CHEMISTRY 12 – UNIT II – EQUILIBRIUM

D: Dynamic Equilibrium (Introduction) ***It is expected that students will be able to…***

D1: Defining a reversible reaction

1. What does it mean for a reaction to be reversible?
   Use the reaction: $2H_2 + O_2 \rightleftharpoons 2H_2O$ in your answer's explanation.
   Make sure to use the reactants and products in your answer.

   Both the forward and reverse reactions can happen simultaneously. The reactants, hydrogen and oxygen gas, are colliding and forming the products, water, while the water molecules are colliding and reforming hydrogen and oxygen gas.
2. What is the reason that some reactions are spontaneous while other reactions are reversible?

   Many reactions, such as burning fuel, are spontaneous (or irreversible) - they go to completion and cannot be reversed easily. Reversible reactions are different. In a reversible reaction, the products can react to produce the original reactants again.

   When writing chemical equations for reversible reactions, we do not use the usual one-way arrow. Instead, we use two arrows, each with just half an arrowhead - the top one pointing right, and the bottom one pointing left.In spontaneous reactions the formation of products is greatly favoured over the reactants. In a reversible reaction the product is only slightly favoured over the reactants and can proceed in both directions.

   The tendencies of a reaction to favour minimum enthalpy and maximum entropy both favour products in a spontaneous reaction while in a reversible reaction the tendencies favour opposing sides of the reaction.

D2: Defining Equilibrium

1. Comparing a reversible reaction and a reaction at equilibrium…
   a. What is the similarity between the two reactions?

   - Both forward and reverse reaction can occur

   - Presence of both reactants and products

   For example,

   ammonium chloride ⇌ ammonia + hydrogen chloride

   The equation shows that ammonium chloride (a white solid) can break down to form ammonia and hydrogen chloride. It also shows that ammonia and hydrogen chloride (colourless gases) can react to form ammonium chloride again.

   b. What is the difference between the two reactions?

   - A system at equilibrium has equal forward and reverse reaction rates

   - An equilibrium system must be in a closed system and there are no changes to macroscopic properties.

2. An equilibrium system is said to be dynamic because at equilibrium the…

   Reaction never stops! Particles are still colliding and therefore still reacting. Forward and reverse reaction continue to occur.

   Define macroscopic properties and give three examples of macroscopic properties of a chemical reaction.

   Macroscopic properties are visible, measureable, large-scale properties.

   Examples: colour intensity, concentration, volume, pressure, pH, etc

D2: Defining Equilibrium Continued…

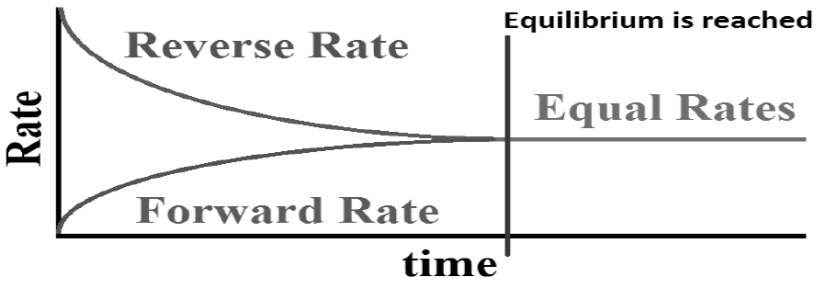
4. For the following reversible reaction: X ↔ Z + 10 kJ
   relate the changes in [reactant] and [product] if only particle Z was added to a reaction vessel and the reaction was allowed to proceed to equilibrium.

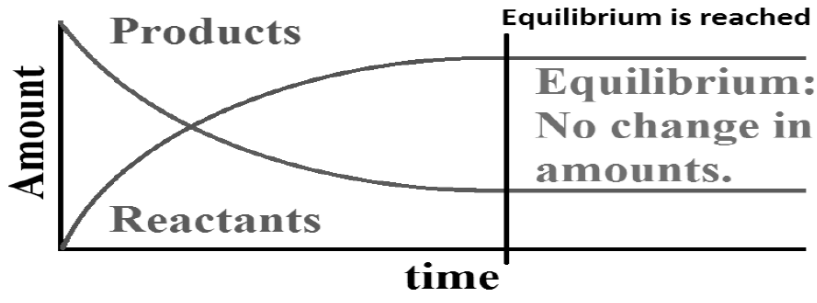
   a. Sketch a [concentration] vs. reaction proceeding graph to help you explain your answer!

   b. On the graph, show where equilibrium is reached.

   c. Indicate on your graph when the forward and reverse rates are equal

As equilibrium is established, the concentration of Z will decrease as it reacts and forms X. As the concentration of Z decreases, the number of collisions also decreases resulting in a decrease in the rate of the reverse reaction. As X is produced it's concentration will be increasing over time. As the concentration of X increases, the number of collisions between X particles will also increase, resulting in an increase in the forward reaction rate. Eventually both the forward and reverse reaction rates will become equal, the concentration of both Z and X will remain constant over time and equilibrium has been established.





D7: Predicting the spontaneity of a reaction

1. Define ENTROPY and explain if chemical reactions prefer minimum or maximum entropy. In terms of ENTHALPY, do reactions prefer minimum or maximum enthalpy?

   Entropy is the randomness (or disorder) of the system. Reactions prefer maximum entropy and therefore tend to favour the reaction that increases the randomness.

   Enthalpy is a measure of energy and reactions prefer minimum enthalpy and therefore tend to favour the exothermic reaction.

2. Consider the following:

   $2\ SO_{2(g)} + O_{2(g)}$?←?→? $2\ SO_{3(g)} + 197$ kJ

   Describe how the enthalpy and entropy change in the forward direction and state the result (will there be a reaction? If so, will it react completely or reach equilibrium?)

   Enthalpy decreases and entropy decreases therefore this is a reversible reaction and an equilibrium can form.

3. For the following reaction: $CO_{(g)} + 2\ H_{2(g)}$?←?→? $CH_2OH_{(g)}$; $\Delta H = 45$ kJ

   It was found that when carbon monoxide and hydrogen gas are mixed at room temperature the reaction did not occur. Give an explanation of why this is true.

   For the forward reaction entropy decreases and enthalpy increases. Both driving forces favour reactants and therefore no reaction will occur.

   OR

   Reactants are more random than the products (3 moles of gas compared to 1 mole of gas) and the reactants are lower in energy (forward reaction is endothermic). Both driving forces favour reactants and therefore no reaction will occur.