Name: Key
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CHEMISTRY 12
ACID BASES UNIT
Lesson #10

THE RELATIVE STRENGTHS OF ACIDS AND BASES

Example 1. If solutions containing H_2CO_3 and SO_3^{2-} are mixed, the following acid base equilibrium exists: $\longrightarrow$

$$\underset{acid}{H_2CO_3} + \underset{base}{SO_3^{2-}} \rightleftharpoons \underset{base}{HCO_3^-} + \underset{acid}{HSO_3^-}$$

Here SO_3^{2-} must act as the Base as it lacks an H^+!

Example 2. If solutions containing CO_3^{2-} and $H_2PO_4^-$ are mixed, the following acid-base equilibrium exists: $\longrightarrow$

$$\underset{acid}{H_2PO_4^-} + \underset{base}{CO_3^{2-}} \rightleftharpoons \underset{base}{HPO_4^{2-}} + \underset{acid}{HCO_3^-}$$

In the above two equilibrium there are acids on BOTH SIDES of the equation, just as there are bases on both sides of the equation. However, in a BRØNSTED-LOWRY acid-base equilibrium the side of the equilibrium that is favoured is the side with the WEAKER ACID!!!!

Therefore, in **Example 1** the side of the equilibrium that is favoured is determined by comparing the strengths of the TWO ACIDS. Because HSO_3^- is a weaker acid than H_2CO_3, the PRODUCTS are favoured.

In **Example 2** the side of the equilibrium that is favoured is also determined by comparing the strengths of the TWO ACIDS. Because HCO_3^- is a weaker acid than $H_2PO_4^-$, the PRODUCTS are favoured.

Here is another way of determining which side is favoured in a Bronsted-Lowry acid-base equilbrium:

Using the chemical equation from **Example 2**:

$$\underset{base}{CO_3^{2-}} + \underset{acid}{H_2PO_4^-} \text{<---->} \underset{acid}{HCO_3^-} + \underset{base}{HPO_4^{2-}}$$

Write out the Keq expression:

$$K_{eq} = \frac{[HCO_3^-][PO_4^{2-}]}{[CO_3^{2-}][H_2PO_4^-]}$$

two acids

$$\frac{H_2PO_4^- + H_2O(l) \rightleftharpoons HPO_4^{2-} + H_3O^+}{HCO_3^- + H_2O(l) \rightleftharpoons CO_3^{2-} + H_3O^+}$$

$$K_{a\,(H_2PO_4^-)} = \frac{[HPO_4^{2-}][H_3O^+]}{[H_2PO_4^-]} \; ; \; K_{a\,(HCO_3^-)} = \frac{[CO_3^{2-}][H_3O^+]}{[HCO_3^-]}$$

$$Keq = \frac{[HCO_3^-][PO_4^{2-}]}{[CO_3^{2-}][H_2PO_4^-]} \Rightarrow Keq = \frac{Ka(\text{acid on reactant})}{Ka(\text{acid on product})}$$

The Keq expression can be RE-WRITTEN AS:

$$Keq = \frac{[H_3O^+][HPO_4^{2-}]}{[H_2PO_4^-]} \times \frac{[HCO_3^-]}{[H_3O^+][CO_3^{2-}]} \Rightarrow Ka(H_2PO_4^-) \times \frac{1}{Ka(HCO_3^-)}$$

OR SIMPLY AS:

$$\therefore Keq = \frac{Ka(H_2PO_4^-)}{Ka(HCO_3^-)} = \frac{6.2 \times 10^{-8}}{5.6 \times 10^{-11}} = 1.1 \times 10^{+3} \quad (Keq > 1)$$

PRODUCTS ar favoured

RECALL:
If the Keq value = 1 BOTH SIDES EQUALLY FAVOURED
If the Keq value > 1 PRODUCTS ARE FAVOURED
If the Keq value < 1 REACTANTS ARE FAVOURED

THE GENERIC Keq expression for acid-base equilbria is:

$$Keq = \frac{\textbf{Ka(REACTANT ACID)}}{\textbf{Ka (PRODUCT ACID)}}$$

Example 3. When HS- and HCO_3^- are mixed, does the resulting equilibrium favour the reactant or the products?

1. Choose which of these two reactants is going to act as the acid. (higher on table)

HCO_3^- will act as the acid

2. Write out the acid-base equilbrium:

$$\underset{acid}{HCO_3^-} + \underset{base}{HS^-} \rightleftharpoons \underset{base}{CO_3^{2-}} + \underset{acid}{H_2S}$$

3.Identify the TWO ACIDS involved in the equilibrium:

HCO_3^- and H_2S

a. Solve the problem using the WEAKER ACID rule

Because HCO_3^- is weaker the REACTANTS are favoured.

b. Solve the problem using the Keq equation

$$Keq = \frac{Ka(\text{reactant})}{Ka(\text{product})} = \frac{Ka(HCO_3^-)}{Ka(H_2S)} = \frac{5.6 \times 10^{-11}}{9.1 \times 10^{-8}} = \boxed{6.2 \times 10^{-4}}$$

B/c keq < 1 the Reactants are favoured!!!

SEATWORK/HOMEWORK: Exercises 38-46 in Hebden pg 131
PLO's: K8+K9