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.

1) $HB + 2\,O_2 \Leftrightarrow HB(O_2)_2$

$$K = \frac{[HB(O_2)_2]}{[HB]\,[O_2]^2}$$

2) $N_2(g) + 3\,H_2(g) \Leftrightarrow 2\,NH_3(g)$

$$K = \frac{[NH_3][NH_3]}{[N_2][H_2][H_2][H_2]}$$

$$K = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

3) $AgCl(s) \Leftrightarrow Ag^+ + Cl^-$

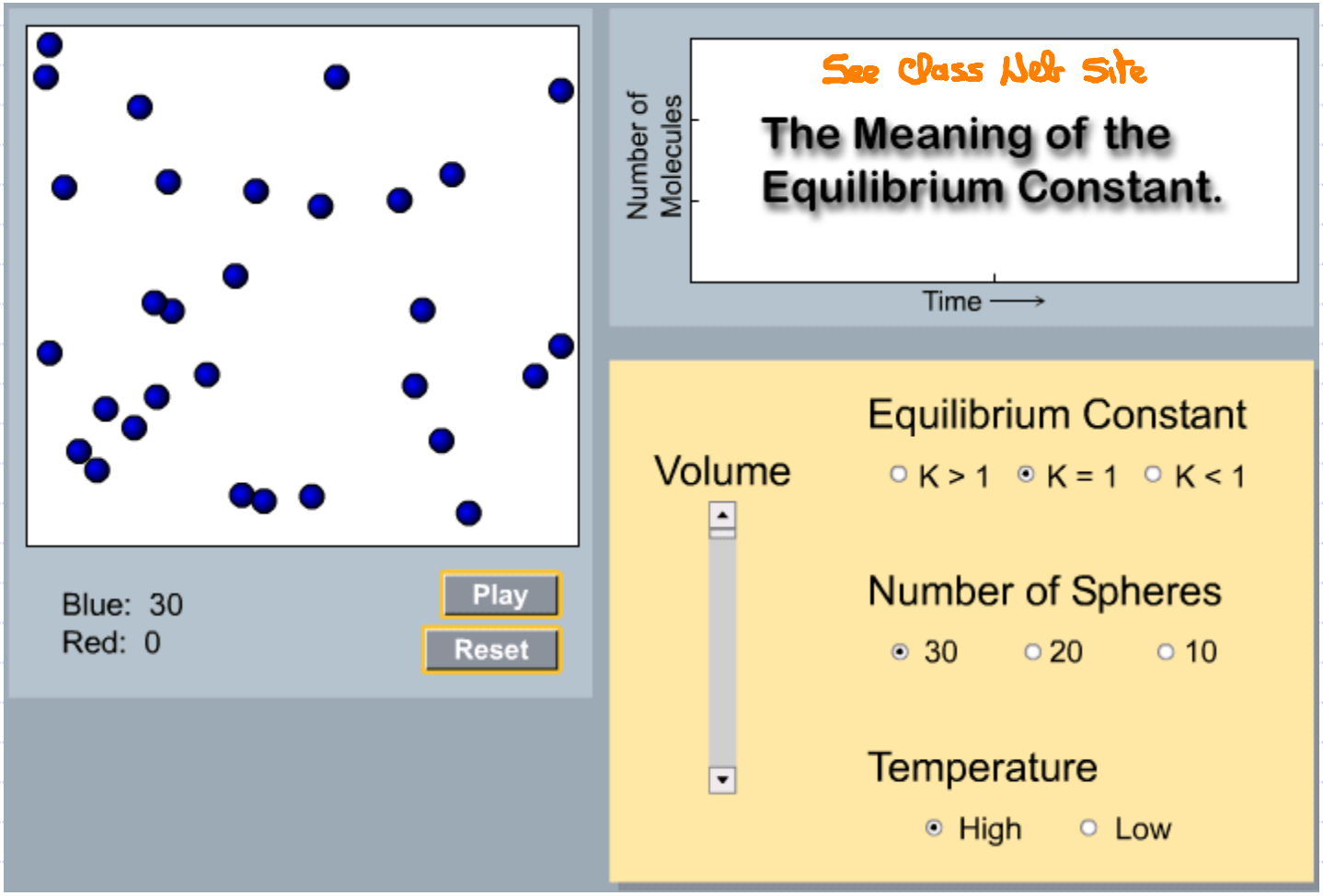
$$K = [Ag^+][Cl^-]$$

4) $HF(aq) + H_2O(l) \Leftrightarrow H_3O^+ + F^-$

$$K = \frac{[H_3O^+][F^-]}{[HF]}$$

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

The Significance of the Magnitude of K



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.

1) $N_2(g) + 3\,H_2(g) \Leftrightarrow 2\,NH_3(g)$

$K = 3.5 \times 10^8$ @ 25°C
$K \gg 1$, thus product favored at Eq.

2) $HF(aq) + H_2O(l) \Leftrightarrow H_3O^+ + F^-$

$K = 7.6 \times 10^{-5}$ @ 25°C
$K \ll 1$, thus reactant favored at Eq.

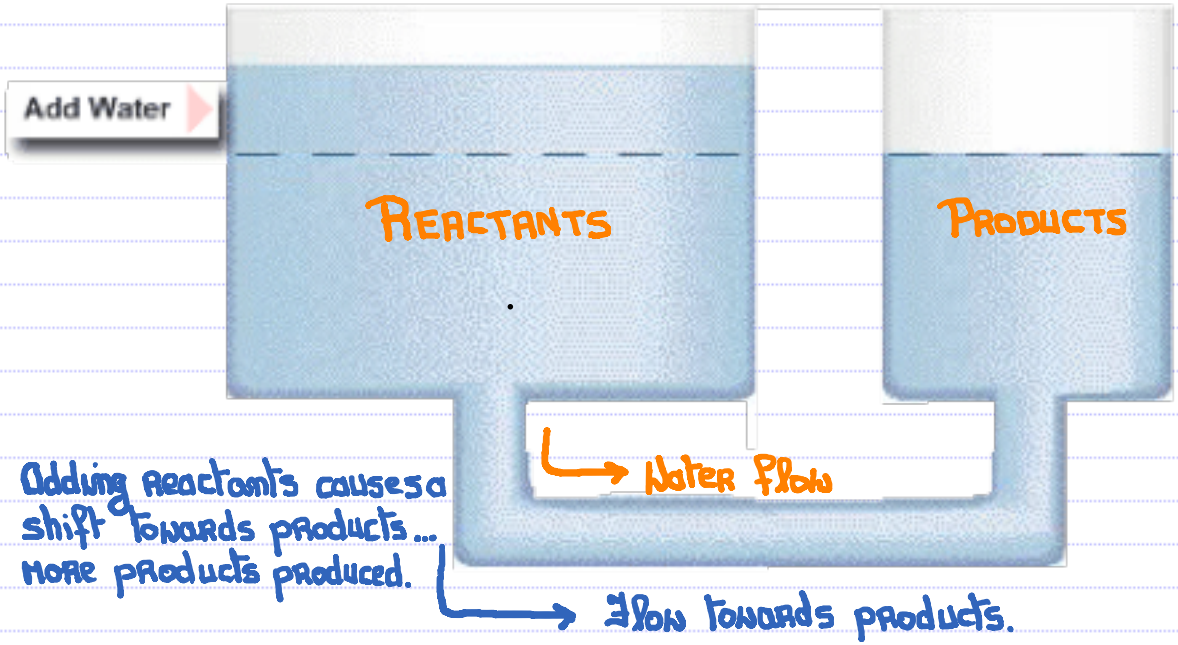
3) $Hg + 2O_2 \Leftrightarrow Hg(O_2)_2$

$K \approx 12$ @ 25°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?

$$R \Leftrightarrow P$$

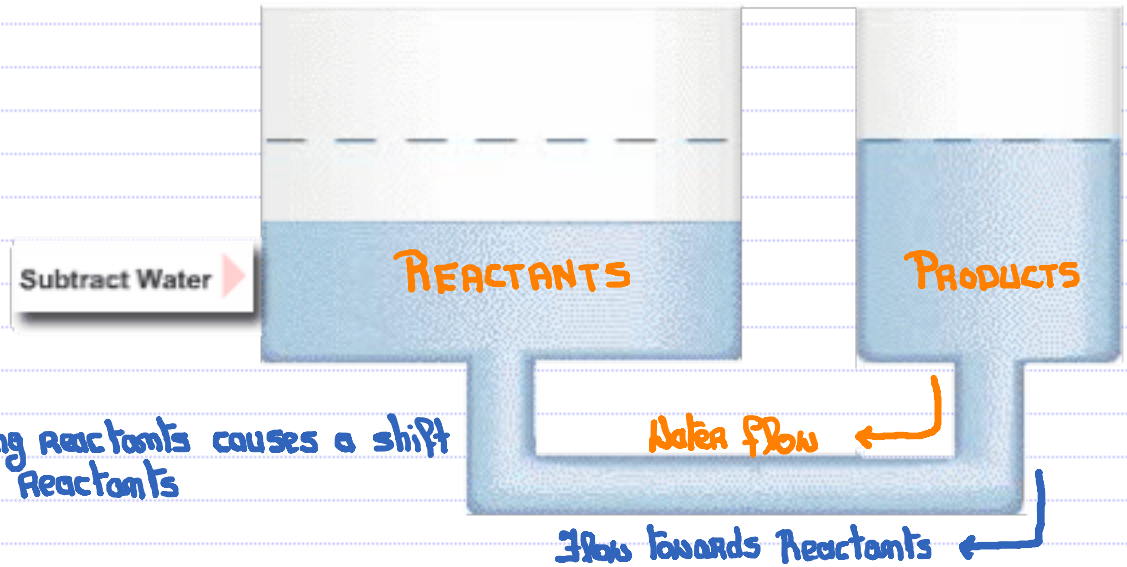
$$K = \frac{[P]}{[R]}$$

Adding R causes [P]/[R] to become < K, the equilibrium reacts to restore this value, thus [R]↓ and [P]↑ 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?

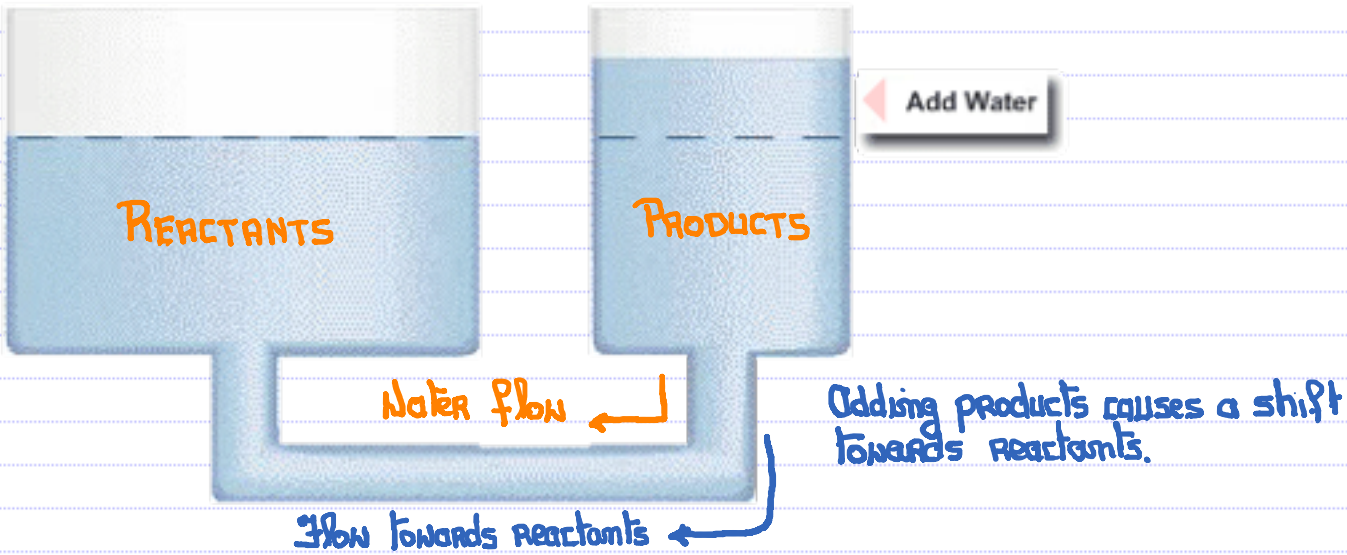
$$A \Leftrightarrow P \qquad K = \frac{[P]}{[R]}$$

Removing R causes [P]/[R] to become > K, the equilibrium wants to restore this value, thus [P]↓ and [R]↑ 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



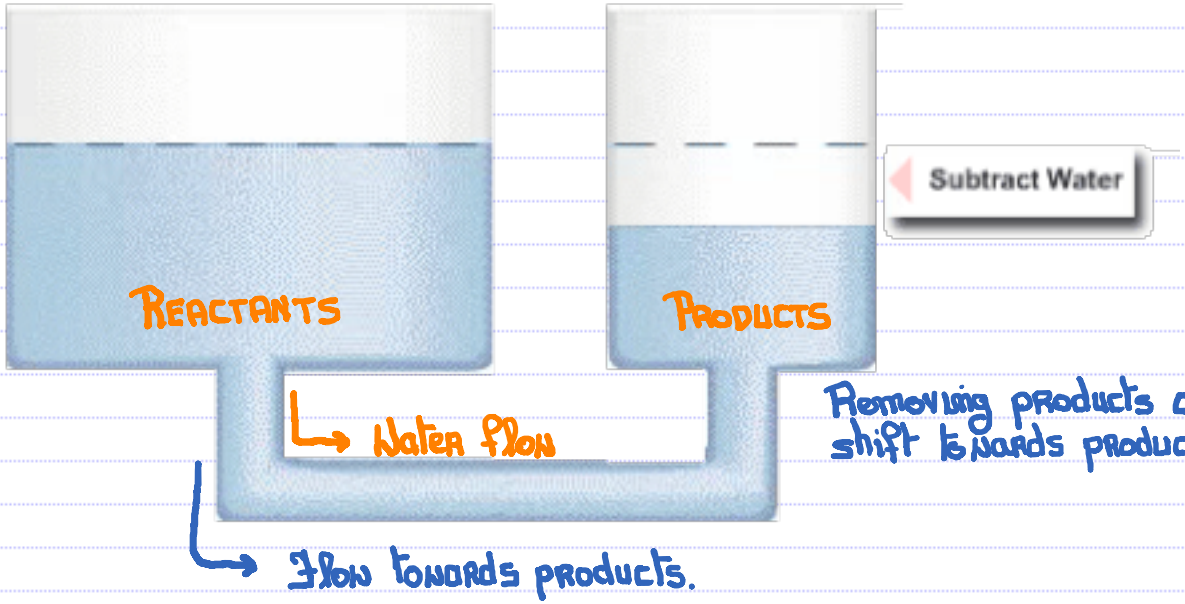
Why ?: $R \Leftrightarrow P$ $\quad K = \frac{[P]}{[R]}$

Adding P causes the [P]/[R] to become > k, the equilibrium wants to restore this value, thus [P]↓ and [R]↑ 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 ?

$R \Leftrightarrow P$

$K = \frac{[P]}{[R]}$

Removing P causes the [P]/[R] to become < K, the equilibrium wants to restore this value, thus [P]↑ and [R]↓ 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 –

$$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$$

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

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

$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$

H_3O^+ → Remove H_3O^+ = Removing P

Shift to produce more → $H_3O^+ + CN^-$

$[CN^-]$ original + more $[CN^-]$

7.7 What Is Le Chatelier's Principle

Adding/Removing Reactant and Products

HCN is a weak acid –

$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$

Addition of OH^- to this equilibrium will cause the $[CN^-]$ 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

→ always ... $OH^- + H_3O^+ = 2\,H_2O(l)$ (100%)

$HCN(aq) + H_2O(l) \Leftrightarrow H_3O^+ + CN^-$

H_3O^+ → OH^- Removes H_3O^+ = Removing P.

Shift to Produce more → $H_3O^+ + CN^-$

CN^- original + more CN^-