Name:_____
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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:

$4.3 \cdot 10^{-7}$ H_2CO_3 (acid) + SO_3^{2-} (base) $\rightleftharpoons$ HCO_3^- (base) + HSO_3^- (acid) $1.0 \cdot 10^{-7}$

Here SO_3^{2-} must act as the base as it lacks a proton

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

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

$6.2 \cdot 10^{-8}$ $1.6 \cdot 10^{-11}$

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 BRONSTED-LOWRY acid-base equilibrium the side of the equilibrium that is favoured is the side with the weaker acid (weaker base) !!!! — arm wrestling analogy

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 equilibrium:

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

equation: $CO_3^{2-} + H_2PO_4^- \text{ <----> } HCO_3^- + HPO_4^{2-}$

($H_2PO_4^-$: reactant acid; HCO_3^-: product acid)

Write out the Keq expression:

$$K_{eq} = \frac{[HCO_3^-][HPO_4^{2-}]}{[CO_3^{2-}][H_2PO_4^-]}$$

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

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

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

The Keq expression can be RE-WRITTEN AS:

$$K_{eq} = \frac{[HPO_4^{2-}][H_3O^+]}{[H_2PO_4^-]} \cdot \frac{[HCO_3^-]}{[CO_3^{2-}][H_3O^+]} \Rightarrow$$

$= K_a$ (reactant acid) $\cdot$ $1/K_a$ (product acid)

OR SIMPLY AS:

$$K_{eq} = K_a(H_2PO_4^-) \cdot \frac{1}{K_a(\text{product})} \Rightarrow \frac{6.2 \cdot 10^{-8}}{5.6 \cdot 10^{-11}}$$

RECALL:

If the Keq value = 1 Both sides equally favoured

If the Keq value > 1 Product side favored

If the Keq value < 1 reactant side favoured

HCO_3^- acid $= 1.1 \cdot 10^{3}$

$K_{eq} > 1$

∴ Product

THE GENERIC Keq expression for acid-base equilbria is:

$$K_{eq} = \frac{K_a(\text{REACTANT ACID})}{K_a(\text{PRODUCT ACID})}$$

$1.1 \cdot 10^{-3}$

Example 3. When HS^- and HCO_3^- are mixed, does the resulting equilibrium favour the reactant or the products? $5.6 \cdot 10^{-11}$

1. Choose which of these two reactants is going to act as the acid.

Higher on the Left hand side ∴ stronger acid

2. Write out the acid-base equilbrium:

$$HCO_3^- \text{ (acid)} + HS^- \text{ (base)} \rightleftharpoons CO_3^{2-} \text{ (base)} + H_2S \text{ (acid)}$$

3. Identify the TWO ACIDS involved in the equilibrium:

HCO_3^- acid reactant side; H_2S acid product side

a. Solve the problem using the WEAKER ACID rule

K_a $5.6 \cdot 10^{-11}$ $9.1 \cdot 10^{-8}$

∴ Reactant side is favoured

b. Solve the problem using the Keq equation

$$K_{eq} = \frac{K_a(\text{reactant})}{K_a(\text{product})} = \frac{5.6 \cdot 10^{-11}}{9.1 \cdot 10^{-8}} = 6.2 \cdot 10^{-4}$$

← "small"

$K_{eq} < 1$ reactants are favoured!

SEATWORK/HOMEWORK: Exercises 38-46 in Hebden pg 131

PLO's: K8+K9