Chemistry 12

Acid-Base Equilibrium IV

Name:
Date:
Block:

1. K_a / K_b Calculations

Complete the following statements:

1. As a solution becomes more acidic…
   - $[H_3O^+]$ increases or decreases?
   - pH increases or decreases?
   - [OH-] increases or decreases?
   - pOH increases or decreases?
2. If the pH of a solution equals 5.00, the [OH-] equals ____________________M.
3. If the pOH of a solution decreases by 5, then the $[H_3O^+]$ has ____________________ (increased or decreased) by a factor of ____________________.

Calculations Involving K_a and K_b

Recall…

Acid = HA and Base = B

$$HA + H_2O \leftrightharpoons H_3O^+ + A^-$$

$$K_a = \frac{[A^-][H_3O^+]}{[HA]}$$

$$B + H_2O \leftrightharpoons HB^+ + OH^-$$

$$K_b = \frac{[HB][OH^-]}{[B]}$$

Write the chemical equation and K_a expression that represents the reaction of HNO_2 in water.

Write the chemical equation and K_b expression that represents the reaction of NH_3 in water.

CALCULATIONS FOR WEAK ACIDS

Problem Type 1: Calculating pH

Example: Calculate the pH and pOH of 0.50 M solution of hydrofluoric acid.

- Is HF a strong or weak acid?

- What is the chemical equation? (What kind of arrow will you use?)

- What is the K_a value (from the table!) and expression?

- Since this is a weak acid, equilibrium is established. ICE TABLE!!

	$HF_{(aq)}$	+	$H_2O_{(l)}$	$\leftrightharpoons$	$F^-_{(aq)}$	+	$H_3O^+_{(aq)}$
Initial							
Change							
Equilibrium							

We don't include the concentration of water because we assume the $[H_2O]$ remains constant.

- Fill out values for the K_a expression.

- The expression in the denominator: 0.50 M - x can be assumed to be ≅ 0.50M.
  - The value of K_a is very small compared to the initial concentration of the acid. This means that the percent of the acid that actually ionizes will not significantly change the original concentration.
  - **If initial [HA] is at least 10^3 times larger than the K_a value, the assumption is valid.**

- Solve for unknown.

Practice 1: Hydrogen sulphide is a poisonous flammable gas whose "rotten egg" smell is perceptible at concentrations as low as 0.00047 ppm. It is also a weak acid when dissolved in water. Calculate the pH and pOH of 0.0500M H_2S.

Problem Type 2: Calculating initial [HA]

Example: What concentration of benzoic acid is required to produce a solution with a pOH of 10.70?

- Using given pOH, calculate the $[H_3O^+]$
- Construct an ICE table.
- What is the K_a for benzoic acid?
- Solve for the unknown.

Problem Type 3: Calculating K_a

Example: A 0.100 M solution of acetylsalicylic acid, $C_8H_7O_2COOH$, is found to have a pH of 2.27. Calculate the K_a for this acid.

- Using given pH, calculate the $[H_3O^+]$ at equilibrium

- Construct an ICE table.

- What is the K_a expression? Solve for K_a.

Hebden Workbook: Pg. 152 #74-80, 82, 83

CALCULATIONS FOR WEAK BASES

As with acids, most bases are weak. Using the symbol "B" for a weak base, we can represent the equilibria of weak bases in water:

$B_{(aq)} + H_2O_{(l)} \leftrightharpoons HB^+_{(aq)} + OH^-_{(aq)}$ $K_b =$

We must calculate the K_b for that base by using the K_a value of its conjugate acid

Consider the conjugate acid/base pair of NH_4^+ and NH_3 and their respective Ka and Kb expressions:

NH_4^+	NH_3
Reaction:	Reaction:
$K_a =$	$K_b =$

Two common terms appear in each equation.

- Multiply the two expressions together and cancel the common terms…

$K_a \times K_b =$

This allows us to formulate the following relationship for conjugate acid-base pairs:

$$K_a \text{ (conjugate acid) } \times K_b \text{ (conjugate base) } = K_w = 1.0 \times 10^{-14}$$

For the following weak bases, write out the equation with water and calculate the K_b.

CN^-

NO_2^-

The following species are amphiprotic. Compare K_a and K_b.

$HC_2O_4^-$

$H_2PO_4^-$

HPO_4^{2-}

Problem Type 1: Calculating pOH

Practice: Calculate the pH and pOH of a 0.50 M solution of HSO_3^-.

Practice: Calculate the pH of a solution containing 0.20 M CN-.

Problem Type 2: Calculating initial [B]

Practice: What concentration of NH_3 would be required to produce a solution with pH = 10.50?

Problem Type 3: Calculating K_b

Practice: A solution is prepared by dissolving 9.90 g of the weak base hydroxylamine, NH_2OH in enough water to produce 500.0 mL of solution. The pH of the solution is found to be 9.904. Calculate the K_b for hydroxylamine.

Practice: A 0.400 M solution of the weak base methylamine, CH_3NH_2, is found to have a pH of 13.30. Calculate the K_b and pK_b of methylamine.

Hebden Workbook: Pg. 153-4 #84-93