



Edexcel Chemistry A-level

Topic 10: Equilibrium I

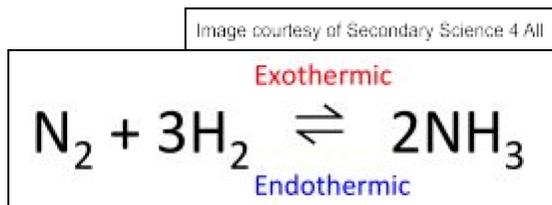
Detailed Notes



Dynamic Equilibrium

Reversible reactions are reactions in which the products of a reaction can react together to reform the original reactants. They are represented using a **double arrow**.

Example:



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

These reversible reactions will eventually reach a state of **dynamic equilibrium**. This occurs when the **rate** of the forward reaction is **equal** to the rate of the backward. At this point, the **concentrations** of the reactants and products remain **constant**. Dynamic equilibrium can only occur in **closed systems** where no substances can get in or out.

Le Chatelier's Principle

Le Chatelier's principle 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 a useful principle to consider in industry, since 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** of gas, as this will help to release the built up in pressure. It will increase the yield of the products on the side of the reaction with the fewest moles of gas.

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 direction that **produces the products** as more molecules are available to react. It will increase the yield of the products.

Likewise, **decreasing** the concentration of products will favour the reaction that **reforms the reactants**.

Catalysts

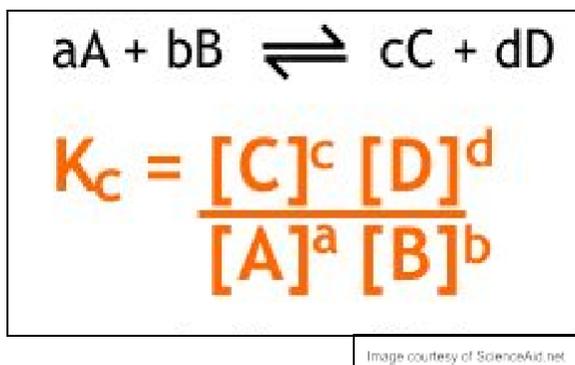
Catalysts appear not to affect the equilibrium position as they **affect the forward and backward reaction equally**. However, they do allow equilibrium to be reached **faster**.

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 are changed, which in turn changes the position of equilibrium and therefore Kc.

In order to find the value of Kc, the **concentrations** of the reactants and products at equilibrium need to be known. Kc 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.

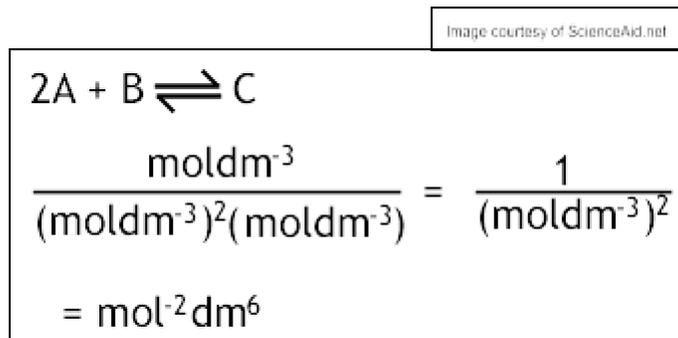
Example:





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:



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.

Compromise between Rate of Reaction and Product Yield

Changing the conditions of reaction can shift the position of the equilibrium to favour the production of either the products or the reactants, as described above. However, a condition change which produces a **higher proportion of the product** may also **reduce the rate of the reaction**. The rate of reaction is increased by increases in temperature, pressure or concentration.

For example, **decreasing the temperature** of reaction with a **forward endothermic reaction** would **increase** the product **yield**, but **decrease** the **rate** of reaction.

In the industry, when a factor increases the product yield but decreases the rate of a reaction, a **compromise** must be made. If the product yield was the only thing taken into account, the rate of reaction would occur **so slowly** that the product is not actually made at a useful rate. Therefore, reaction conditions are selected to give both a **relatively good product yield** and a **relatively fast rate of reaction**.