Topic 10: Equilibrium I

Edexcel A Level Chemistry • Paper 1 (9CH0/01)

10.1 Know that many reactions are readily reversible and that they can reach a state of dynamic equilibrium in which: (i) the rate of the forward reaction is equal to the rate of the backward reaction, (ii) the concentrations of reactants and products remain constant.

Dynamic equilibrium occurs in a closed system when:

- The rate of the forward reaction equals the rate of the reverse reaction.
- The concentrations of reactants and products remain constant (but are NOT necessarily equal).
- Both forward and reverse reactions are still occurring – it is dynamic, not static.

Equilibrium can only be achieved in a closed system (no substances can enter or leave).

10.2 Be able to predict and justify the qualitative effect of a change in temperature, concentration or pressure on a homogeneous system in equilibrium.

Le Chatelier's Principle: if a system at equilibrium is disturbed, it will shift to oppose the change and restore equilibrium.

Temperature: increasing T favours the endothermic direction; decreasing T favours the exothermic direction. This is the only change that alters the value of K.

Concentration: increasing [reactant] shifts equilibrium to the right (towards products); increasing [product] shifts it to the left.

Pressure (gases only): increasing pressure shifts equilibrium towards the side with fewer moles of gas; decreasing pressure shifts it towards more moles of gas.

Catalyst: does NOT affect the position of equilibrium or K – it speeds up both forward and reverse reactions equally.

10.3 Evaluate data to explain the necessity, for many industrial processes, to reach a compromise between yield and rate of reaction.

Industrial compromise: conditions are chosen to balance yield and rate (and cost).

E.g. Haber process ($N_2 + 3H_2 \quad 2NH_3$, exothermic):

- Low temperature favours yield (forward is exothermic) but gives a slow rate.
- High pressure favours yield (fewer moles on right) but is expensive and has safety risks.
- Compromise: moderate temperature (~450°C) for a reasonable rate; high pressure (~200 atm) for good yield; iron catalyst to increase rate without affecting equilibrium position.

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10.4

Be able to deduce an expression for Kc, for homogeneous and heterogeneous systems, in terms of equilibrium concentrations.

For the reaction: aA + bB ⇌ cC + dD

$K_c = [C]^c[D]^d / [A]^a[B]^b$ (products over reactants, raised to stoichiometric powers)

Homogeneous: all species in the same phase – all appear in the Kc expression.

Heterogeneous: species in different phases – pure solids and pure liquids are omitted from the Kc expression (their concentrations are constant).

E.g. $CaCO_3(s)$ ⇌ $CaO(s) + CO_2(g)$: $K_c = [CO_2]$ only.

ABOUT THESE NOTES

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