MOLES : STOICHIOMETRY

↳ An avogadro's constant (6.02×10^{23}) of something

Space for Chemist Shopkeeper Example :

Avogadro's Constant (L) : 6.02×10^{23} ___ / mol of a substance
↳ this blank can be filled by any particle (ie. atom, molecule, ions, electrons, etc.)

The mass of 1 mol of a substance is equal to the Ar or Mr of the substance in grams.

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

Definitions :

Mole : A mole is the amount of a substance containing 6.02×10^{23} particles of that substance

OR

A mole contains as many particles as there are atoms in 12g of carbon-12.

No. of particles (in a sample) = moles × Avogadro's constant

No. of particles = n × L

1 a) How many molecules of oxygen are there in 4 grams of oxygen gas?

O_2 molecule → moles = $\frac{\text{mass}}{Mr}$

$n = \frac{4.0}{32}$

$n = 0.125$ mols

molecules = 0.125 mols × 6.02×10^{23}

= 7.53×10^{22} molecules

b) How many atoms of oxygen are there in 4 grams of oxygen gas?

$O \neq O \rightarrow O + O$

4g = 0.125 mols   n = 0.125 + n = 0.125 of atom.

No. of atoms = 2(0.125)
= 0.25 mols of oxygen atoms

= $0.25 \times 6.02 \times 10^{23}$
= 1.51×10^{23} atoms of oxygen

Volume

1 mol of any gas has a volume of $24.0\,dm^3$ (→ molar gas volume) at R.T.P (25°C)

Vol. of gas = moles × molar gas volume

i) How many molecules and atoms are present in $9.6\,dm^3$ of Cl_2 gas?

Moles of Cl_2 = $\frac{9.6}{24}$
= 0.4 mols

No. of molecules = $0.4 \times 6.02 \times 10^{23}$
= 2.41×10^{23} molecules → Ans.

No. of atoms = $2(0.4) \times 6.02 \times 10^{23}$
= 4.82×10^{23} atoms → Ans.

MCQ

which of these samples of gas contains the same number of atoms as 1g of hydrogen (M_r = H_2, 2)

A. 22g CO_2 (M_r 44) → 3 × 0.5 mols of atoms
B. 8g CH_4 (M_r 16) → 5 × 0.5 mols of atoms
$\boxed{C}$ 20g Ne (M_r 20) → 1 × 1 mols of atoms
D. 8 g of O_3 (M_r 48) → 3 × 0.167 mols of atoms

matches

n(H_2) = ½ = 0.5 mol H_2 gas
n(H atoms) = 2 × 0.5 = 1 mol H atoms

Molar gas volume = 1 mole of a gas occupies a volume $24\,dm^3$ at rtp. (25°C)

rtp = room temperature and pressure (25°c, 1 atm) ($24\,dm^3$)
stp = standard temperature and pressure (0°C, 1 atm) ($22.4\,dm^3$)

Vol. of gas = moles × molar gas volume

Example

Calculate the moles in $500\,cm^3$ of CH_4.

vol = mol × mgv

$0.5dm^3 = mol \times 24dm^3$

$\frac{0.5}{24} = mol$

0.0208 moles → Ans.

EMPIRICAL AND MOLECULAR FORMULAS

Empirical formula : The simplest whole number ratio of the elements present in one molecule of a compound

Molecular formula = The molecular formula of a compound shows the actual number of the atoms of each element present in the compound.

*For ionic compounds, their normal formula is also their empirical formula

!! Important : Show all the working (for P2)

Example

① A sample of a compound has the following composition. What is it's empirical formula.

element	mass /g	moles	ratio	whole no. ratio
Na	9.20 / 23	0.4 / 0.4	1	2
S	12.80 / 32	0.4 / 0.4	1	2
O	9.60 / 16	0.6 / 0.4	1.5	3

∴, the empirical formula = $Na_2S_2O_3$ → sodium thiosulfate

② Glucose has an empirical formula CH_2O (1 : 2 : 1) (C H O). The relative molecular mass of glucose is 180. What is the molecular formula of glucose? → Easy q., but the caveat is showing all working

Molecular mass = n × empirical mass where n is the factor that relates the molecular formula and the empirical formula

...t working that needs to be shown

CH_2O → empirical mass
= 12 + 2 + 16
= 30

180 = n × 30

$n = \frac{180}{30}$

Important: $n = 6$ → need to change empirical formula by a factor of 6

$(CH_2O)_6 = C_6H_{12}O_6$ → molecular formula

CONCENTRATION → mol/dm³ or g/dm³

tells us how many moles or grams are dissolved in 1 dm³ of water.

Q. What is a standard solution?
Simply, a solution of known concentration.

Making a standard solution
ie. making 250 cm³ of $\underline{0.1 \text{ mol/dm}^3}$ of NaOH solution.
concentration

1. Convert moles to mass

$\text{mols} = \frac{\text{mass}}{Mr}$ $\quad Mr = 23 + 16 + 1 = 40 \text{ g/mol}$

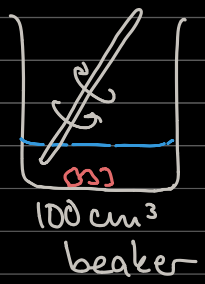
$\text{mols} \times Mr = \text{mass}$

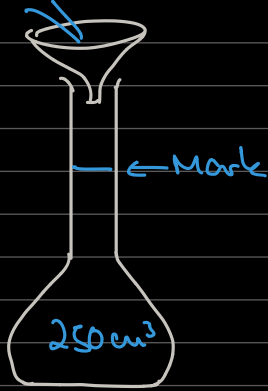
$0.1 \times 40g = \text{mass of } 0.1 \text{ mol}$

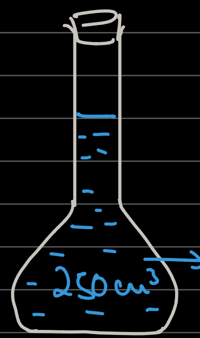
$4g = \text{mass of } 0.1 \text{ mol NaOH in } 1 \text{ dm}^3$

in 250 cm³ or 0.25 dm³ → $4 \times 0.25 = 1$ g NaOH in our standard solution

1. Use a digital balance to weigh out 4g of NaOH. * NaOH is hydroscopic : absorbs water very rapidly.
2. Transfer NaOH (1.0g) to a 100 cm³ beaker → so that the rinse water can also be added later
3. Add a minimum amount of distilled water to dissolve, by stirring with a glass rod
4. Transfer the solution using a funnel to a 250 cm³ volumetric flask
5. Rinse the beaker, the glass rod and funnel into the volumetric flask with more distilled water.
6. Fill the volumetric flask up to the mark with distilled water.
7. Stopper + mix thoroughly by inverting a few times







→ standard solution

+ for colourless solutions, look at the lower meniscus

Converting mol / dm^3 to g/ dm^3 and vice versa

ie. NaCl (aq) 0.25 mol / dm^3 $\longrightarrow$ g/dm^3

Mr(NaCl) = 23 + 35.5 = 58.5 g/mol

mols = $\frac{\text{mass}}{\text{Mr}}$

Mass = 0.25 x 58.5 = 14.63 g/dm^3