Moles

You should be able to	Ways to practise skills	R	A	G	Comments
3	Calculate reacting masses in simple proportions. Calculations will not involve the mole concept	☐	☐	☐	
3.3 The mole and the Avogadro constant					
1	State that concentration can be measured in g / dm^3 or mol / dm^3	☐	☐	☐	
2	State that the mole, mol, is the unit of amount of substance and that one mole contains 6.02×10^{23} particles, e.g. atoms, ions, molecules; this number is the Avogadro constant	☐	☐	☐	
3	Use the relationship amount of substance $= \frac{\text{mass (g)}}{\text{molar mass (g/mol)}}$ to calculate: a. amount of substance b. mass c. molar mass d. relative atomic mass or relative molecular / formula mass e. number of particles, using the value of the Avogadro constant	☐	☐	☐	
4	Use the molar gas volume, taken as 24 dm^3 at room temperature and pressure, r.t.p. in calculations involving gases	☐	☐	☐	
5	Calculate stoichiometric reacting masses, limiting reactants, volumes of gases at r.t.p., volumes of solutions and concentrations of solutions expressed in g / dm^3 and mol / dm3, including conversion between cm^3 and dm^3	☐	☐	☐	
6	Use experimental data from a titration to calculate the moles of solute, or the concentration or volume of a solution	☐	☐	☐	
7	Calculate empirical formulae and molecular formulae, given appropriate data	☐	☐	☐	
8	Calculate percentage yield, percentage composition by mass and percentage purity, given appropriate data	☐	☐	☐	

What is mole?

The mole is the amount of substance.

What is 6.02×10^{23} ?

Avogadros Constant.

How is the mole related to our chemical calculations?

Particles / molecules / atoms / ions

1- Mole = $\frac{\text{Particles}}{6.02 \times 10^{23}}$

0.5 moles of CH_4 how many particles will it have.

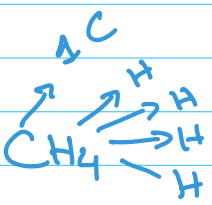
$0.5 = \frac{P}{6.02 \times 10^{23}}$

$P = 0.5 \times 6.02 \times 10^{23}$

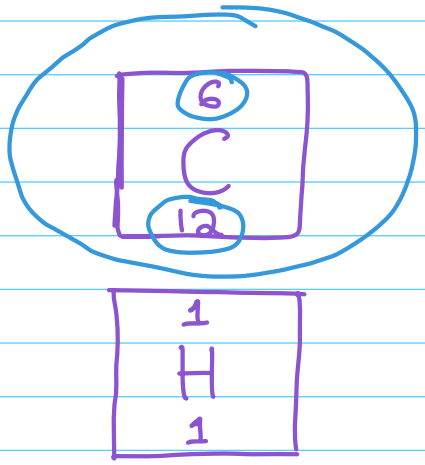
$= 3.01 \times 10^{23}$

2- Mole = $\frac{\text{mass}}{\text{Molar mass}}$

Find the M_r of CH_4



$12 + (4 \times 1) = 16$



5 g of CH_4

moles = ?

$$\text{moles} = \frac{5}{16} = 0.3125 = 0.313$$

3- Mole = Concentration x Volume

mol/dm³ Concentration

V = 25 cm³ of NaOH

C = 0.5 mol/dm³

n = ?

$$\text{mol} = \text{Conc} \times \text{Vol} = \frac{0.5 \times 25}{1000} = 0.0125 \text{ mol.}$$

4- Volume = Mole x Molar Volume

0.5 mol of CH_4.

Vol = ?

Gases!

Volume = mole x Molar Volume → 24 dm³ → 24000 cm³

$$\text{Vol} = 0.5 \times 24 = 12 \text{ dm}^3$$

$$= 0.5 \times 24000 = 12000 \text{ cm}^3.$$

STOICHIOMETRY

$1\,NaOH + 1\,HCl \rightarrow 1\,NaCl + 1\,H_2O$

1 mol, 1 mol, 1 mol, 1 mol

0.5 mol of NaOH

→ how many moles of HCl

→

NaOH	:	HCl
1		1
0.5	:	x

$x = 0.5$

Lets Solve Some questions !!!

2024 March Feb Paper 42

Q1

(g) Dilute nitric acid, $HNO_3(aq)$, reacts with aqueous calcium hydroxide, $Ca(OH)_2(aq)$, as shown.

$$2HNO_3(aq) + Ca(OH)_2(aq) \rightarrow Ca(NO_3)_2(aq) + 2H_2O(l)$$

$20.0\,cm^3$ of $0.0150\,mol/dm^3$ $Ca(OH)_2(aq)$ reacts with $25.0\,cm^3$ of $HNO_3(aq)$.

Calculate the concentration of $HNO_3(aq)$ in g/dm^3.

Use the following steps.

- Calculate the number of moles of $Ca(OH)_2(aq)$ used.

$mol = C \times V$

$= \frac{0.015 \times 20}{1000} = 3 \times 10^{-4}\ mol$

..... 3×10^{-4} ..... mol

- Determine the number of moles of $HNO_3(aq)$ which react with the $Ca(OH)_2(aq)$.

$HNO_3 : Ca(OH)_2$

$2 : 1$

$x : 3 \times 10^{-4}$

$x = 6 \times 10^{-4}$

..... 6×10^{-4} ..... mol

- Calculate the concentration of $HNO_3(aq)$ in mol/dm^3.

$mol = C \times V$

$6 \times 10^{-4} = \frac{C \times 25}{1000}$

$C = \frac{6 \times 10^{-4} \times 1000}{25}$

$C = 0.025$

..... 0.025 ..... mol/dm^3

- Calculate the concentration of $HNO_3(aq)$ in g/dm^3.

$mol = \frac{mass}{Mr.}$

$= 0.025 \times 63$

$= 1.575 \rightarrow 1.58\ g/dm^3$

H → 1
N → 14
O → 16

$Mr = 1 + 14 + (16 \times 3) = 63$

..... g/dm^3 [5]

2024 Oct Nov Paper 22.

Q2

The equation for the decomposition of ammonium carbonate, $(NH_4)_2CO_3$, is shown.

$$1(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + CO_2(g) + H_2O(l)$$

[M_r: $(NH_4)_2CO_3$, 96]

The **total** volume of gas produced is $360\,cm^3$ at r.t.p.

360

Volume = mol × Molar vol.

$mol = \frac{360}{24000} = 0.015\ mol$

Which mass of ammonium carbonate, $(NH_4)_2CO_3$, is decomposed?

A 0.24 g **B** 0.48 g **C** 0.96 g **D** 1.44 g

$(NH_4)_2CO_3$: All gases

$\frac{1}{x} : \frac{3}{0.015}$

$x = 5 \times 10^{-3}\ mol$

$mol = \frac{mass}{Mr.}$

$5 \times 10^{-3} \times 96 = 0.48\ g$

Try it yourself !!!

When magnesium nitrate is heated strongly, magnesium oxide is formed.

(a) The equation for this reaction is shown.

$$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$$

(iii) Calculate the volume of NO_2 gas, at r.t.p., formed when 7.40 g of $Mg(NO_3)_2$ is heated.

Use the following steps.

- Calculate the M_r of $Mg(NO_3)_2$.

.....

- Calculate the number of moles of $Mg(NO_3)_2$ used.

..... mol

- Determine the number of moles of NO_2 formed.

..... mol

- Calculate the volume of NO_2 gas, in cm^3, at r.t.p.

..... cm^3
[4]

Is this what you got?

When magnesium nitrate is heated strongly, magnesium oxide is formed.

(a) The equation for this reaction is shown.

$$2Mg(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2$$ ✓

(iii) Calculate the volume of NO_2 gas, at r.t.p., formed when 7.40 g of $Mg(NO_3)_2$ is heated.

Use the following steps.

- Calculate the M_r of $Mg(NO_3)_2$.

$24 + 2(14 + 3(16)) = 148$

148

- Calculate the number of moles of $Mg(NO_3)_2$ used.

$\text{mole} = \frac{\text{mass}}{M_r}$

$\text{mole} = \frac{7.4}{148} = 0.05$

0.05 mol

- Determine the number of moles of NO_2 formed.

$2 : 4$
$0.05 : x$

$x = \frac{0.05 \times 4}{2}$
$= 0.1$

0.1 mol

- Calculate the volume of NO_2 gas, in cm^3, at r.t.p.

Volume = mole x molar volume
$= 0.1 \times 24000$
$= 2400$

2400 cm^3
[4]