

7.6

What is an Equilibrium Constant and How Do We Use It?

Writing Equilibrium Expressions

1) Convention:
$$\frac{[\text{PRODUCTS}]}{[\text{REACTANTS}]} = K$$

K = Equilibrium Constant.

2) When writing equilibrium expressions ... equations ... pure solids and liquids do not appear in the expression.



$$K = \frac{[\text{H}_2 (\text{O}_2)_2]}{[\text{H}_2] [\text{O}_2]^2}$$



$$K = \frac{[\text{NH}_3][\text{NH}_3]}{[\text{N}_2][\text{H}_2][\text{H}_2][\text{H}_2]}$$

$$K = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$



$$K = [\text{Ag}^+][\text{Cl}^-]$$



$$K = \frac{[\text{H}_3\text{O}^+][\text{F}^-]}{[\text{HF}]}$$

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What is an Equilibrium Constant and How Do We Use It?

The Significance of the Magnitude of K

The simulation interface is divided into several sections:

- Top Left:** A rectangular box containing 30 blue spheres representing molecules in a container.
- Top Right:** A graph with the y-axis labeled "Number of Molecules" and the x-axis labeled "Time". Above the graph, the text "See Class Web Site" is written in orange, and "The Meaning of the Equilibrium Constant." is written in bold black.
- Bottom Left:** A control panel showing "Blue: 30" and "Red: 0" with "Play" and "Reset" buttons.
- Bottom Right:** A yellow control panel with three sections:
 - Equilibrium Constant:** Radio buttons for $K > 1$, $K = 1$ (selected), and $K < 1$.
 - Number of Spheres:** Radio buttons for 30, 20, and 10.
 - Temperature:** Radio buttons for High and Low (selected).

7.6 What is an Equilibrium Constant and How Do We Use It?

The Significance of the Magnitude of K

- 1) $K \gg 1$: At equilibrium the products predominate.
- 2) $K \ll 1$: At equilibrium the reactants predominate.
- 3) $K \sim 1$: At equilibrium significant quantities of reactants and products are present.



$$K = 3.5 \times 10^8 \text{ @ } 25^\circ\text{C}$$

$K \gg 1$, thus product favored at eq.



$$K = 7.6 \times 10^{-5} \text{ @ } 25^\circ\text{C}$$

$K \ll 1$, thus reactant favored at eq.

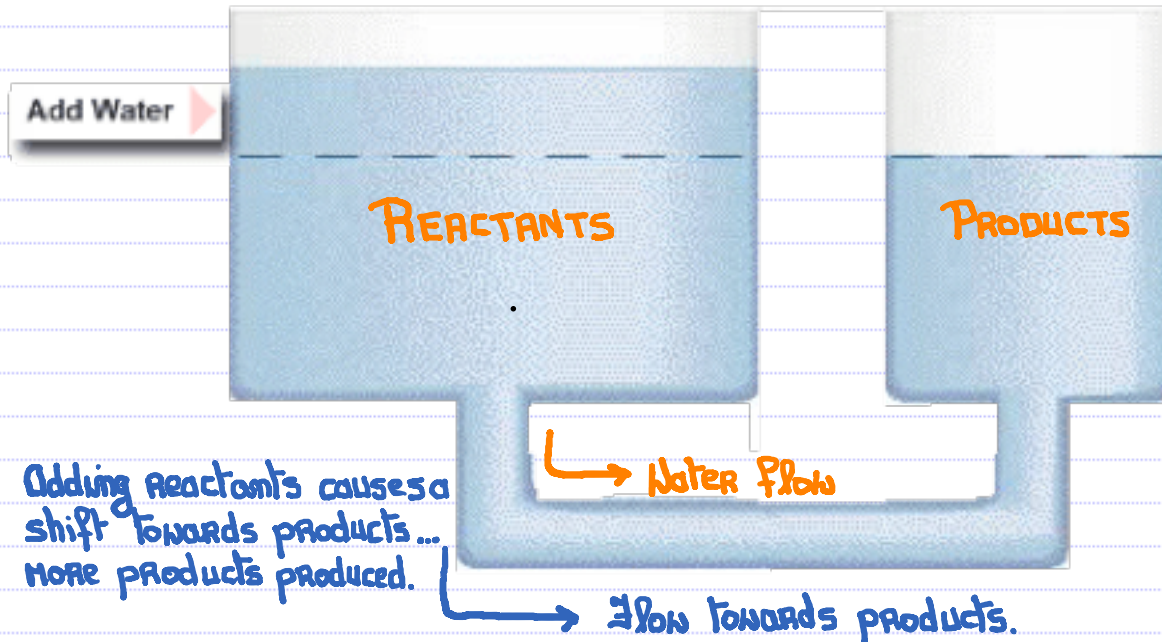


$$K \approx 12 \text{ @ } 25^\circ\text{C}$$

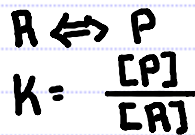
$K \sim 1$, thus significant amounts of reactants and products found at eq.

7.7 What Is Le Chatelier's Principle Adding Reactants.

Chemistry Interactive: LeChatelier's Principle - The Water Tank Analogy



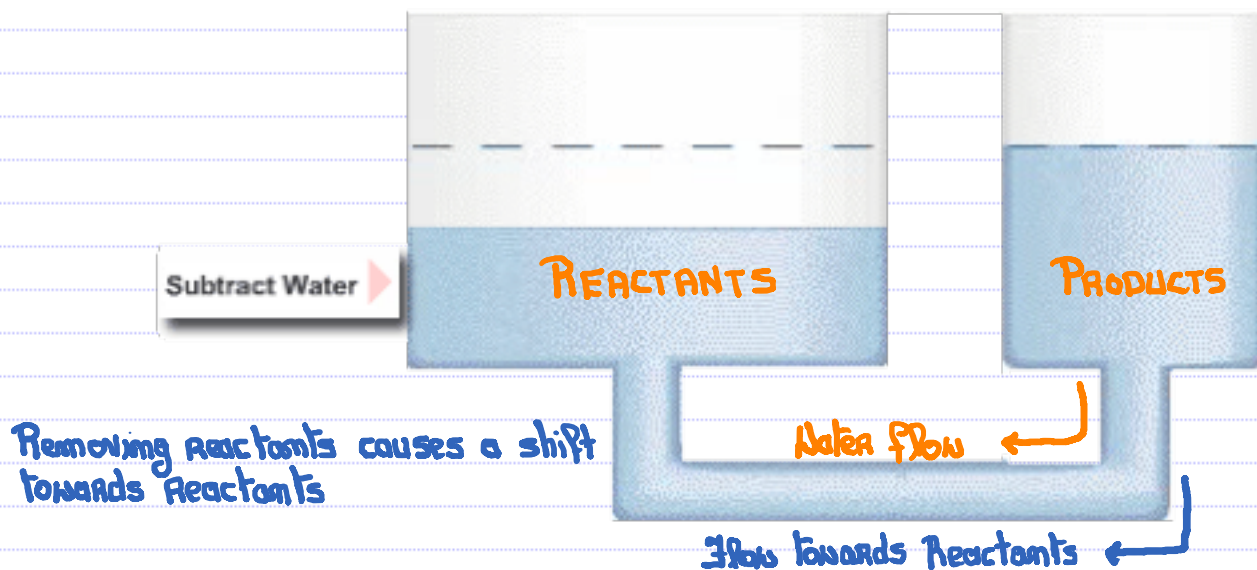
Why?



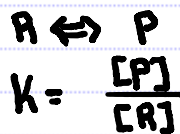
Adding R causes $[P]/[R]$ to become $< K$, the equilibrium wants to restore this value, thus $[R] \downarrow$ and $[P] \uparrow$ until the ratio returns back to its original value.

7.7 What Is Le Chatelier's Principle Removing Reactants.

Chemistry Interactive: LeChatelier's Principle - The Water Tank Analogy



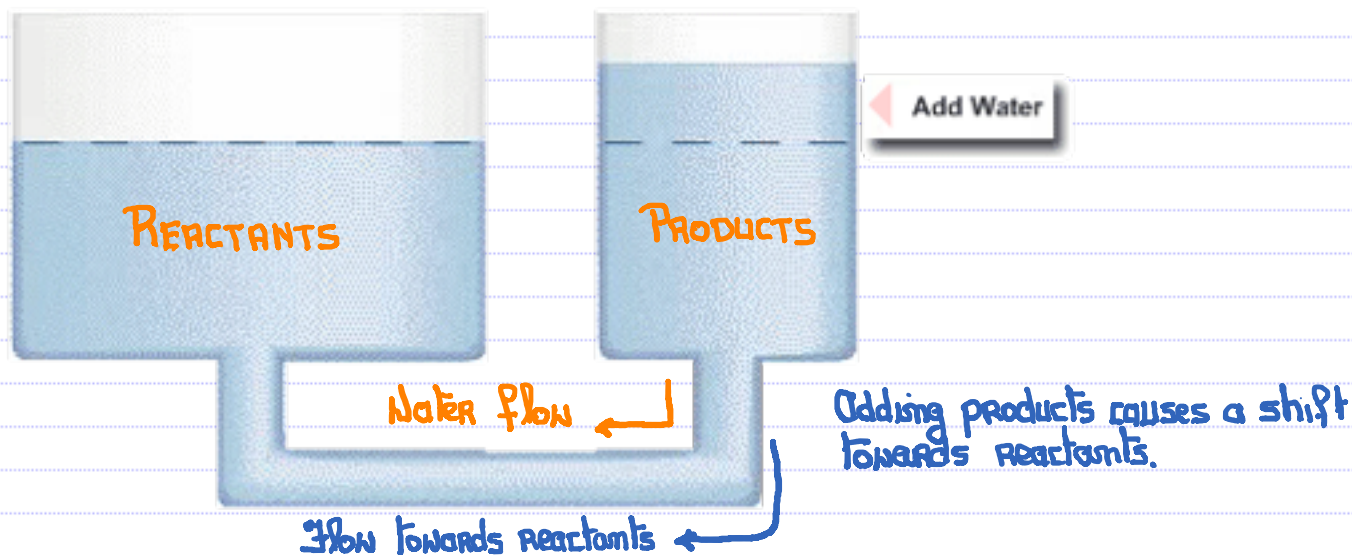
WHY?



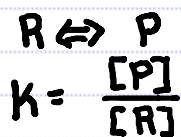
Removing A causes $[P]/[A]$ to become $> K$, the equilibrium wants to restore this value, thus $[P] \downarrow$ and $[A] \uparrow$ until the ratio returns back to its original value.

7.7 What Is Le Chatelier's Principle Adding Products .

Chemistry Interactive: LeChatelier's Principle - The Water Tank Analogy



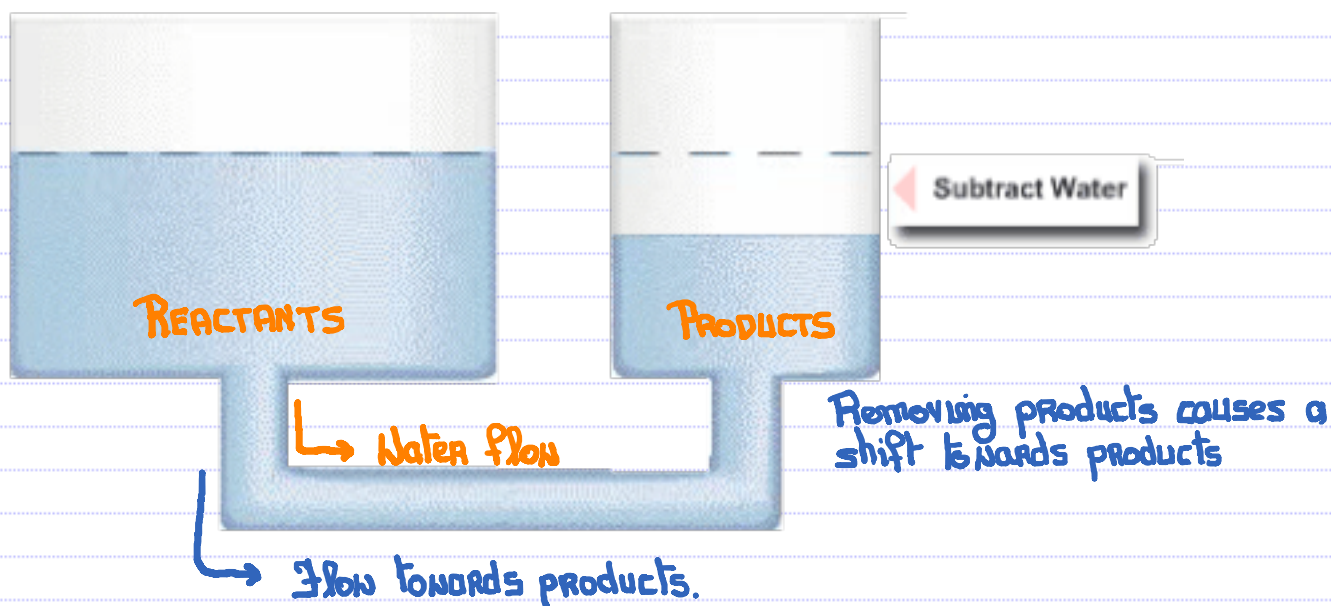
Why? :



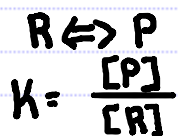
Adding P causes the $[P]/[R]$ to become $> K$, the equilibrium wants to restore this value, thus $[P] \downarrow$ and $[R] \uparrow$ until the ratio returns back to its original value.

7.7 What Is Le Chatelier's Principle Removing Products .

Chemistry Interactive: LeChatelier's Principle - The Water Tank Analogy



Why?



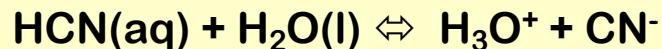
Removing P causes the $\frac{[P]}{[R]}$ to become $< K$, the equilibrium wants to restore this value, thus $[P] \uparrow$ and $[R] \downarrow$ until the ratio returns to its original value.

7.7

What Is Le Chatelier's Principle

Adding/Removing Reactant and Products

HCN is a weak acid –



Removal of H_3O^+ from this equilibrium will cause the $[\text{CN}^-]$ to

- a) Increase ✓
- b) Decrease
- c) Remain unchanged
- d) Impossible to determine



Remove H_3O^+ = Removing P

Shift to produce more



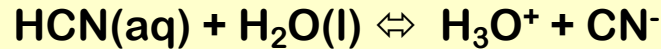
$[\text{CN}^-]$ original + more $[\text{CN}^-]$

7.7

What Is Le Chatelier's Principle

Adding/Removing Reactant and Products

HCN is a weak acid –



Addition of OH^- to this equilibrium will cause the $[\text{CN}^-]$ to

- a) Increase ✓
- b) Decrease
- c) Remain unchanged ? Why not?
- d) Impossible to determine



At first glance you would be correct to expect c) ... since OH^- is neither a reactant or a product ... **BUT**



→ OH^- Removes H_3O^+ = Removing P.

Shift to produce more → $\text{H}_3\text{O}^+ + \text{CN}^-$

CN^- original + more CN^-