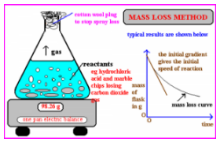
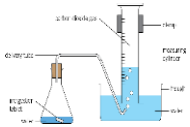
Knowledge Organiser: **The Rate and Extent of Chemical Change**

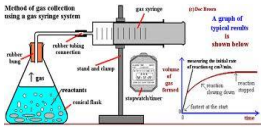
Section 1 - Measuring Rate of Reaction

Mean rate of reaction =

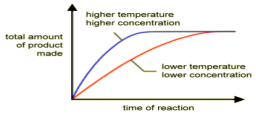
$$\frac{\text{quantity of reactant used}}{\text{Time}} \quad \text{or} \quad \frac{\text{quantity of product formed}}{\text{Time}}$$







Measured in grams (g), volume (cm^3) or moles (mol).
Rate of reaction measured in g/s, cm^3/s or mol/s.
Interpret rate of reaction graphs



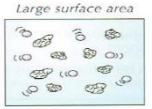
Higher Tier – Calculate the gradient of a tangent to the curve as a measure of rate of reaction at a specific time.

Section 2 - Factors Affecting Rate

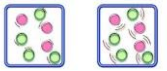
Increasing Concentration of reactants in solution
– **increases frequency** of collisions

Increasing Pressure of reacting gases
– **increases frequency** of collisions

Increasing the Surface area of solid reactants
– **increases frequency** of collisions



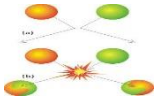
Increasing the Temperature of the reaction
– **increases energy** of reacting particles
-- **increases the frequency** of collisions



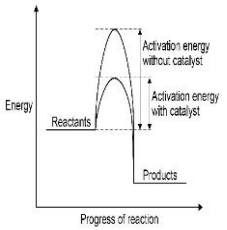
Presence of a **catalyst**

Section 3 - Collision Theory

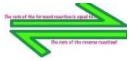
Chemical reactions can only occur when reacting **particles collide** with each other and **with sufficient energy**.



Activation Energy is the minimum amount of energy particles must have to react.
Catalysts: increase rate of reaction but are not used up during reaction.
Different reactions need different catalysts.
Enzymes act as catalysts in biological systems
Catalysts increase the rate of reaction by providing an **alternative pathway** that has a **lower activation energy**.

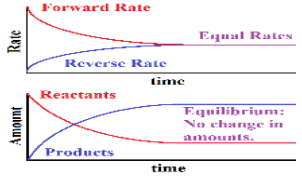


Section 4- Reversible Reactions and Dynamic Equilibrium



Reversible reaction: a reaction where the products can react to form the original reactants.

$$A + B \rightleftharpoons C + D$$



If a reversible reaction is **exothermic in one direction** it is **endothermic in the opposite direction**.

In a **closed system** equilibrium is reached when

rate of the forward reaction = rate of the reverse reaction.

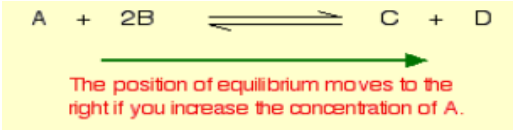
Higher Tier

Section 5- Le Chatelier's Principle

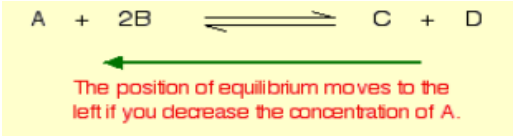
When a system at equilibrium is disturbed, the system acts to reverse the effect of the disturbance.

Effect of concentration on Equilibrium

Increasing the concentration of a reactant



Decreasing the concentration of a reactant



Section 8 -Industrial Application

The Haber Process

Nitrogen + Hydrogen ⇌ Ammonia (+ heat)

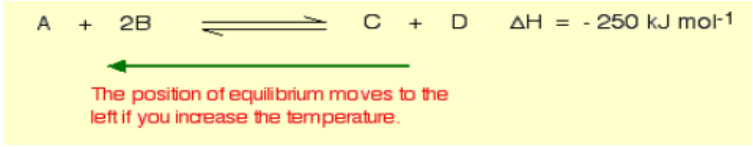
$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ (+ heat)

The industrial conditions are

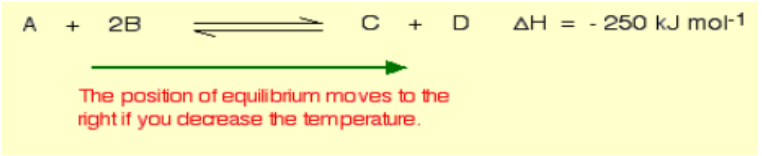
1) **Temperature** between 450 °C and 500 °C.
2) **Pressure** of 200 atmospheres..
3) **iron catalyst.**

Section 6 - Effect of Temperature on Equilibrium

Exothermic reaction - raise the temperature and the equilibrium moves to the left,



lower the temperature and the equilibrium moves to the right.

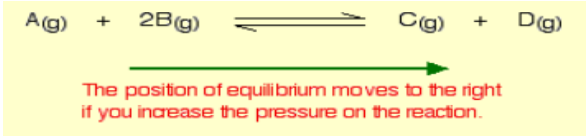


Endothermic - raise the temperature and the equilibrium moves to the right, lower it and the equilibrium moves to the left.

Section 7 - Effect of Pressure on Equilibrium

Pressure only affect reactions that involve at least one gas.

Increasing pressure causes equilibrium position to shift towards the side with fewer moles of gas.



Decreasing pressure causes equilibrium position to shift towards the side with more moles of gas.