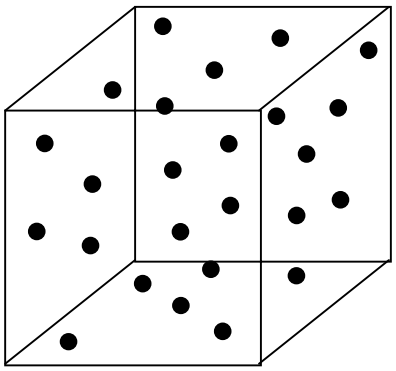
Avagadro's Hypothesis

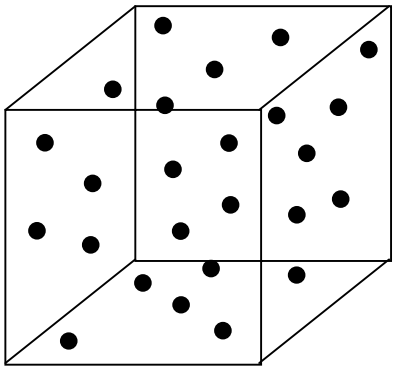
Equal volumes of gas contain equal number of particles, assuming the same temperature and pressure)

Now imagine we have a box that contains 100 molecules of H_2.



RMM H_2 = 2

Then another box, same size, same temp. and press. would contain 100 molecules of O_2.



RMM O_2 = 32

However, each O_2 molecule is 16 times heavier than each H_2 molecule. So the total mass of oxygen must be 16 times greater than the total mass of hydrogen. So the density of oxygen must be 16 times the density of hydrogen.

Molecular Formulae

From Avagadro's hypothesis we've determined that the ratio of the densities of any two gases must be the same as the ratio of their RMMs.

Or

$$\frac{\text{Density of gas}}{\text{Density of } H_2} = \frac{\text{RMM of gas}}{\text{RMM of } H_2}$$

Rearranging gives

$$\text{RMM of gas} = \frac{\text{RMM of } H_2 \times \text{ Density of gas}}{\text{Density of } H_2}$$

Remember that this assumes the same temp. and press. We use STP, 273K and 1 atm.

$$\text{RMM of gas} = \frac{\text{RMM of } H_2 \times \text{ Density of gas at STP}}{\text{Density of } H_2 \text{ at STP}}$$

The Gas Laws

Boyle's Law: $PV = \text{Constant}$

Charles' Law $\frac{V}{T} = \text{Constant}$

These two laws allow us to calculate the volume of a known mass of a gas at STP if we measure the volume at any temperature and/or pressure.

The volume of 12 g of aluminium chloride gas, measured at standard pressure and 900 K, is 3.3 litres. What is its molecular formula?

1. What is the volume of the gas at STP?
2. What is the density of the gas at STP?
3. What is its RMM?
4. What would be the RMM of the empirical formula $AlCl_3$?
5. What is the molecular formula?

Any exam Q. that asks for a molecular formula and gives the density of H_2 at STP will expect you to follow these steps…

1. Convert volume to volume at STP
2. Calculate density at STP
3. Calculate RMM $\text{RMM} = \frac{2 \times \text{density}}{0.09899 \text{ g L}^{-1}}$
4. Compare to RMM of empirical formula
5. To get molecular formula