AQA Chemistry A-level

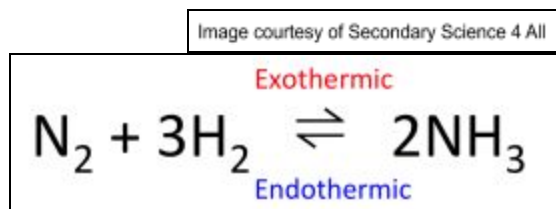# 3.1.6: Equilibria

Detailed Notes

3.1.6.1 - Le Chatelier's Principle

Some reactions are **reversible**, where the reactants react to form products, which can then react to reform the original reactants. It is represented using a **double arrow**.

Example:

Image courtesy of Secondary Science 4 All

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

Exothermic / Endothermic

In each reaction system, one reaction will be **endothermic** and the opposite reaction will be **exothermic**.

Dynamic Equilibrium

Reversible reactions will eventually reach **dynamic equilibrium**. This is when the forward and backward **rate of reaction is the same** and remains at a **constant** rate. At this point, the concentrations of the reactants and products are constant and appear not to change.

Dynamic equilibrium can only occur in **closed systems** where no substances can get in or out in order to influence the reactions.

Le Chatelier's Principle

This theory is used to predict how an equilibrium mixture will change if the **reaction conditions are altered**. It states:

> **When a system is subject to change, the system will alter to lessen the effect of that change.**

It is therefore a useful principle to consider in industry so that the reaction conditions can be altered to **maximise the yield** of a desired product.

Changing Temperature

Increasing temperature favours the **endothermic reaction** (+ve ΔH) as the excess heat needs to be removed from the system to lessen the effect of the initial increase. It will increase the yield of the endothermic products. Likewise, **decreasing** temperature favours the **exothermic reaction** (-ve ΔH) as heat needs to be gained and the yield of the exothermic products will be increased.

In exam questions, the **ΔH of the forward reaction will be given** so it is clear which direction is endothermic and which is exothermic.

Changing Pressure
Increasing pressure favours the side of the reaction with **fewer moles** as this will help to release the build up in pressure. It will increase the yield of the products on this side of the reaction.
Likewise, **decreasing** pressure favours the side of the reaction with **more moles** as pressure has been lost. The yield of the products on this side of the reaction will be increased.

Changing Concentration
Increasing the concentration of the reactants will favour the reaction that **produces the products** as more molecules are available to react. It will increase the yield of the products. Likewise, **increasing** the concentration of products will favour the reaction that **reforms the reactants**.

Catalysts
Catalysts appear not to affect the equilibrium position as they **affect the forward and backward reaction equally**. However it does allow equilibrium to be reached **faster**.

3.1.6.2 - Equilibrium Constant (Kc)

For reversible reactions, there is an equilibrium constant, **Kc**, that indicates the **position of equilibrium** for a reaction at a certain temperature. Kc for a reaction always has the **same value** unless the reaction conditions and therefore the position of equilibrium is changed.

In order to find the value of Kc, the **concentrations** of the substances in the reaction at the equilibrium position needs to be known. It is equal to the **concentration of the products divided by the concentration of the reactants**. Any variation in the number of moles, **raises that substance to a power** with the same value as the number of moles.

Example:

Image courtesy of ScienceAid.net

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$
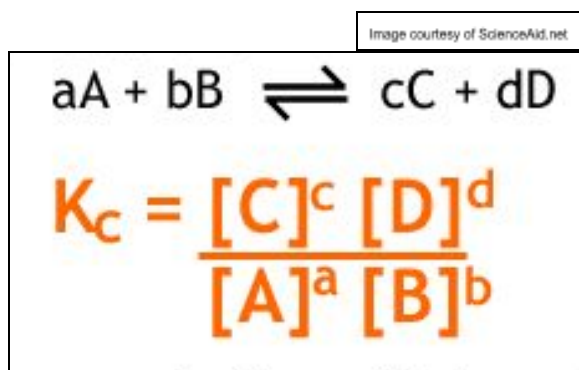
The equilibrium constant has **varying units** depending on the chemical reaction. It can be calculated by **subbing the units into the Kc expression**. Some of these then cancel to give the overall units of Kc for that reaction.

Example:

Image courtesy of ScienceAid.net

$$2A + B \rightleftharpoons C$$

$$\frac{moldm^{-3}}{(moldm^{-3})^2(moldm^{-3})} = \frac{1}{(moldm^{-3})^2}$$

$$= mol^{-2}dm^6$$

The value of Kc is **not affected by concentration change or use of a catalyst**, however it is affected by changing the reaction **temperature** as the equilibrium position change results in different concentrations of reactants and products.