Chemistry with Chloe

AQA A Level Chemistry — Paper 2 — 3.1 Physical Chemistry

3.1.5 Kinetics

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3.1.5.1 *Collision theory, activation energy. Why most collisions do not lead to a reaction.*

Activation energy (Ea): the minimum energy required for a collision to result in a chemical reaction.

Most collisions are unsuccessful because:

- Particles do not have sufficient energy (less than Ea) — the collision cannot break the necessary bonds.
- Particles do not collide with the correct orientation — reactive parts of molecules must meet.

Only a small fraction of collisions are successful (sufficient energy AND correct orientation).

3.1.5.2 *Maxwell–Boltzmann distribution. Effect of temperature on distribution and rate.*

Maxwell–Boltzmann distribution: shows the spread of molecular energies in a gas at a given temperature.

Key features: starts at origin (no molecules with zero energy), rises to a peak (most probable energy), then tails off asymptotically (no upper limit).

The area under the curve to the RIGHT of Ea = proportion of molecules that can react.

Effect of increasing temperature: the curve flattens and shifts right. The peak is lower and moves to higher energy. The area to the right of Ea increases significantly → rate increases greatly.

A catalyst: lowers Ea. The Ea line moves left → more molecules have sufficient energy → rate increases. The distribution curve is UNCHANGED.

3.1.5.3 *Effect of concentration, pressure, surface area and catalysts on rate. Qualitative explanations.*

Increasing concentration (or pressure for gases): more particles per unit volume → more frequent collisions → greater rate.

Increasing surface area (solids): more exposed particles → more frequent collisions → greater rate.

Catalysts: provide an alternative reaction pathway with lower Ea. More molecules have sufficient energy to react → greater rate. Catalyst is not consumed.

Note: these factors affect rate of reaction but do NOT change Kc or the position of equilibrium.

3.1.5.4 *Catalysts: homogeneous and heterogeneous. Economic and environmental importance.*

Heterogeneous catalyst: different phase from reactants. Reactants adsorb onto the catalyst surface, bonds weaken, reaction occurs, products desorb.

Homogeneous catalyst: same phase as reactants. Reacts with a reactant to form an intermediate, then is regenerated.

Economic importance: lower temperatures → less energy needed → lower cost.

Environmental importance: reduces energy demand → fewer fossil fuels burned → lower CO2 emissions.

★ RPRP3

Investigation of How the Rate of a Reaction Changes with Concentration

Method (iodine clock example): prepare solutions of H_2O_2, KI, $Na_2S_2O_3$ and starch. Mix and time until starch turns blue-black (when $S_2O_3^{2-}$ exhausted). Vary [KI] or $[H_2O_2]$ while keeping other concentrations constant. Repeat for at least 5 concentrations. Calculate rate = 1/t. Plot rate vs concentration.

Or: reaction of $Na_2S_2O_3$ + HCl (sulfur precipitate). Cross appears under flask. Time until cross disappears. Vary concentration.

Uncertainties: stopwatch ±0.01 s; measuring cylinder ±0.5 cm^3; visual judgement of endpoint.

Common errors: subjective endpoint; temperature not controlled; inaccurate volumes; not accounting for change in total volume when varying concentrations.

Improvements: use colorimeter for objective measurement; thermostat water bath; accurate pipettes; keep total volume constant by adding water.