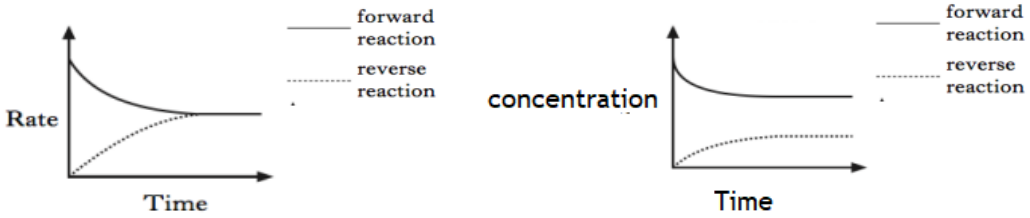
Equilibrium

1. Rate

Rate of the **forward** reaction = **rate** of the **backward** reaction

2. Concentrations

The **concentrations** of reactants and products are **constant**



Le Chatelier's Principle:

> If a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium moves to counteract the change.

The following changes (TCP) can be made to maximise the product production.

· Temperature
· Concentration
· Pressure

1. Temperature

Increasing the temperature
Favours the endothermic reaction (ΔH = +)

Decreasing temperature
Favour the exothermic reaction (ΔH = -)

Example

$$NH_3(g) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$
$$\Delta H = -36\ kJ\ mol^{-1}$$

Lowering the temperature will promote the exothermic (ΔH = -) forward reaction.

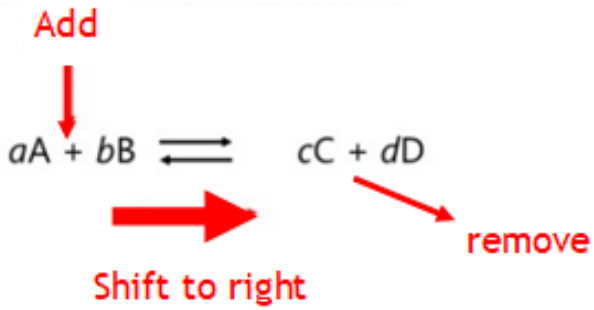
Increasing the temperature will promote the endothermic (ΔH = +) backward reaction

Equilibrium

2. Concentration

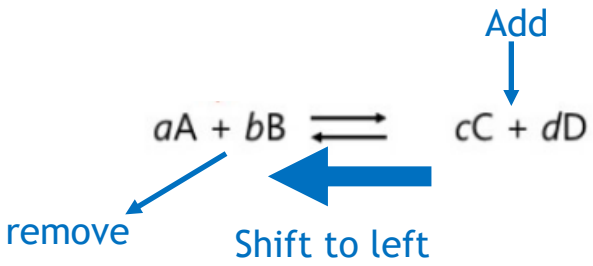
Removing the product/adding more reactant.

Shifts the equilibrium to the **right** (promotes forward reaction) thus producing more product.



Removing the reactant/adding more product .

Shifts the equilibrium to the left (promotes backward reaction) thus producing more reactant



Example $Cl_2(g) + H_2O(\ell) \rightleftharpoons 2H^+(aq) + ClO^-(aq) + Cl^-(aq)$

Forward reaction (shifts right) promoted by:

1. Increasing Cl_2 or H_2O molecules into the reaction
2. Removing H^+ /CLO^-/Cl^- ions from the reaction.

** H^+ ions can be removed by adding OH^- ion into the reaction.**

Backward reaction (shifts left) promoted by:

1. Removing Cl_2 or H_2O molecules from the reaction
2. Adding H^+ /CLO^-/Cl^- ions into the reaction

Equilibrium

3. Pressure

Will only have an impact on equilibrium reactions which are carried out in a **sealed container.**

Increasing pressure

Favours the side of **least volume** of **gas.**

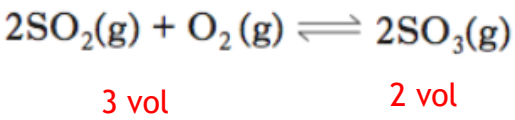
Decreasing the pressure

Favours the side of **greatest volume** of **gas.**

Same Volume each side

If both sides have the same volumes of gas they will be affected equally and the position of equilibrium will be **unaffected.**

Example 1



3 vol 2 vol

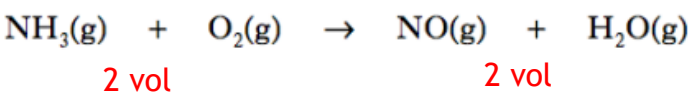
Increasing the pressure

Promotes the forward reaction (shifts right) with the lower volume of gas.

Decreasing the pressure

Promotes the backward reaction (shifts left) to the side with the higher volume of gas.

Example 2



2 vol 2 vol

Increasing or decreasing the pressure does not affect the position of equilibrium as there is the same volume of gas on both sides.