Worksheet 1.1: Reversible Reactions & Equilibrium — ChemistrySheets

Specification: GCSE Chemistry (AQA 5.6.2 / Edexcel SC17)

Core Concepts: Understand that some reactions are reversible and reach dynamic equilibrium. Explain Le Chatelier's Principle and predict the effect of changing temperature, pressure, and concentration on the position of equilibrium.

Section A: Key Terms & Concepts

A1. Match the following key terms to their correct definitions.

(i) A reaction where products can react to reform reactants.

Reversible reaction

(ii) A state where the rate of the forward reaction equals the rate of the reverse reaction, and the concentrations of reactants and products remain constant.

Dynamic equilibrium

(iii) When conditions are changed in a system at equilibrium, the system will shift in a direction that counteracts the change.

Le Chatelier's Principle

(iv) A reaction that releases energy to the surroundings, usually as heat.

Exothermic

(v) A reaction that absorbs energy from the surroundings, usually as heat.

Endothermic

A2. Complete the following sentences using the most appropriate scientific terms.

(i) For a reversible reaction to reach equilibrium, it must be carried out in a **closed** system.

(ii) At dynamic equilibrium, the **rates** of the forward and reverse reactions are equal.

(iii) Increasing the concentration of a reactant will shift the equilibrium to the **right** (towards products) to reduce the concentration of that reactant.

(iv) A catalyst **does not affect** the position of equilibrium, but it **increases** the rate at which equilibrium is reached.

Section B: Core Explanations

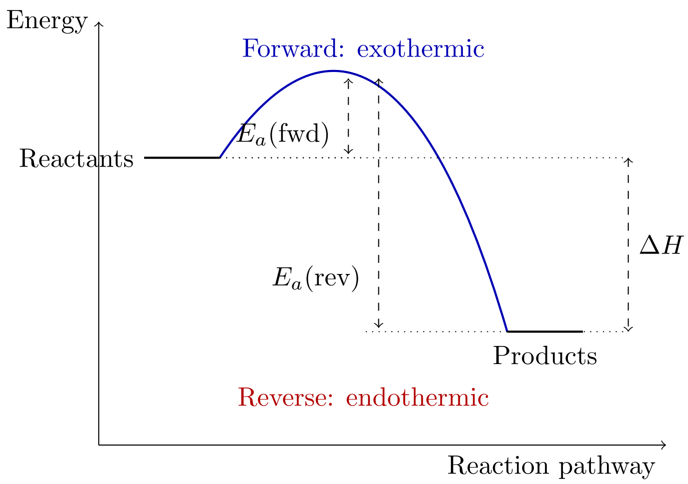

Figure 1: Energy profile for a reversible reaction (exothermic forward)

B1. Define what is meant by a reversible reaction and provide a chemical example.

Model Answer:
A reversible reaction is one where the products can react together to reform the original reactants. This is indicated by a double arrow ($\rightleftharpoons$) in the chemical equation. Example: Hydrated copper sulfate $\rightleftharpoons$ Anhydrous copper sulfate + Water.

B2. Explain what is meant by the term 'dynamic equilibrium' in the context of a reversible reaction.

Model Answer:
Dynamic equilibrium is a state in a reversible reaction where the rate of the forward reaction is equal to the rate of the reverse reaction. At this point, the concentrations of reactants and products remain constant, but both reactions are still occurring.

B3. State Le Chatelier's Principle.

Model Answer:
Le Chatelier's Principle states that if there is a change in condition (temperature, pressure, or concentration) in a system at equilibrium, the system will shift its position of equilibrium in a direction that tends to counteract the change.

B4. Using Figure 1, describe the effect of increasing the temperature on an exothermic reversible reaction at equilibrium.

Model Answer:
For an exothermic reaction, the forward reaction releases heat. If the temperature is increased, the system will try to counteract this change by absorbing heat. Therefore, the equilibrium will shift in the endothermic direction (the reverse reaction, from products to reactants) to absorb the added heat, decreasing the yield of products.

Section C: Exam Application

C1. Consider the reversible reaction: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$. Nitrogen dioxide ($NO_2$) is a brown gas, and dinitrogen tetroxide (N_2O_4) is colourless. If more NO_2 is added to the system at equilibrium, what visible change would occur and why?

Model Answer:
If more NO_2 (brown gas) is added, the system will try to reduce its concentration. According to Le Chatelier's Principle, the equilibrium will shift to the left (towards reactants), favouring the formation of colourless N_2O_4. The visible change would be that the brown colour of the gas mixture would become paler.

C2. The Haber process for ammonia production is a reversible reaction: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ ($\Delta H = -92$ kJ/mol) Explain how changing the temperature and pressure affects the yield of ammonia, justifying your answer using Le Chatelier's Principle. (6 marks)

Model Answer:
Effect of Temperature: The forward reaction is exothermic ($\Delta H = -92$ kJ/mol), meaning it releases heat. According to Le Chatelier's Principle, to maximise ammonia yield, a lower temperature should be used. This is because the system will shift to the right (exothermic direction) to release heat and counteract the decrease in temperature, thus producing more ammonia. However, too low a temperature significantly slows down the reaction rate, so a compromise temperature (around 450°C) is used to achieve a reasonable rate and yield.
Effect of Pressure: There are 4 moles of gaseous reactants (1 N_2 + 3 H_2) and 2 moles of gaseous products (2 NH_3). To maximise ammonia yield, a higher pressure should be used. The system will shift to the side with fewer moles of gas to reduce the pressure. Shifting the equilibrium to the right (towards products) produces fewer moles of gas, thus increasing the yield of ammonia. High pressures (around 200 atmospheres) are used to achieve a good yield.