

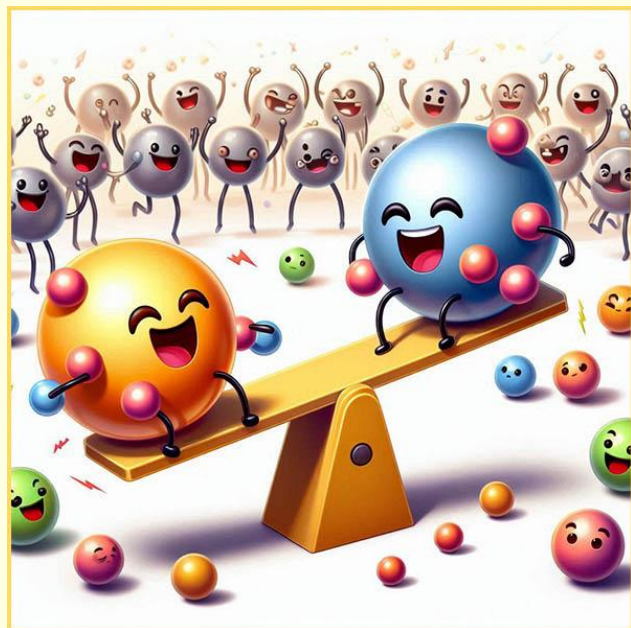
Le Chatelier's Principle

Henri Le Chatelier dynamic equilibrium

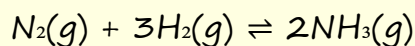


Answer all the questions below and then check your answers

1. State Le Chatelier's Principle.
2. Name three factors that can affect the position of equilibrium in a chemical reaction.
3. A reaction is exothermic in the forward direction. Explain how increasing the temperature would affect the position of equilibrium.
 - a. If the concentration of reactants in a reaction at equilibrium is increased, in which direction will the equilibrium shift?
 - b. Describe how the equilibrium position changes when the pressure is increased in a reaction involving gases.
 - c. What happens to the equilibrium position if a catalyst is added to a reaction?
 - d. Explain the effect of decreasing the temperature on the equilibrium position of an endothermic reaction.
 - e. How does changing the concentration of products affect the equilibrium position according to Le Chatelier's Principle?

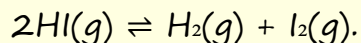


4. For the following reaction



Predict the effect of increasing the pressure on the position of equilibrium.

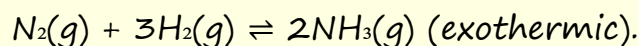
5. Hydrogen iodide decomposes according to the following equation:



This reaction is endothermic.

(a) State the effect of increasing temperature on the position of equilibrium.
Explain your answer

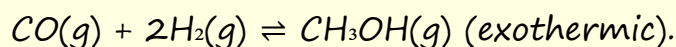
6. Ammonia is produced industrially by the Haber Process:



(a) Explain the effect of increasing the pressure on the yield of ammonia.

(b) Suggest why a moderate temperature (around 450°C) is used, rather than a very high or very low temperature.

7. Methanol is produced by the reaction:



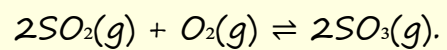
A high pressure is used to increase the yield of methanol.

(a) Explain why high pressure increases the yield.

(b) State and explain the effect of increasing the temperature on the yield and rate of the reaction.

(c) Suggest a reason why a catalyst is used in this process.

8. Consider the equilibrium reaction:



The reaction is exothermic. Explain how the position of equilibrium will be affected by:

(a) an increase in pressure

(b) an increase in temperature

(c) adding more $\text{O}_2(\text{g})$.

Answers

1. State Le Chatelier's Principle.

When a system at equilibrium is subjected to a change in conditions, it will shift to counteract that change.

2. Name three factors that can affect the position of equilibrium in a chemical reaction.

Temperature, pressure, concentration.

3. A reaction is exothermic in the forward direction. Explain how increasing the temperature would affect the position of equilibrium.

Increasing the temperature favours the endothermic reaction (the backward reaction in this case) to absorb the extra heat. The equilibrium shifts to the left.

- a. If the concentration of reactants in a reaction at equilibrium is increased, in which direction will the equilibrium shift?

The equilibrium will shift to the right, favouring the production of products.

- b. Describe how the equilibrium position changes when the pressure is increased in a reaction involving gases.

When the pressure is increased, the equilibrium will shift towards the side with fewer moles of gas to reduce the pressure.

- c. What happens to the equilibrium position if a catalyst is added to a reaction?

Adding a catalyst does not change the position of equilibrium; it only speeds up the rate at which equilibrium is reached.

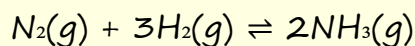
- d. Explain the effect of decreasing the temperature on the equilibrium position of an endothermic reaction.

Decreasing the temperature in an endothermic reaction will shift the equilibrium to the left, favouring the reactants, because the system will absorb heat to counteract the decrease in temperature.

- e. How does changing the concentration of products affect the equilibrium position according to Le Chatelier's Principle?

Increasing the concentration of products will shift the equilibrium to the left, favouring the formation of reactants, whereas decreasing the concentration of products will shift the equilibrium to the right, favouring the formation of more products.

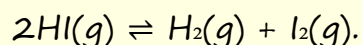
4. For the following reaction



Predict the effect of increasing the pressure on the position of equilibrium.

Increasing pressure favours the side with fewer gas molecules. The equilibrium shifts to the right (towards ammonia production).

5. Hydrogen iodide decomposes according to the following equation:

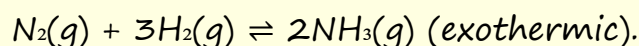


This reaction is endothermic.

- (a) State the effect of increasing temperature on the position of equilibrium. Explain your answer

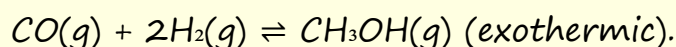
Equilibrium shifts to the right. Increasing temperature favours the endothermic reaction to absorb the extra heat.

6. Ammonia is produced industrially by the Haber Process:



- (a) Explain the effect of increasing the pressure on the yield of ammonia.
- (b) Suggest why a moderate temperature (around 450°C) is used, rather than a very high or very low temperature.
- (a) Increased pressure favours the side with fewer gas molecules, shifting equilibrium to the right, increasing ammonia yield.
- (b) High temperatures favour the reverse endothermic reaction, reducing yield. Low temperatures slow down the rate of reaction. A compromise temperature gives a reasonable yield at an acceptable rate.

7. Methanol is produced by the reaction:

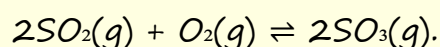


A high pressure is used to increase the yield of methanol.

- (a) Explain why high pressure increases the yield.
- (b) State and explain the effect of increasing the temperature on the yield and rate of the reaction.
- (c) Suggest a reason why a catalyst is used in this process.

- (a) High pressure favours the side with fewer gas molecules, increasing the yield of methanol.
- (b) Increasing temperature favours the reverse endothermic reaction, decreasing the yield. However, it increases the rate of reaction.
- (c) A catalyst increases the rate of reaction without affecting the position of equilibrium.

8. Consider the equilibrium reaction:



The reaction is exothermic. Explain how the position of equilibrium will be affected by:

- (a) an increase in pressure
 - (b) an increase in temperature
 - (c) adding more $\text{O}_2(\text{g})$.
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- (a) Increase in pressure: The equilibrium will shift to the right, favouring the formation of $\text{SO}_3(\text{g})$, because there are fewer moles of gas on the right side (3 moles on the left vs. 2 moles on the right), reducing the pressure.
 - (b) Increase in temperature: The equilibrium will shift to the left, favouring the formation of $\text{SO}_2(\text{g})$ and $\text{O}_2(\text{g})$, as the reaction is exothermic and the system will try to absorb the added heat by favouring the endothermic reverse reaction.
 - (c) Adding more $\text{O}_2(\text{g})$: The equilibrium will shift to the right, favouring the formation of more $\text{SO}_3(\text{g})$, to counteract the increase in the concentration of $\text{O}_2(\text{g})$ by consuming it.