

SL & HL Answers to Equilibrium questions

1. In dynamic equilibrium the changes taking place are still proceeding but the rate of the forward change is equal to the rate of the reverse change so the concentrations of the products and reactants remains constant at equilibrium. In static equilibrium all movement has stopped.

2. i. The warmth from the sun increases the temperature which increases the vapour pressure of the water.

ii. As the water molecules vaporise the wind blows them away so they cannot condense back on the clothes.

(iii) When the water molecules go into the air the lack of humidity means that the air does not become saturated with water vapour so reduces condensation.

3. i. Initially when the concentrations of the acid and alcohol are high the rate of the forward reaction is much faster than the rate of the reverse reaction, as products are formed the rate of the reverse reaction increases and the rate of the forward reaction decreases. After one week equilibrium is reached when the rate of the forward reaction is equal to the rate of the reverse reaction so the concentration of reactants and products does not change.

ii. The value for Q will initially be very low as very little products are present. As the week progresses the concentration of the products will increase and the concentration of the reactants will decrease so the value of Q will continue to increase until eventually it becomes the value for K_c . At this point the position of equilibrium has been reached.

iii. The catalyst speeds up the rate of both the forward and reverse reaction by the same amount. So equilibrium is reached quicker but there is no effect on the position of equilibrium.

iv. The concentration of the acid and alcohol were originally equal and one mole of acid reacts with one mole of alcohol. At equilibrium the concentration of the ester and water formed will be twice the concentration of the remaining acid and alcohol.

Mathematically if $[\text{ester}] = [\text{water}] = x$ at equilibrium, then $[\text{acid}] = [\text{alcohol}] = \frac{1}{2}x$ at equilibrium

$$K_c = \frac{([\text{ester}] \times [\text{water}])}{([\text{acid}] \times [\text{alcohol}])} = \frac{x^2}{\frac{1}{4}x^2} = 4$$

Note that HL students could work out that if the initial amount of the acid and the alcohol in a fixed volume was a mol each then the total amount present initially = 2a mol. Since the total amount of particles does not change and the volume remains constant then there are a total of 3x mol of particles at equilibrium so $3x = 2a$ so $x = \frac{2}{3}a$. Hence the concentration of the acid and the alcohol will have reduced to $\frac{1}{3}$ of their original value and the concentration of the ester and water formed will each be two thirds of the original concentration of the acid or alcohol.



4. i.
$$K_c = \frac{[\text{CH}_3\text{OH}(\text{g})]}{[\text{CO}(\text{g})] \times [\text{H}_2(\text{g})]^2}$$

ii. The equilibrium lies more on the product side but there will still be appreciable amounts of hydrogen and carbon monoxide in the equilibrium mixture even though the concentration of methanol will be greater as K_c is not extremely large.

5. i. Because the reaction is exothermic at higher temperatures the equilibrium will move towards the reactant side so the value of K_c will be lower and the yield of ammonia will also be lower.

ii. Four moles of reactants are converted into two moles of product. Applying Avogadro's law four volumes are converted into two volumes and a higher pressure will favour the lower volume side.

iii. To increase the surface area of the catalyst which will increase the rate of the reaction as more reactant particles can be brought closer together.

6. i.
$$K_c = \frac{[\text{NO}(\text{g})]^2}{[\text{N}_2(\text{g})] \times [\text{O}_2(\text{g})]}$$

ii. It will have no effect as there is no change in volume (two moles of gas on each side) .

iii. (a) The yield of nitrogen(II) oxide will increase as the reaction is endothermic .

(b) The rate of the reaction will increase as more reactant particles will have the necessary activation energy and there will be more successful collisions.

(c) The value of the equilibrium constant, K_c will increase as at higher temperatures the concentration of the product will be higher and the concentration of the reactants will be lower.

