LE CHATELIER'S PRINCIPLE

Le Chatelier's Principle: If an equilibrium system is subjected to a change in temperature or concentration of reacting species, causing the equilibrium position to be disturbed, the system chemically responds in a manner that partially counteracts the imposed change in order to regain equilibrium.

**Note: In all gas phase systems, ideality is always assumed (molecules are considered to be dimensionless).

Response to Le Chatelier Principle questions:

The (addition of …/increase in temperature etc.) disturbs the position of the equilibrium, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the (right/left) and the (forward/back) reaction will be favoured in order to minimise the effect of (adding …/removing … etc.) in the system. This will result in the formation of more (products/reactants).

Examples:

$$A_{(g)} + B_{(g)} \rightleftharpoons C_{(g)} \qquad \Delta H = -ve$$

Add more A or B at CV/CT:

The addition of more A or B disturbs the equilibrium position by increasing the concentration of A or B only, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the right and the forward reaction will be favoured so that A or B is consumed. This will result in the formation of more C.

Add more C at CV/CT:

The addition of more C disturbs the equilibrium position by increasing the concentration of C only, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the left and the back reaction will be favoured so that C is consumed. This will result in the formation of more A and B.

Remove some A or B at CV/CT:

The removal of A or B disturbs the equilibrium position by decreasing the concentration of A or B only, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the left and the back reaction will be favoured so that A or B is produced. This will result in the formation of more A and B.

Remove some C at CV/CT:

The removal of C disturbs the equilibrium position by decreasing the concentration of C only, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the right and the forward reaction will be favoured so that more C is produced. This will result in the formation of more C.

Increase the volume at CT:

The increase of volume will disturb the equilibrium position by decreasing the concentration of all reacting species, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the left and the back reaction will be favoured as 2 mole ⇌ 1 mole. This will result in the formation of more A and B at the expense of C.

Decrease the volume at CT:

The decrease in volume disturbs the equilibrium position by increasing the concentration of all reacting species, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the right and the forward reaction will be favoured as 2 mole ⇌ 1 mole. This will result in the formation of more C.

Add equilibrium mixture at CV/CT:

The addition of more equilibrium mixture disturbs the equilibrium position by increasing the concentration of all reacting species, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the right and the forward reaction will be favoured as 2 mole ⇌ 1 mole. This will result in the formation of more C.

Increase temperature at CV:

The increase in temperature disturbs the equilibrium position, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the left and the back reaction will be favoured as it is endothermic. This will result in the formation of more A and B.

Decrease temperature at CV:

The decrease in temperature disturbs the equilibrium position, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. Therefore the position of the equilibrium will shift to the right and the forward reaction will be favoured as it is exothermic. This will result in the formation of more C.

Adding inert gas at CV/CT:

The addition of an inert gas at constant volume has no effect on the equilibrium position. This is because though the inert gas will increase the total pressure of the system, it will not change the partial pressures of the individual gases since the volume remains constant. Therefore, no change is observed.

Adding inert gas at CP/CT:

The addition of an inert gas at constant pressure disturbs the equilibrium position, necessitating a response. According to Le Chatelier's Principle, the system will chemically respond by partially opposing the change in order to regain equilibrium. The addition of inert gas decreases the partial pressures of each gaseous component which has the same effect as increasing the volume. Therefore, the position of the equilibrium will shift to the left and the back reaction will be favoured as 2 mole ⇌ 1 mole. This will result in the formation of more A and B.

Adding catalyst:

Adding a catalyst to the system has no effect on the equilibrium position. This is because a catalyst increases the rate of the forward reaction and back reaction equally. Yet, a catalyst may work to achieve equilibrium faster.

**Note: The equilibrium constant (K_c) is only changed when there is a change in temperature.

**Note: We are assuming ideal gas behaviour for all gases.

$$A_{(aq)} + B_{(aq)} \rightleftharpoons C_{(aq)}$$

Increase or decrease in pressure:

The increase or decrease in pressure will not affect the equilibrium position as the reacting species are all in an aqueous medium.