Mole calculations / Stoichiometry

* **Relative atomic mass Ar**: average mass of the isotopes of an element compared to 1/12 th of the mass of an atom of carbon-12

Ar unit : $g\,mol^{-1}$

* **Relative molecular mass Mr**: sum of the relative atomic masses of each atom in a molecule.

* use periodic table to find Ar.

e.g Calculate Mr for $(NH_4)_3N$

3 N + 12 H + 1 N

4 N + 12 H

$(4 \times 14) + (12 \times 1) = 68\ g\,mol^{-1}$

* **Mole**: amount of substance, 1 mol contains 6.02×10^{23} particles

* $1\ mol = 6.02 \times 10^{23}$ atoms or molecules or ions

* $mol = \frac{mass}{Ar}$ ← from periodic tabl

Avogadro constant :

6.02×10^{23}

e.g calculate moles and number of atoms in 150g of sodium sulfate Na_2SO_4

$\boxed{1}$ to calculate moles : $\text{moles} = \dfrac{\text{mass}}{M_r}$

from question

$$= \frac{150}{(2 \times 23) + 32 + (4 \times 16)}$$

from periodic table

$$= 1.05 \text{ mol}$$

(2) to calculate ~~#~~ atoms

$1 \text{ mol} = 6.02 \times 10^{23}$ atoms

$1.05 = x$

$x = 1.05 \times 6.022 \times 10^{23}$

$= 6.32 \times 10^{23}$ Atom

* using Avogadro number

e.g find the mass of 7.9×10^{23} atoms of Carbon.

Step 1 convert to moles.

$1 \text{ mol} = 6.02 \times 10^{23}$ atom

$x = 7.9 \times 10^{23}$

$$\frac{\cancel{6.02 \times 10^{23}}\, x}{\cancel{6.02 \times 10^{23}}} = \frac{7.9 \times 10^{23}}{6.02 \times 10^{23}}$$

$x = 1.31$ mol

Step 2 convert to mass

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

$$1.31 = \frac{\text{mass}}{12} \qquad \text{mass} = 15.74 \text{ g}$$

* Molar gas volume

at room temperature and pressure r.t.p two gases of the same volume will have equal amounts of mol

$$\rightarrow \quad mol = \frac{Volume}{24} \quad \leftarrow \text{unit: } dm^3$$

r.t.p

20°C

1 atm

remember :
$1\ dm^3 = 1000\ cm^3$
to convert from cm^3 to dm^3 divide by a 1000

* Concentration

$$mol = Concentration \times Volume$$

unit: $mol\ dm^{-3}$ (Concentration)

dm^3 (Volume)

✱ Mole ratio in chemical equations

e.g. Calculate mass of Aluminium oxide produced when 20g of Aluminium is burned with enough oxygen.

Step 1 write balanced equation.

Step 2 circle substances question is asking about

$$4\,Al_{(s)} + 3\,O_{2(g)} \longrightarrow 2\,Al_2O_{3(s)}$$

20g mass ??

must convert to moles

$$\text{moles} = \frac{\text{mass}}{Ar}$$

$$= \frac{20}{27} = 0.74\ \text{mol}$$

ratio

step 1 from equation

step 2 from question

$$Al : Al_2O_3$$

$$4 : 2$$

$$0.74 : x$$

cross multiplication

$$\frac{4x}{4} = \frac{2 \times 0.74}{4}$$

$$x = 0.37\ \text{mol}\ Al_2O_3$$

final step: Convert moles to mass

$$0.37 = \frac{\text{mass}}{(2\times 27)+(3\times 16)}$$

mass = 37.7 g

★ Limiting reactant and excess reactant

Limiting: substance that used up and limits the amount of product

↳ will produce less amount of product.

Excess: substance that will not used up totally

How to find the limiting reactant.

$$3H_2 + N_2 \longrightarrow 2\boxed{NH_3}$$

6g   6g

step 1: convert to moles

$\frac{6}{2\times1}$ $\frac{6}{2\times14}$

3 mol   0.21 mol

step 2: two ratios to find amount of product

$H_2 : NH_3$

3 : 2

3 : x

$\frac{\cancel{3}x}{\cancel{3}} = \frac{6}{3}$

$x = 2$ mol

$N_2 : NH_3$

1 : 2

0.21 : x

$x = 2 \times 0.21$

$x = \underline{0.42 \text{ mol}}$

lower

→ N_2 is limiting

* any amount will be calculated using limiting reactant ratio

★ percentage composition by mass

$$= \frac{\text{mass of substance in compound}}{\text{Total mass of compound}} \times 100\%$$

e.g. find percentage composition of Fe in Fe_2O_3

$$= \frac{2 \times 55.8}{(2 \times 55.8) + (3 \times 16)} \times 100 = 69.9\ \%$$

← Fe

← Fe_2O_3

from experiment (given)

★ Percentage yield

$$\text{Percentage yield} = \frac{\text{actual mass of product}}{\text{theoretical mass of product}} \times 100$$

calculated

e.g. 9 g of Al reacted with excess chlorine

mass of $AlCl_3$ collected was 35.6 g

actual yield

calculate percentage yield.

$$2Al + 3Cl_2 \rightarrow 2AlCl_3$$

$\frac{9\text{ g}}{27} = 0.33$ mol

? theoritical mass

Al	:	$AlCl_3$
2	:	2
0.33	:	x

x = 0.33 mol

$$0.33 = \frac{\text{mass}}{27 + (3 \times 35.4)}$$

theo. mass = 44.5 g

$$\text{Percentage yield} = \frac{35.6}{44.5} \times 100 = 80\ \%$$

* percentage purity = $\frac{\text{mass of pure product}}{\text{total mass of impure product}} \times 100$

e.g pure aspirine has a mass of 58.5g (pure), but sample shows 1.5g impurities, calculate percentage purity

$= \frac{\text{pure}}{\text{impure}} \times 100 = 97.5\%$ pure

pure → 58.5

impure → 58.5 + 1.5

* Empirical formula and Molecular formula

Empirical formula: simplest ratio between atoms e.g. CH_3

Molecular formula: Actual formula, can be simplified e.g. C_2H_6

finding E. formula

[1] find moles

[2] divide each by lowest number

finding M. formula

[1] divide : $\frac{\text{M.F. mass}}{\text{E.F. mass}}$

[2] multiply answer by E.F

e.g. calculate E.f for a compound contains

26.67 % C and 2.22 % H rest is oxygen

$100 - (26.67 + 2.22)$
$= 71.11$

	C	H	O
find moles	$\frac{26.67}{12}$	$\frac{2.22}{1}$	$\frac{71.11}{16}$
divide each by 2.22	$\frac{2.22}{2.22}$	$\frac{2.22}{2.22}$	$\frac{4.44}{2.22}$
	1	1	2

Formula CHO_2

if molecular formula mass is 90 $g\ mol^{-1}$

find molecular formula

$\frac{90}{45}$ ← given

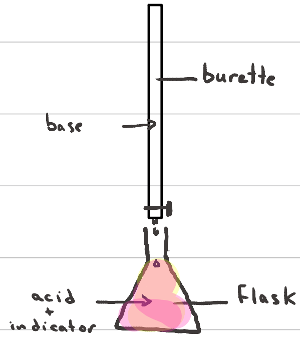
→ Empirical mass $(12 + 1 + (2 \times 16))$

$= 2 \times [CHO_2]$

Molecular formula $C_2H_2O_4$

* Titration

is a method used to find unkown concentration of an acid-base reaction.



indicator is used to show the change in color wher rxn is completed

* use mole = Concentration × Volume

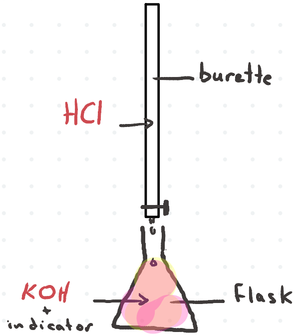
  Concentration: mol dm^{-3}; Volume: dm^3

* write equation and use ratios to find moles then concentration

to convert from cm^3 to dm^3

divide by 1000

Solved Question



25 cm^3 of KOH ✓ of unknown conc. ??

is put into a flask

with indicator.

indicator changes colour when 30 cm^3 ✓ of HCl of

a concentration of 0.20 mol dm^{-3} has been added.

= moles

conc.

Calculate concentration of KOH.

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

$\boxed{1}$ find moles of HCl mole = C × V = 0.2 × $\frac{30}{1000}$

= 0.006 mol HCl

$\boxed{2}$ ratio between KOH : HCl 1 : 1

0.006 : x

x = 0.006 mol KOH

$\boxed{3}$ convert moles KOH to concentration

mole = C × V

0.006 = C × $\frac{25}{1000}$

C = 0.24 mol dm^{-3}