

★ Stoichiometry A-Level ★

★ unified atomic mass: one twelfth of the mass of a carbon-12 atom

★ relative atomic mass A_r : the average mass of atoms of an element compared to the unified atomic mass unit.

★ relative molecular mass M_r : the average mass of a molecule compared to the unified atomic mass unit

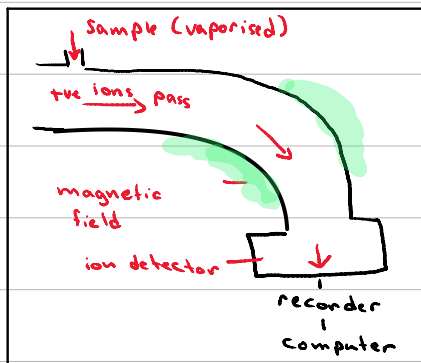
★ relative isotopic mass: the mass of an atom of an isotope compared to the unified atomic mass unit

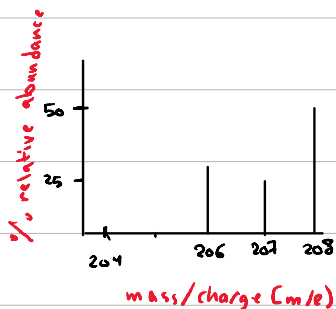
<https://aseelkhatib.com/chemistry-resources>



mass spectrometer:

- 1- atoms are converted to positive ions
- 2- positive ions travel to a detector
- 3- lighter ions move faster
- 4- computer displays the mass spectrum.





mass spectrum of sample of Pb

* it shows 4 isotopes

* each isotope has an abundance

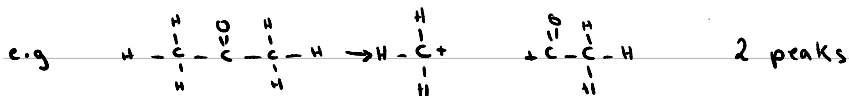
$$\text{relative atomic mass} = \frac{\text{mass} \times \% \text{ of isotope 1} + \text{mass} \times \% \text{ of isotope 2} + \dots}{\text{total abundance}}$$

$$= \frac{204 \times 2 + 206 \times 24 + 207 \times 22 + 208 \times 52}{2 + 24 + 22 + 52}$$

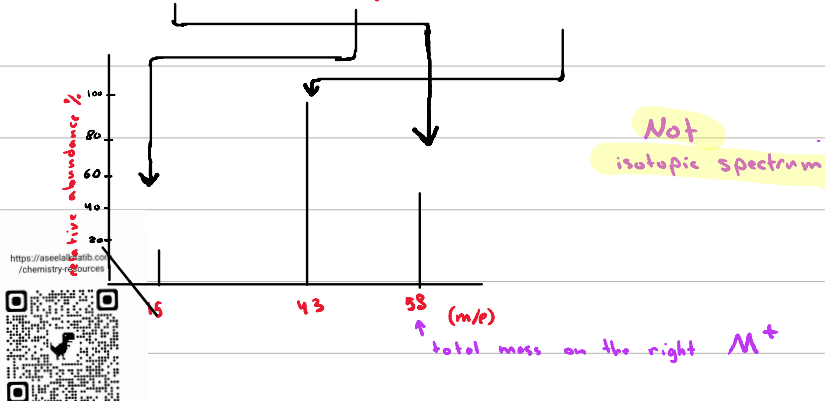
$$= \frac{20722}{100} = 207.22$$



Fragmentation: the breaking up of a covalent compound during mass spectrometry into smaller positively charged species.



total mass: 58 mass: 15 mass 43



* using $M+1$ peak

carbon has 2 isotopes ^{12}C and ^{13}C
↑ more % ↑ less %

M^+ peak represents carbon-12 isotope

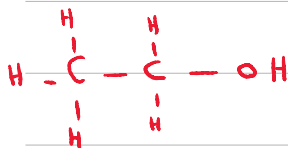
$M+1$ peak represents carbon-13 isotope

* mass spectrum of ethanol (C_2H_5OH)

Since there is carbon in it, both isotopes of carbon are there M^+ , $M+1$

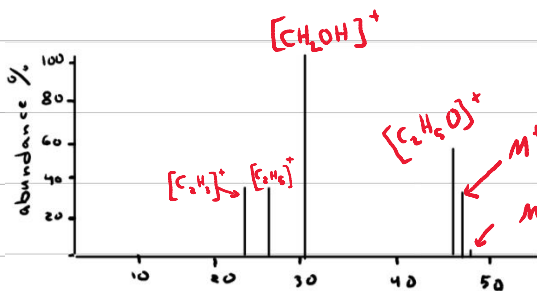
mass of total compound
with ^{12}C

mass of total compound
with ^{13}C



break it into fragments
and check masses

<https://www.khanlab.com>



$M+1$ → this peak is very small and it is +1 mass

we can find number of carbons in the compound using the formula:

$$n = \frac{100}{1.1} \times \frac{\text{abundance of } [M+1]^+}{\text{abundance of } M^+}$$

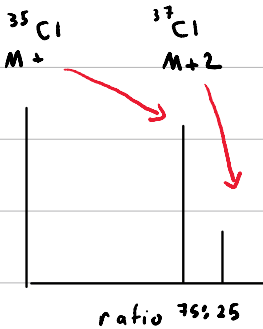
$$= \frac{100}{1.1} \times \frac{0.45}{20} = 2 \text{ carbons}$$

this is relevant

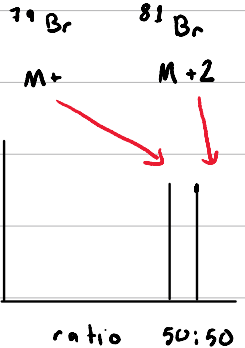
because ethanol has 2 carbons

M + 2 mass

Chlorine isotopes



Bromine isotopes

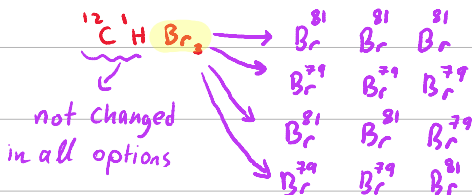


look at the right side and check the mass difference if it is 2, it could be Br or Cl then check the ratio length between spectrums

* How many peaks can be seen



let's make up our compound options



4 peaks

mole: the amount of substance which contains
 6.02×10^{23} (atoms or particles or ions ...)



Avogadro constant.

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

* $\text{mol} = \frac{\text{mass}}{A_r}$ ← from periodic table

e.g calculate moles and number of atoms

in 150g of sodium sulfate Na_2SO_4

<https://aseelkhatib.com/chemistry-resources>

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



from question →

$$= \frac{150}{}$$

$$(2 \times 23) + 32 + (4 \times 16)$$

from periodic table →

$$= 1.05 \text{ mol}$$

② to calculate atoms

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

$$1.05 = x$$

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

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

* Molar gas volume

at room temperature and pressure r.t.p

two gases of the same volume will have equal amounts of mol

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

r.t. p
↑ ↑
20°C 1 atm

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

* Concentration

$$\text{mol} = \text{Concentration} \times \text{Volume}$$

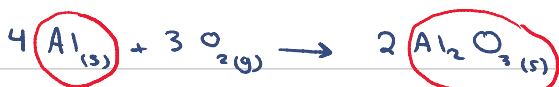
unit: $\uparrow \text{ mol dm}^{-3}$ $\uparrow \text{ dm}^3$

* 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



must convert
to moles

20g

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

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

mass??

ratio

step 1
from equation

step 2

from question



cross multiplication

$$4x = \frac{2 \times 0.74}{1}$$

$$x = 0.37 \text{ mol Al}_2\text{O}_3$$

final step: Convert moles to mass

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

$$\text{mass} = 37.7 \text{ g}$$



* Limiting reactant and excess reactant

substance that used up and
limits the amount of product

substance that will
not used up totally

↳ will produce less amount of
product.

How to find the limiting reactant.



step 1: convert
to moles

$$\frac{6}{2 \times 1} \quad \frac{6}{2 \times 14}$$

3 mol 0.21 mol



step 2: two

ratios to find
amount of product



$$3 : 2$$

$$3 : x$$

$$\frac{3}{3}x = \frac{6}{3}$$
$$x = 2 \text{ mol}$$



$$1 : 2$$

$$0.21 : x$$

$$x = 2 \times 0.21$$

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

lower
→ N_2 is limiting

* any amount will be calculated
using limiting reactant ratio

from experiment (given)

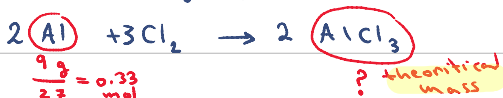
$$\text{Percentage yield} = \frac{\text{actual mass of product}}{\text{theoretical mass of product}} \times 100$$

↓
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.



$$x = 0.33 \text{ mol}$$

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

$$\text{theo. mass} = 44.5 \text{ g}$$

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

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 Fe₂O₃



* Empirical formula and Molecular formula

Simplest ratio between

atoms e.g. CH_3

Actual formula

can be simplified e.g. C_2H_6

finding E. formula

finding M. formula

1 find moles

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

2 divide each by

E.F. mass

lowest number

2 multiply answer by

E.f

detailed question will be found in o level stoichiometry summary notes

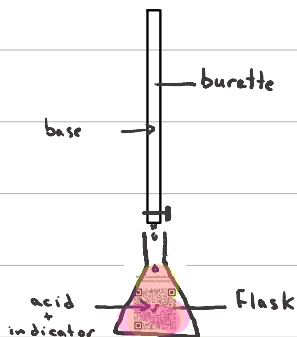


* Titration

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

indicator is used to

show the change in color when rxn is completed



* use $\text{mole} = \text{Concentration} \times \text{Volume}$

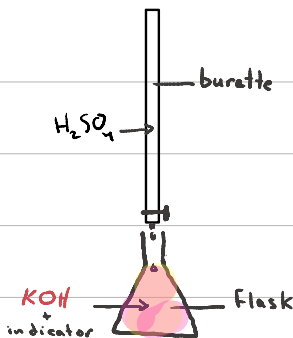
$\uparrow$ $\uparrow$
 mol dm^{-3} dm^3

* write equation and use ratios to find moles then concentration

Q1

25 cm³ of KOH
✓
of unknown conc. ??

is put into a flask
with indicator.



indicator changes colour when 30 cm³ of H₂SO₄ of
a concentration of 0.20 mol dm⁻³ has been added.
= moles
↓
conc.

Calculate concentration of KOH.



1 find moles of H₂SO₄ mole = $C \times V = 0.2 \times \frac{30}{1000}$
 $= 0.006 \text{ mol H}_2\text{SO}_4$

2 ratio between KOH : H₂SO₄ 2 : 1
0.006 : x
x = 0.003 mol KOH

3 convert moles KOH to concentration
mole = C × V

$$0.003 = C \times \frac{25}{1000}$$

$$C = 0.12 \text{ mol dm}^{-3}$$



Q2 ^{moles} 25.0 cm³ of 0.0500 mol dm⁻³ solution of metal hydroxide titrated against 0.2000 mol dm⁻³ HCl and required 12.5 cm³ ^{moles} of HCl, write the equation for this titration.

→ equation needs moles stoichiometry.

moles of metal hydroxide $M(OH)_x$ ← we don't know the charge of the metal

$$\begin{aligned} \text{mol} &= C \times V = 0.0500 \times \frac{25}{1000} \\ &= 1.25 \times 10^{-3} \text{ mol} \end{aligned}$$

moles of HCl



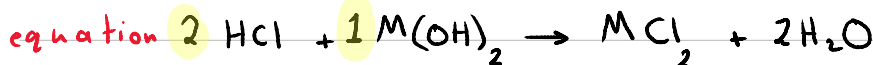
$$\begin{aligned} \text{mol} &= C \times V = 0.200 \times \frac{12.5}{1000} \\ &= 2.50 \times 10^{-3} \end{aligned}$$

ratio between HCl : $M(OH)_x$

$$\text{moles: } \frac{2.5 \times 10^{-3}}{1.25 \times 10^{-3}} \quad \frac{1.25 \times 10^{-3}}{1.25 \times 10^{-3}}$$

divide by smaller:

$$2 : 1$$



we know that 1 mol of H^+ must neutralise 1 mol of OH^-

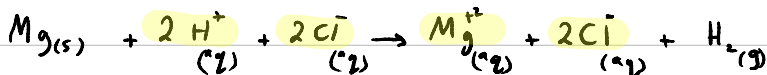
but we have 2 mol of acid (H^+), so it needs 2 OH^-

Balancing Ionic Equations

1: complete and balance full equation

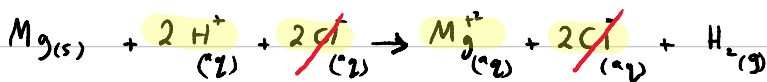


2: write down ions present in aqueous state only



3: cancel out ions that appear on both sides as

lone ions (spectator ions)



4: write net ionic equation

