Topic 7: Equilibrium

4.5 hours

Essential idea: Many reactions are reversible. These reactions will reach a state of equilibrium when the rates of the forward and reverse reaction are equal. The position of equilibrium can be controlled by changing the conditions.

7.1 Equilibrium

Nature of science:

Obtaining evidence for scientific theories—isotopic labelling and its use in defining equilibrium. (1.8)

Common language across different disciplines—the term dynamic equilibrium is used in other contexts, but not necessarily with the chemistry definition in mind. (5.5)

Understandings:

- A state of equilibrium is reached in a closed system when the rates of the forward and reverse reactions are equal.
- The equilibrium law describes how the equilibrium constant (K_c) can be determined for a particular chemical reaction.
- The magnitude of the equilibrium constant indicates the extent of a reaction at equilibrium and is temperature dependent.
- The reaction quotient (Q) measures the relative amount of products and reactants present during a reaction at a particular point in time. Q is the equilibrium expression with non-equilibrium concentrations. The position of the equilibrium changes with changes in concentration, pressure, and temperature.
- A catalyst has no effect on the position of equilibrium or the equilibrium constant.

Applications and skills:

- The characteristics of chemical and physical systems in a state of equilibrium.
- Deduction of the equilibrium constant expression (K_c) from an equation for a homogeneous reaction.
- Determination of the relationship between different equilibrium constants (K_c) for the same reaction at the same temperature.

International-mindedness:

- The Haber process has been described as the most important chemical reaction on Earth as it has revolutionized global food production. However, it also had a large impact on weaponry in both world wars.

Theory of knowledge:

- Scientists investigate the world at different scales; the macroscopic and microscopic. Which ways of knowing allow us to move from the macroscopic to the microscopic?
- Chemistry uses a specialized vocabulary: a closed system is one in which no matter is exchanged with the surroundings. Does our vocabulary simply communicate our knowledge; or does it shape what we can know?
- The career of Fritz Haber coincided with the political upheavals of two world wars. He supervised the release of chlorine on the battlefield in World War I and worked on the production of explosives. How does the social context of scientific work affect the methods and findings of science? Should scientists be held morally responsible for the applications of their discoveries?

Utilization:

- Square brackets are used in chemistry in a range of contexts: eg concentrations (topic 1.3), Lewis (electron dot) structures (topic 4.3) and complexes (topic 14.1).

7.1 Equilibrium	
• Application of Le Châtelier's principle to predict the qualitative effects of changes of temperature, pressure and concentration on the position of equilibrium and on the value of the equilibrium constant. **Guidance:** • Physical and chemical systems should be covered. • Relationship between K_c values for reactions that are multiples or inverses of one another should be covered. • Specific details of any industrial process are not required.	Syllabus and cross-curricular links: Topic 8.4—the behaviour of weak acids and bases **Aims:** • **Aim 6**: Le Châtelier's principle can be investigated qualitatively by looking at pressure, concentration and temperature changes on different equilibrium systems. • **Aim 7**: Animations and simulations can be used to illustrate the concept of dynamic equilibrium. • **Aim 8**: Raise awareness of the moral, ethical, and economic implications of using science and technology. A case study of Fritz Haber can be used to debate the role of scientists in society.