GAS LAWS - Form 3 Chemistry Notes

Kinetic Particle Theory

- Matter is made up of particles that are in constant motion
- The higher the temperature, the faster the particles move (more energy)
- Increase in temperature increase weakens interparticle forces, causing particles to spread apart and increase in volume/size (i.e. Expansion)
- Gases have greatest average energy while solids have smallest average energy

According to the kinetic theory, matter is made up of particles (atoms, molecules or ions) which are in constant motion because they have energy at all temperatures above zero Kelvin (absolute zero, 0K) or -273^0C. This energy is in the form of kinetic energy.

Consider heating a solid;

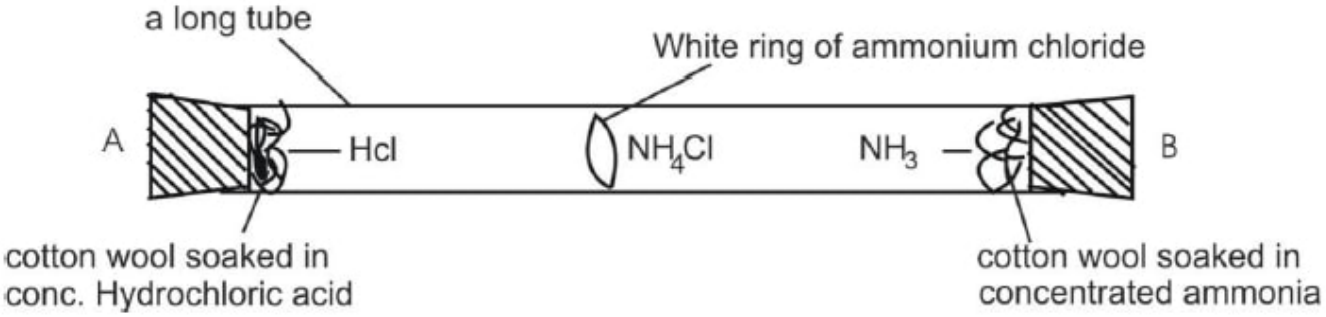
- When a solid is heated, the particles vibrate more strongly as they gain kinetic energy and the particle attractive forces are weakened.
- Eventually, at the melting point, the attractive forces are too weak to hold the particles in the structure together in an ordered way and so the solid melts.
- The particles become free to move around and lose their ordered arrangement. Energy is needed to overcome the attractive forces and give the particles increased kinetic energy of vibration.
- On heating further, the particles gain more kinetic energy and move faster. In evaporation and boiling the particles with the highest kinetic energy can ‘escape’ from the attractive forces of the other liquid particles.
- The particles lose any order and become completely free to form a gas or vapour.
- Boiling is rapid evaporation anywhere in the bulk liquid and at a fixed temperature called the boiling point and requires continuous addition of heat.

Diffusion and Kinetic Energy

- The natural rapid and random movement of the particles means that gases readily ‘spread’ or diffuse.
- **Diffusion** *is the movement of gas or solid particles from a region of high concentration to a region of low concentration.*
- Diffusion is fastest in gases where there is more space for them to move. The rate of diffusion increases with increase in temperature as the particles gain kinetic energy and move faster.

Diffusion of Ammonia and Hydrogen Chloride

- The following experiment is set up. One filter soaked in a solution of ammonia solution and the other soaked in a solution of concentrated hydrochloric acid are placed on the end of along glass tubing as shown.



- When colourless NH3 and HCl fumes meet, dense white smoke (fumes) of ammonium chloride are observed.
  $NH_{3\ (ag)} + HCl_{\ (ag)} \rightarrow NH_4Cl_{\ (s)}$
- Ammonia is diffused more rapidly than the hydrogen chloride because the gas traveled a longer distance in the same amount of time.
- Gases with greater R.M.M have higher densities than gases which have small molecules e.g. hydrogen chloride are heavier than ammonia molecules.
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- If the concentration of hydrochloric acid and that of ammonia were increased in a separate experiment, the rate of diffusion would be faster.

Gas	**Mass**
NH_3	17
HCl	35.5

- Large heavy molecules move more slowly than small, light molecules. Therefore, dense gases diffuse more slowly than gases of low density.
- The rate of diffusion depends on the molecular mass/density of gas. Rate of diffusion is inversely proportional to mass of a gas.

RATE OF DIFFUSION;

- Increases with temperature
- Decreases with increasing R.M.M or R.A.M
- Increases with concentration

Graham's Law of Diffusion

- Graham's law of diffusion relates the rate of diffusion of a gas to its density.
- It states that *the rate of diffusion of a gas at constant temperature and pressure is inversely proportional to the square root of its density.*
  Rate of diffusion $\propto {}^{1}/_{\sqrt{density}}$
- If two gases A and B diffuse under the same conditions of temperature and pressure, then
  $\frac{\text{Rate of diffusion of A}}{\text{Rate of diffusion of B}} = \frac{\sqrt{\text{density of B}}}{\sqrt{\text{density of A}}}$
- The density of a gas is proportional to its molecular mass.
- Hence, rate of diffusion of a gas $\propto {}^{1}/_{\sqrt{\text{Molecular mass}}}$