17.2 – The Equilibrium Law

17.2.1 - Solve homogeneous equilibrium problems using the expression for K_c

A **homogenous equilibrium system** is when all the substances involved in the reaction are in the same state. For the reaction:

$$aA + bB + \cdots \leftrightarrow pP + qQ + \cdots$$

The equilibrium constant expression is:

$$K_c = \frac{[P]^p[Q]^q \ldots}{[A]^a[B]^b \ldots}$$

This is valid, provided the temperature and concentrations are constant. The larger the equilibrium constant is, the more of the products there will be. Ensure that you quote the temperature with this value, otherwise it cannot be reused for other calculations!

If K_c >> 1, the reaction goes almost to completion

If K_c << 1, the reaction hardly proceeds

K_c can never equal **0**.

The equilibrium constant always has different units, so these must be calculated each time. They are found by cancelling the units in the equation.

For the reaction: $N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

$$K_c = \frac{[NO_2]^2}{[N_2O_4]}$$

$$\text{units: } \frac{(\text{mol dm}^{-3})^2}{\text{mol dm}^{-3}} = \text{mol dm}^{-3}$$

We can use data from experiments to work out the equilibrium constant, telling us the concentrations of the substances when they reach equilibrium. If we obtain data from multiple experiments, then we can find the average equilibrium constant for all of them.

Using the equation, we can find the value of K_c. **DON'T PANIC**: you will never be asked to perform a calculation of K_c that involves quadratic formulas.

Find the equilibrium constant for the reaction:

$$Ag^+_{(aq)} + 2NH_{3(aq)} \rightleftharpoons Ag(NH_3)^+_{2\,(aq)}$$

$[Ag^+] = 1.00 \text{ mol dm}^{-3}$
$[NH_3] = 5.00 \times 10^{-3} \text{ mol dm}^{-3}$
$[Ag(NH_3)_2^+] = 0.401 \text{ mol dm}^{-3}$

$$K_c = \frac{[Ag(NH_3)_2^+]}{[Ag^+][NH_3]^2}$$

$$= \frac{0.401}{1.00 \times (5.00 \times 10^{-3})^2}$$

$$= 1.60 \times 10^4 \text{ mol}^{-2} \text{ dm}^6$$

Other things to consider:

- Since you are not always given the information in this format, you may have to find the concentrations of the reactants and products yourself, using other data. When the questions become longer like this, then make sure you **set out your work properly**!
- If the equilibrium is found while the reaction is still progressing, then:
    - If it is increasing, it is continuing towards the right
    - If it is decreasing, then it is continuing towards the left