Summary

- Open system:
  Some of the reactants/products escape from the system and energy can be released or absorbed.
  Example:
  - $Mg(s) + HC\ell(g) \rightarrow MgC\ell_2(aq) + H_2(g)$ in open container
  - $H_2(g)$ escapes
  - Temperature changes due to exothermic reaction.

- Closed system:
  None of the reactants/products escape from the reaction system.
  Only energy can be released or absorbed.
  Example:
  - Water in a pot with a lid; evaporation and condensation occurs; energy can change; H_2O (g) and (ℓ) cannot escape from the reaction system.
  - $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ in a closed container: energy can change; none of the gases escape.

- Isolated system:
  None of the reactants/products escape from the reaction system. Energy also remains constant.
  Example:
  - Water in a vacuum flask; evaporation and condensation occurs in the flask; H_2O (g) and (ℓ) cannot escape from the reaction system; temperature of the system remains constant.
  - $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ in a closed insulated container; none of the gases escape; the temperature remains constant.

- Dynamic equilibrium:
  - Forward and reverse reactions occur continually and simultaneously; and at the same rate in an isolated system.
  - Macroscopic changes stop.
  - Microscopic changes keep going.
  - Concentrations of all the substances remain constant.

- Reversible reaction: reactants change into products and products continually change back to the original reactants.

- Equilibrium constant:
  - Indicates ratio between products and reactants.
  - Only a number, with no unit
  - $K_C > 1$: [products] are high ∴ reaction is economically viable.
  - $K_C < 1$: [products] is low ∴ reaction is not economically viable.
  - If forward reaction is favoured by ΔT, K_C value increases.
  - Only ΔT causes change in K_C value.

$$\text{no unit} \leftarrow K_C = \frac{[\text{Products}] \rightarrow \text{mol}\cdot\text{dm}^{-3}}{[\text{Reactants}] \rightarrow \text{mol}\cdot\text{dm}^{-3}}$$

Summary

- Catalyst:
  - Increases rate of forward and reverse reactions equally.
  - Equilibrium is reached sooner.
  - Has no effect on equilibrium concentrations of the reactants or products.

- Le Chatelier's principle: If the equilibrium in an isolated system is disturbed by changing one of the equilibrium conditions (temperature, concentration or pressure), the system reacts by counteracting the change and reaching a new equilibrium.

- Factors that influence a chemical equilibrium system:
  - Temperature of the reaction system
  - Concentration of the (g) or (aq) reactants
  - Pressure on the system in the case of gases

Factor	Disturbance	Influence on equilibrium
Concentration	Increase concentration of reactants.	Forward reaction is favoured.
	Increase concentration of products.	Reverse reaction is favoured.
	Decrease concentration of reactants.	Reverse reaction is favoured.
	Decrease concentration of products.	Forward reaction is favoured.
Temperature	Increase temperature.	Rate of both reactions increases, but the endothermic reaction is favoured.
	Decrease temperature.	Rate of both reactions decreases, but the exothermic reaction is favoured.
Pressure	Increase pressure.	Reaction which produces the smallest number of moles of gas is favoured.
	Decrease pressure.	Reaction which produces the largest number of moles of gas is favoured.

- To predict reactions according to Le Chatelier, five questions are posed:
  1. What is disturbing the equilibrium?
  2. How will the system counteract this disturbance?
  3. Which reaction will be favoured?
  4. What changes will occur in the concentrations of reactants and products?
  5. What is the effect on the K_c value?

- Equilibrium in solutions:
  In a solution, equilibrium is influenced by:
  - concentration of the ions;
  - temperature of the solution.

Summary

- Common ion effect:
  If two different solutions contain the same ion, the ion is called a common ion.
  Addition of a solution with a common ion:
  - Increases the concentration of the ion.
  - Favours the reaction that uses the ion as reactant and therefore the ion concentration decreases.

- The effect of the addition of solutions to a system at equilibrium:
  In a solution, equilibrium is influenced by:
  - addition of HCℓ(aq): $[H^+]$ and $[Cℓ^-]$ increase or $[OH^-]$ decreases.
  - addition of NaOH(aq): $[OH^-]$ increases or $[H^+]$ decreases.
  - addition of $AgNO_3$(aq): AgCℓ(s) forms if there is $Cℓ^-$ ∴ $[Cℓ^-]$ decreases.
  - addition of H_2SO_4(c): $[H^+]$ and $[SO_4^{2-}]$ increase or $[OH^-]$ decreases or acts as dehydrating agent and removes water.

- Equilibrium in industry:
  Optimal reaction conditions for the Haber process:
  - Temperature: ±450°C
  - Pressure: ±200 atm
  - Catalyst: Fe (iron) or FeO (iron(II) oxide)

  Optimal reaction conditions for the Contact process:
  - Temperature: ±450°C
  - Pressure: ±1 – 2 atm
  - Catalyst: V_2O_5 (vanadium pentoxide)

Notes