Ideal gases

Gas laws

The pressure of a gas is the force per unit area that the gas exerts normally on a surface. It is dependent on temperature, the volume of the gas container, and the mass of gas in the container.

- **Boyle's Law**: pV = constant for fixed m constant T
  - Pressure of gas at constant T increased by reducing its volume as gas molecules travel less distance between impacts - hence more impacts per second and so greater pressure

- **Charles' Law**: $V \propto T \Rightarrow \frac{V}{T}$ = constant for fixed m and constant p
- Any change at constant pressure is **isobaric** - when work is done to change the volume of a gas, energy must be transferred by heating to keep pressure constant and so:

$$\text{work done, } W = p\Delta V$$

- **Pressure law**: $p \propto T \Rightarrow \frac{p}{T}$ = constant for fixed m and constant V
  - pressure of a gas at constant volume increased by raising its temperature - raises average speed of molecules and so impacts on the container walls are harder and more frequent: raising pressure.

Note: T must always be in Kelvin.

Ideal gas law

- A number of assumptions must be made, including:
  1. Intermolecular forces are negligible except during a collision
  2. Volume of the molecules negligible compared to volume of gas
  3. Collisions between molecules and between molecules and the container walls are perfectly elastic
  4. Duration of a collision negligible compared to time between collisions.
  5. Laws of Newtonian Mechanics apply
  6. All molecules of a particular gas are identical
  7. The motion of molecules is random
  8. There is a large number of molecules

- **Brownian motion** can be seen when smoke particles are observed with a microscope - they move unpredictably. The motion of each particle is because it is bombarded unevenly and randomly by individual molecules - thus particles experience forces which change in magnitude and direction at random.

Moles

- Avogadro's constant, N_A, is the number of atoms in 12 g of Carbon-12.
- One atomic unit (au) is $\frac{1}{12}$ the mass of a Carbon-12 atom
- 1 mol of a substance of identical particles is the quantity of the substance that contains N_A particles.
- **Molar mass** of a substance is the mass of 1 mol of the substance

$$number\ of\ moles = \frac{mass\ of\ substance}{molar\ mass}$$

$$number\ of\ molecules = N_A \times number\ of\ moles$$

- An ideal gas is one which obeys Boyle's Law.

Combining gas laws: $\frac{pV}{T}$ = constant for fixed m of ideal gas

For 1 mol of any ideal gas, $\frac{pv}{T} = R$

Graph of pV against T for n mol is a straight line through absolute zero and has gradient nR.

Hence $pV = nRT$ where n is number of moles

$pV = NkT$ where N is the number of molecules