Name: **ANSWER KEY**

Chemistry 30

Unit 5: Acids & Bases

39

Assignment 2 – K_a, K_b, K_w and pH

---

3 1. Given the following balanced ionization reactions for the following weak acids and bases, write the K_a or K_b expressions for each.

a. ascorbic acid: $HC_6H_7O_{6\,(aq)} \rightleftharpoons H^+_{(aq)} + C_6H_7O^-_{6\,(aq)}$	$K_a = \frac{[H^+][C_6H_7O_6^-]}{[HC_6H_7O_6]}$
b. boric acid: $H_3BO_{3\,(aq)} \rightleftharpoons H^+_{(aq)} + H_2BO^-_{3\,(aq)}$	$K_a = \frac{[H^+][H_2BO_3^-]}{[H_3BO_3]}$
c. methyl amine: $CH_3NH_{2\,(aq)} + H_2O_{(l)} \rightleftharpoons CH_3NH^+_{3\,(aq)} + OH^-_{(aq)}$	$K_b = \frac{[CH_3NH_3^+][OH^-]}{[CH_3NH_2]}$

2 2. Calculate $[OH^-]$ is a solution containing 100.0 g of potassium hydroxide in 2.50 L solution. Potassium hydroxide is a strong base.

The molar mass of KOH is 56.1 $g{\cdot}mol^{-1}$

$$[KOH] = \frac{mol}{56.1g} \times \frac{100.0g}{1} \times \frac{1}{2.50L} = \frac{0.713mol}{L} = 0.713M$$

$KOH\ (aq) \rightarrow K^+\ (aq) + OH^-(aq)$

Since KOH is a strong base, based on the balanced equation $[OH^-] = [KOH] = 0.713$ M

2 3. A solution is prepared in which 0.600 mole of hydrogen chloride is dissolved in enough water to make 5.80 L. Calculate the concentration of hydrogen ions in this solution.

$$[HCl] = \frac{0.600mol}{5.80L} = \frac{0.103mol}{L} = 0.103M$$

$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

Since HCl is a strong acid, based on the balanced equation $[H^+] = [HCl] = 0.103$ M

Name: **ANSWER KEY**

2 4. A solution is prepared that contains 0.0445 mole of sulfuric acid in a total solution volume of 12.1 L. Sulfuric acid typically undergoes complete ionization according to the equation:

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Calculate $[H^+]$. Sulfuric acid is a strong acid.

$[H_2SO_4] = \dfrac{0.0445 mol}{12.1 L} = \dfrac{3.68 \times 10^{-3} mol}{L} = 3.68 \times 10^{-3} M$

Since H_2SO_4 is a strong acid, based on the balanced equation $[H^+] = 2 \times [H_2SO_4] = 7.36 \times 10^{-3}$ M

4 5. Phosphoric acid is a **weak** acid that undergoes the following ionization reaction:

$$H_3PO_4(aq) \rightleftharpoons H^+(aq) + H_2PO_4^-(aq)$$

If there are 1.32×10^{-2} mole of phosphoric acid present in 875 mL of solution, calculate the concentration of hydrogen ions, H^+, in solution. K_a for phosphoric acid is 7.0×10^{-3}.

Begin by calculating $[H_3PO_4]$. Then use K_a to determine $[H^+]$.

$[H_3PO_4] = \dfrac{1.32 \times 10^{-2} mol}{0.875 L} = \dfrac{1.51 \times 10^{-2} mol}{L} = 1.51 \times 10^{-2} M$

Since H_3PO_4 is a **weak** acid, we must find $[H^+]$ using K_a for this acid:

$K_a = \dfrac{[H^+][H_2PO_4^-]}{[H_3PO_4]}$ ☞ $7.0 \times 10^{-3} = \dfrac{(x)(x)}{(1.51 \times 10^{-2})}$ ☞ $x^2 = (7.0 \times 10^{-3})(1.51 \times 10^{-2})$

$x^2 = 1.056 \times 10^{-4}$

$x = 1.02 \times 10^{-2}$

Answer: $[H^+] = 1.02 \times 10^{-2}$ M

6 Determine the pH of each of the following solutions, and tell whether the solution is acidic or basic.

		Acid or Base?
a) $[H^+] = 1.0 \times 10^{-3}$ M	pH = **3**	**Acid**
b) $[H^+] = 2.5 \times 10^{-5}$ M	pH = **4.6**	**Acid**
c) $[OH^-] = 0.01$ M	pH = **12**	**Base**

6

Name: **ANSWER KEY**

4 7. Calculate both $[H^+]$ and $[OH^-]$ for the following solutions. All are either strong acids or strong bases. Be sure to clearly identify all answers.

a) 2.5 M NaOH

$[OH^-] = [NaOH] = 2.5$ M

$$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.0 \times 10^{-14}}{2.5} = 4.0 \times 10^{-15} M$$

b) 0.045 M HCl

$[H^+] = [HCl] = 0.045$ M

$$[OH^-] = \frac{K_w}{[H^+]} = \frac{1.0 \times 10^{-14}}{0.045} = 2.2 \times 10^{-13} M$$

3 8. Calculate the pH of a 0.1 M solution of sodium hydroxide, NaOH, a strong base.

Since NaOH is a strong base, and based on the balanced equation $NaOH \rightarrow Na^+ + OH^-$

$[OH^-] = [NaOH] = 0.1$ M

Use K_w to find $[H^+]$: $$[H^+] = \frac{K_w}{[OH^-]} = \frac{1.0 \times 10^{-14}}{0.1} = 1.0 \times 10^{-13} M$$

$pH = -\log[H^+] = -\log(1.0 \times 10^{-13}) = 13$

9 a) Determine the concentration of hydrogen ions, $[H^+]$ in a solution whose pH is 5.17.

1 $[H^+] = \text{antilog}(-pH) = \text{antilog}(-5.17) = 6.8 \times 10^{-6}$ M

b) Calculate the hydroxide ion concentration, $[OH^-]$, for this solution.

1 $$[OH^-] = \frac{K_w}{[H^+]} = \frac{1.0 \times 10^{-14}}{6.8 \times 10^{-6}} = 1.5 \times 10^{-9} M$$

10. Determine $[H_3O^+]$ in a solution whose pH = 9.22. (Hint: $[H_3O^+] = [H^+]$)

1 $[H_3O^+] = \text{antilog}(-pH) = \text{antilog}(-9.22) = 6.03 \times 10^{-10}$ M

Name: **ANSWER KEY**

5 11. A 2.67 g sample of hydrogen fluoride gas (HF) is dissolved in sufficient water to make 1.05 L of solution at 25°C to form an acidic solution. Hydrogen fluoride is a weak acid with $K_a = 6.6 \times 10^{-4}$.

Calculate the pH of this solution.

Begin by calculating [HF]. Then use K_a to determine $[H^+]$. Finally convert $[H^+]$ to pH.

The molar mass of HF is 20.0 g· mol^{-1}

$$[HF] = \frac{mol}{20.0g} \times \frac{2.67g}{1} \times \frac{1}{1.05L} = \frac{0.127mol}{L} = 0.127M$$

Since HF is a **weak** acid, we must find $[H^+]$ using K_a for this acid:

$$K_a = \frac{[H^+][F^-]}{[HF]} \quad ☞ \quad 6.6 \times 10^{-4} = \frac{(x)(x)}{(0.127)} \quad ☞ \quad x^2 = (6.6 \times 10^{-4})(0.127)$$

$x^2 = 8.39 \times 10^{-5}$

$x = 9.16 \times 10^{-3}$

$[H^+] = 9.16 \times 10^{-3}$ M

pH = $-\log[H^+] = -\log(9.16 \times 10^{-3})$ = **2.04** **ANSWER**

5 12. The formula for ascorbic acid, better known as Vitamin C, is $HC_6H_7O_6$. K_a for ascorbic acid is 8.00×10^{-5}. Determine the pH of a solution prepared by dissolving a 500.0 mg vitamin C tablet in enough water to make 200.0 mL of solution.

The molar mass of $HC_6H_7O_6$ is 176.0 g· mol^{-1}

$$[HF] = \frac{mol}{176.0g} \times \frac{0.500g}{1} \times \frac{1}{0.200L} = \frac{0.142mol}{L} = 0.142M$$

Since $HC_6H_7O_6$ is a **weak** acid, we must find $[H^+]$ using K_a for this acid:

$$K_a = \frac{[H^+][C_6H_7O_6^-]}{[HC_6H_7O_6]} \quad ☞ \quad 8.0 \times 10^{-5} = \frac{(x)(x)}{(0.142)} \quad ☞ \quad x^2 = (8.0 \times 10^{-5})(0.142)$$

$x^2 = 1.14 \times 10^{-6}$

$x = 1.07 \times 10^{-3}$

$[H^+] = 1.07 \times 10^{-3}$ M

pH = $-\log[H^+] = -\log(1.07 \times 10^{-3})$ = **3.0** **ANSWER**