.02 \times 10^{23}$ C atoms.

→ 5.02×10^{20} C atoms

2. How many oxygen atoms are there in 2.2 g of carbon dioxide?

The elementary particles → CO_2 molecules.

1 mole → 6.02×10^{23} CO_2 molecules

44 g → 6.02×10^{23} CO_2 molecules

So 2.2 g → $^{2.2}/_{44} \times 6.02 \times 10^{23}$ C atoms.

→ 3.01×10^{22} CO_2 molecules

The number of oxygen atoms (CO_2) → $2 \times 3.01 \times 10^{22}$

→ 6.02×10^{22} O atoms

3. Calculate the number of sodium ions in 1.00g of sodium carbonate.

The elementary particles → $(Na^+)_2CO_3^{2-}$ formula units

1 mole → 6.02×10^{23} $(Na^+)_2CO_3^{2-}$ formula units

106g → 6.02×10^{23} $(Na^+)_2CO_3^{2-}$ formula units

So 1.00g → $^{1.00}/_{106} \times 6.02 \times 10^{23}$ $(Na^+)_2CO_3^{2-}$ formula units

→ 5.68×10^{21} $(Na^+)_2CO_3^{2-}$ formula units

The number of Na^+ ions → $2 \times 5.68 \times 10^{21}$

→ **1.14×10^{21} Na^+ ions**

4. A sample of the gas dinitrogen tetroxide, N_2O_4, contained 2.408 x 10^{22} oxygen atoms. What mass of dinitrogen tetroxide was present?

The elementary particles → N_2O_4 molecules

1 mole → 6.02 x 10^{23} N_2O_4 molecules

1 mole → 4 x 6.02 x 10^{23} O atoms

→ 2.408 x 10^{24} O atoms

So 2.408 x 10^{22} O atoms → 2.408 x 10^{22}/ 2.408 x 10^{24} **mol of** N_2O_4

→ 0.01 mol

1 mole of N_2O_4 → 92 g

So 0.01 mole → 0.92 g

End of examples

Molar Volume

The molar volume is the volume occupied by one mole of a gas.

Worked example 1. In an experiment the density of carbon dioxide was measured and found to be 1.85 g l^{-1}.

Calculate the molar volume of carbon dioxide.

1.85 g occupies 1 litre

1 mole of CO_2 weighs 44g

So 1 mole, 44 g occupies $^{44}/_{1.85} \times 1$ = 23.78 litres

Worked example 2. A gas has a molar volume of 24 litres and a density of 1.25 g l^{-1}.

Calculate the mass of 1 mole of the gas.

1 litre of the gas weighs 1.25g

So 1 mole, 24 litres weighs 24×1.25 = 30 g

Molar volume

What is the mass of steam in 180 cm^3 of the gas, when the molar volume is 24 litres mol^{-1}?

24 litres	=	one mole of steam, 18 g
1 litre	=	18/24
0.18 litre	=	(18/24) * 0.18 **Answer: = 0.135 g**

Or

1st work out the number of moles (n) using $\frac{\text{Volume (l)}}{\text{Molar Volume (l)} \times n}$ $n = 0.18/24 = 7.5 \times 10^{-3}$

Then work out the mass using $\frac{\text{mass}}{n \times \text{GFM}}$ Mass $= 7.5 \times 10^{-3} \times 18$

Molar volume

Combustion of methane

Balanced equation	$CH_{4\ (g)}$ +	$2O_{2\ (g)}$ →	$CO_{2\ (g)}$ +	$2\ H_2O_{\ (l)}$
Mole relationship	1 mole	2 mole	1 mole	2 mole
Gas volume relationship	1 vol	2 vol	1 vol	2 vol

What volume of CO_2, at STP, is produced if 100 cm^3 of O_2 is used to completely to burn some CH_4 gas?

Link 2 vol of O_2 = 1 vol of CH_4.

Ans: 50 cm^3

Calculations for you to try.

1. Under certain conditions oxygen has a density of 1.44 g l^{-1}. Calculate the molar volume of oxygen under these conditions.

1.44g occupies 1 litre.

1 mole of O_2 weighs 32g

So 1 mole, 32g occupies $^{32}/_{1.44}$ litres = 22.22 litres

2. A gas has a density of 2.74 g l^{-1} and a molar volume of 23.4 litre mol^{-1}. Calculate the molecular mass of the gas.

1 litre of the gas weighs 2.74 g

So 1 mole, 23.4 litres weighs 23.4 x 2.74 = 64.1 g

End of examples

Calculations from Balanced Equations

A balanced equation shows the number of moles of each reactant and product in the reaction.

Worked example 1. The equation below shows the reaction between calcium carbonate and hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

20g of calcium carbonate reacts with excess hydrochloric acid.

Calculate (a) the mass of calcium chloride formed. (b) the volume of carbon dioxide gas formed. (Take the molar volume to be 23.0 litre mol^{-1})

Write the balanced equation	$CaCO_3(s) + 2HCl(aq)$	$\rightarrow$	$CaCl_2(aq)$	$+ CO_2(g) + H_2O(l)$
Show mole ratio	1 mol	$\rightarrow$	1 mol	1mol
Change moles into required units	100 g	$\rightarrow$	111 g	23.0 litres
Use proportion	20 g	$\rightarrow$	$^{20}/_{100}$ x111 g	$^{20}/_{100}$ x 23.0 litre
		=	22.2 g	4.6 litres

Calculations for you to try.

Excess sodium hydrogen carbonate is added to 200cm^3 of 0.5 mol l^{-1} hydrochloric acid. (Take the molar volume of a gas to be 24 litres per mole)

$$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$$

Calculate the

(a) mass of sodium chloride formed.
(b) number of moles of water formed.
(c) volume of carbon dioxide formed.

$NaHCO_3$ +	HCl	$\rightarrow$	$NaCl$ +	CO_2 +	H_2O
	1 mol	$\rightarrow$	1 mol	1mol	1 mol
	1 mol	$\rightarrow$	58.5 g	24 litres	1 mol
	0.1 mol	$\rightarrow$	(0.1 x 58.5g)	(0.1 x 2.4 l)	(0.1 x 1 mol)
		=	5.85 g	2.4 litres	0.1 mol

The number of moles of HCl used

C x V(l)

0.5 x 0.2

= 0.1 mol

End of examples

Calculations involving excess

As soon as one of the reactant in a chemical reaction is used up the reaction stops. Any other reactant which is left over is said to be 'in excess'. The reactant which is used up determines the mass of product formed.

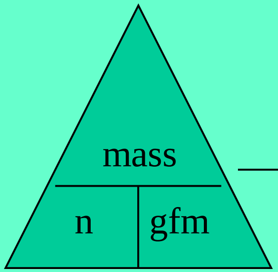
Worked example. Which reactant is in excess when 10g of calcium carbonate reacts with 100cm^3 of 1 mol l^{-1} hydrochloric acid?

Write the balanced equation for the reaction and show mole ratio:-

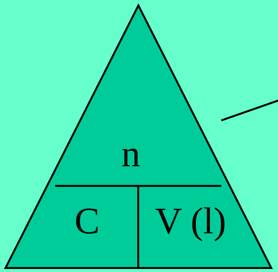
$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

1 mol 2 mol

Calculate the number of moles of each reactant:-



Number of moles in 10g of $CaCO_3$ = $^{10}/_{100}$ = 0.1



Number of moles of HCl = $1 \times {}^{100}/_{1000}$ = 0.1

From equation 0.1 mol of $CaCO_3$ needs 0.2 mol of HCl and as we only have 0.1 mol of HCl the $CaCO_3$ is in excess.

Excess reactants

You can use the relative numbers of moles of substances, as shown in balanced equations, to calculate the amounts of reactants needed or the amounts of products produced.

A limiting reactant is the substance that is fully used up and thereby limits the possible extent of the reaction. Other reactants are said to be in excess.

Which gas is in excess, and by what volume, if 35 cm^3 of methane is reacted with 72 cm^3 of oxygen?

$$CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2\,H_2O_{(l)}$$

$$1\text{mol} + 2\text{mol} \rightarrow 1\text{mol} + 2\text{mol}$$

Link 1 vol to 2 vol, so 35 cm^3 of CH_4 would mean 70 cm^3 of O_2 needed.

Ans: O_2 by 2 cm^3

Calculations for you to try.

1. What mass of calcium oxide is formed when 0.4 g of calcium reacts with 0.05 mole of oxygen?

$$2Ca \quad + \quad O_2 \quad \rightarrow \quad 2CaO$$

$$2Ca \quad + \quad O_2 \quad \rightarrow \quad 2CaO$$

2 mol 1 mol

Number of moles of Ca in 0.4 g = $^{0.4}/_{40}$ = 0.01

From equation 2 mol of Ca reacts with 1 mol of O_2.

So 0.01 mol of Ca reacts with 0.005 mol of O_2.

As we have 0.05 mol of O_2 it is in excess.

All 0.01 mol of Ca is used up

From equation 0.01 mol of Ca will produce 2 x 0.01 mol of CaO

1 mol CaO = 56g

0.01 mol CaO = 0.56g

2. What mass of hydrogen is formed when 3.27g of zinc is reacted with 25cm^3 of 2 mol l^{-1} hydrochloric acid?

$$\begin{array}{ccccccc} Zn & + & 2HCl & \rightarrow & ZnCl_2 & + & H_2 \\ 1\text{ mol} & & 2\text{ mol} & & & & 1\text{ mol} \end{array}$$

Number of moles of Zn in 3.27 g = $^{3.27}/_{65.4}$ = 0.05

Number of moles of HCl = 2 x $^{25}/_{1000}$ = 0.05

From equation 1 mol of Zn reacts with 2 mol of HCl .

So 0.05 mol of Zn reacts with 0.1 mol of HCl .

As we have only 0.05 mol of HCl it is the zinc that is in excess.

All 0.05 mol of HCl is used up

From equation 0.05 mol of HCl will produce 0.5 x 0.05 mol H_2

0.025 mol of H_2 weighs 0.025 x 2 = 0.05 g

End of examples

Enthalpy Changes

A. Enthalpy of neutralisation, ΔH_{neut} is the enthalpy change per mole of water formed when an acid is neutralised by an alkali.

ΔH_{neut} = **-57 kJ mol $^{-1}$** $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$

Calculations

B. Enthalpy of solution, ΔH_{soln} is the enthalpy change when one mole of substance dissolves completely in water.

Calculations

C. Enthalpy of combustion, ΔH_c is the enthalpy change when one mole of substance burns completely in oxygen, all reactants and products being in their standard states at 25°C and 1 atmosphere.

Calculations

Specific heat capacity

Enthalpy of combustion

The enthalpy of combustion of a substance is the amount of energy given out when one mole of a substance burns in excess oxygen.

Worked example 1.

0.19 g of methanol, CH_3OH, is burned and the heat energy given out increased the temperature of 100g of water from 22°C to 32°C.

Calculate the enthalpy of combustion of methanol.

Use $\Delta H = -cm\Delta T$

$\Delta H = -4.18 \times 0.1 \times 10$

$\Delta H = -4.18$ kJ

(c is specific heat capacity of water, 4.18 kJ kg^{-1} °C^{-1}) m is mass of water in kg, 0.1 kg ΔT is change in temperature in °C, 10°C)

Use proportion to calculate the amount of heat given out when

1 mole, 32g, of methanol burns.

0.19 g → -4.18 kJ

So 32 g → $^{32}/_{0.19} \times -4.18$ = -704 kJ

Enthalpy of combustion of methanol is –704 kJ mol^{-1}.

Worked example 2.

0.22g of propane was used to heat 200cm^3 of water at 20^{o}C. Use the enthalpy of combustion of propane in the data book to calculate the final temperature of the water.

From the data booklet burning 1 mole, 44g, of propane ΔH = -2220 kJ

By proportion burning 0.22 g of propane

$$\Delta H = {}^{0.22}/_{44} \times -2220 \quad = \quad -11.1\text{kJ}$$

Rearrange $\Delta H = -c \times m \times \Delta T$ to give

$$\Delta T = \frac{\Delta H}{-cm}$$

$$\Delta T = \frac{-11.1}{-4.18 \times 0.2} = 13.3\ ^oC$$

Final water temperature = 20 + 13.3 = 33.3^{o}C

Calculations for you to try.

1. 0.25g of ethanol, C_2H_5OH, was burned and the heat given out raised the temperature of 500 cm^3 of water from 20.1°C to 23.4°C.

Use $\Delta H = -cm\Delta T$

$\Delta H = -4.18 \times 0.5 \times 3.3 = -6.897$ kJ

Use proportion to calculate the enthalpy change when 1 mole, 46g, of ethanol burns.

0.25 g → -6.897 kJ

So 46g → $^{46}/_{0.25} \times -6.897$ = -1269 kJ mol^{-1}.

2. 0.01 moles of methane was burned and the energy given out raised the temperature of 200cm^3 of water from 18°C to 28.6°C. Calculate the enthalpy of combustion of methane.

Use $\Delta H = -cm\Delta T$ $\Delta H = -4.18 \times 0.2 \times 10.6 = -8.8616$ kJ

Use proportion to calculate the enthalpy change when 1 mole of methane burns.

0.1 mol → -34.768 kJ

So 1mol → $^{1}/_{0.01} \times -34.768$ = -88.62 kJ mol^{-1}.

3. 0.1g of methanol, CH_3OH, was burned and the heat given out used to raise the temperature of 100 cm^3 of water at 21^{o}C.

Use the enthalpy of combustion of methanol in the data booklet to calculate the final temperature of the water.

From the data booklet burning 1 mole, 32g, of methanol ΔH = -727 kJ

By proportion burning 0.1 g of methanol

$$\Delta H = {}^{0.1}/_{32} \times -727 \quad = \quad -2.27 \text{ kJ}$$

Rearrange $\Delta H = -cm\Delta T$ to give

$$\Delta T = \frac{\Delta H}{-c\, m}$$

$$\Delta T = \frac{-2.27}{-4.18 \times 0.1} = 5.4\ ^{o}C$$

Final water temperature = 21 + 5.4 = 26.4^{o}C

4. 0.2g of methane, CH_4, was burned and the heat given out used to raise the temperature of 250 cm^3 of water

Use the enthalpy of combustion of methane in the data booklet to calculate the temperature rise of the water.

From the data booklet burning 1 mole, 16g, of methane ΔH = -891 kJ

By proportion burning 0.2 g of methane.

$$\Delta H = {}^{0.2}/_{16} \times -891 \quad = \quad -11.14 \text{ kJ}$$

Rearrange $\Delta H = -cm\Delta T$ to give

$$\Delta T = \frac{\Delta H}{-cm}$$

$$\Delta T = \frac{-11.14}{-4.18 \times 0.25} = \quad 10.66^{\circ}C$$

End of examples

Enthalpy of neutralisation

The enthalpy of neutralisation of a substance is the amount of energy given out when one mole of water is formed in a neutralisation reaction.

Worked example 1. 100cm^3 of 1 mol l $^{-1}$ hydrochloric acid, HCl, was mixed with 100 cm^3 of 1 mol $^{-1}$ sodium hydroxide, NaOH, and the temperature rose by 6.2°C.

$$\text{Use } \Delta H = -cm\Delta T \quad = \quad \Delta H = -4.18 \times 0.2 \times 6.2$$

$$\Delta H = -5.18 \text{ kJ}$$

The equation for the reaction is: $HCl + NaOH \rightarrow NaCl + H_2O$

Number of moles of acid used = Number of moles of alkali

$= C \times V$ (in litres) $= 1 \times 0.1 = 0.1$ mol

So number of moles of water formed = 0.1 mol

Use proportion to find the amount of heat given out when 1 mole of water is formed.

0.1 mole $\rightarrow$ -5.18 kJ

So 1 mole $\rightarrow$ $^1/_{0.1} \times -5.18$ = -51.8 kJ mol^{-1}.

Calculations for you to try.

1. 400 cm^3 of 0.5 mol l^{-1} hydrochloric acid. HCl, was reacted with 400 cm^3 of 0.5 mol l^{-1} potassium hydroxide and the temperature rose by 6.4°C . Calculate the enthalpy of neutralisation.

Use $\Delta H = -cm\Delta T$

$\Delta H = -4.18 \times 0.8 \times 6.4$

$\Delta H = -21.40$ kJ

The equation for the reaction is

$$HCl + KOH \rightarrow KCl + H_2O$$

Number of moles of acid used = Number of moles of alkali

= C x V (in litres) = 0.5 x 0.4 = 0.2 mol

So number of moles of water formed = 0.2

Use proportion to find the amount of heat given out when 1 mole of water is formed.

0.2 mole → -21.40 kJ

So 1 mole → $^{1}/_{0.2} \times -21.40$ = -107.0 kJ mol^{-1}.

2. 250 cm^3 of 0.5 mol l^{-1} sulphuric acid. **H_2SO_4**, was reacted with 500 cm^3 of 0.5 mol l^{-1} potassium hydroxide and the temperature rose by 2.1°C. Calculate the enthalpy of neutralisation.

Use $\Delta H = -cm\Delta T$ = $\Delta H = -4.18 \times 0.75 \times 2.1$

$\Delta H = -6.58$ kJ

The equation for the reaction is

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

1 mole of acid reacts with 2 moles of alkali to form 1 mole of water.

Number of moles of acid used = $0.5 \times 0.25 = 0.125$

Number of moles of alkali used = $0.5 \times 0.5 = 0.25$

So number of moles of water formed = 0.25

Use proportion to find the amount of heat given out when 1 mole of water is formed.

0.125 mole $\rightarrow$ -6.58 kJ

So 1 mole $\rightarrow$ $^{1}/_{0.25} \times -6.58$ = -26.32 kJ mol^{-1}.

3. 100cm^3 of 0.5 mol l^{-1} NaOH is neutralised by 100cm^3 of 0.5 mol l^{-1} HCl. Given that the enthalpy of neutralisation is 57.3 kJ mol^{-1}, calculate the temperature rise.

The equation for the reaction is

$$HCl + NaOH \rightarrow NaCl + H_2O$$

1 mole of acid reacts with 1 mole of alkali to form 1 mole of water.

Number of moles of acid used = 0.5 x 0.1 = 0.05

Number of moles of alkali used = 0.5 x 0.1 = 0.05

So number of moles of water formed = 0.05 mol

Use proportion to find the amount of energy given out when 0.05 moles of water is formed.

1 mol → -57.3 kJ

So 0.05 mol → $^{0.05}/_{1}$ x -57.3 = -2.865 kJ

$$\Delta T = \frac{\Delta H}{-cm} = \frac{-2.865}{-4.18 \times 0.2} = 3.4^{o}C$$

End of examples

Enthalpy of solution

The enthalpy of solution of a substance is the energy change when one mole of a substance dissolves in water.

Worked example 1. 5g of ammonium chloride, NH_4Cl, is completely dissolved in 100cm^3 of water. The water temperature falls from 21^oC to 17.7^oC.

Use $\Delta H = -cm\Delta T$ = $\Delta H = -4.18 \times 0.1 \times -3.3$

$\Delta H = 1.38$ kJ

Use proportion to find the enthalpy change for 1 mole of ammonium chloride, 53.5g, dissolving.

5g → 1.38 kJ

So 53.5 g → $^{53.5}/_{5} \times 1.38$ = 14.77 kJ mol^{-1}.

Calculations for you to try.

1. 8g of ammonium nitrate, NH_4NO_3, is dissolved in 200cm^3 of water. The temperature of the water falls from 20^oC to 17.1^oC.

Use $\Delta H = -cm\Delta T$ = ΔH = $-4.18 \times 0.2 \times -2.9$= ΔH = +2.42 kJ

Use proportion to find the enthalpy change for 1 mole, 80g, of ammonium nitrate dissolving.

8g → 2.42 kJ

So 80g → $^{80}/_{8} \times 2.42$ = 24.2 kJ mol^{-1}.

2. When 0.1 mol of a compound dissolves in 100cm^3 of water the temperature of the water rises from 19^oC to 22.4^oC . Calculate the enthalpy of solution of the compound.

Use $\Delta H = -cm\Delta T$ = ΔH = $-4.18 \times 0.1 \times 3.4$ ΔH = -1.42 kJ

Use proportion to find the enthalpy change for 1 mole of the compound.

0.1 mol → - 1.42 kJ

So 1 mol → $^{1}/_{0.1} \times -1.42$ = -14.2 kJ mol^{-1}.

3. The enthalpy of solution of potassium chloride, KCl, is + 16.75kJ mol^{-1}. What will be the temperature change when 14.9g of potassium chloride is dissolved in 150cm^3 of water?

Use proportion to find the enthalpy change for 14.9g of potassium chloride dissolving.

74.5g (1 mol) → 16.75 kJ

So 14.9g → $^{14.9}/_{74.5} \times 16.75 = 3.35$ kJ

Rearranging $\Delta H = -cm\Delta T$

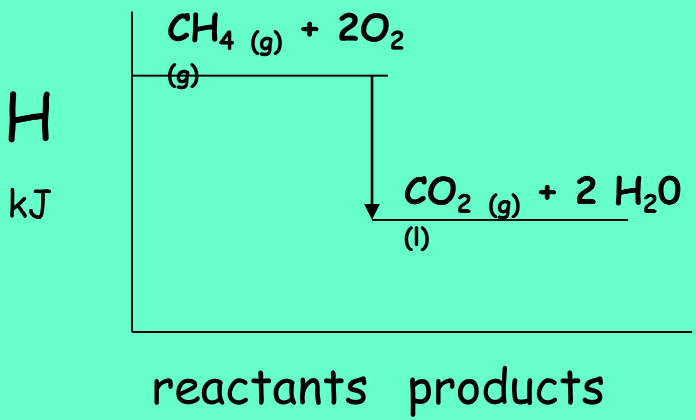
Gives $$\Delta T = \frac{\Delta H}{-cm}$$

$$\Delta T = \frac{3.35}{-4.18 \times 0.15} = -5.34\ ^{o}C$$

End of examples

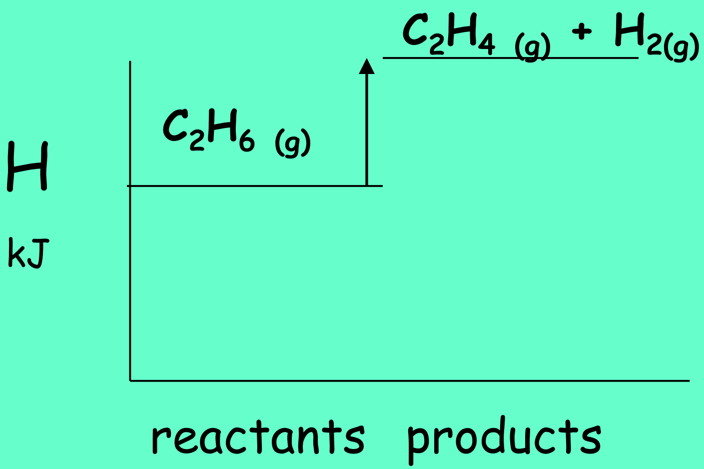
Enthalpy Changes

A. Combustion of methane $CH_{4\,(g)} + 2O_{2\,(g)} \rightarrow CO_{2\,(g)} + 2\,H_2O_{(l)}$



∆ H negative, exothermic reaction

B. Cracking of ethane $C_2H_{6\,(g)} = C_2H_{4\,(g)} + H_{2(g)}$



∆ H positive, endothermic reaction

Specific heat capacity

Calculating the enthalpy change during a chemical reaction in water.

$\Delta H = - c \times m \times \Delta T$

c	=specific heat capacity
m	=mass in Kg
ΔT	=temperature change

The mass of water can be calculated by using the fact that 1 ml = 1 g.

The value for c is usually taken as 4.18 kJ kg $^{-1}$ $^{o}C^{-1}$