**Unit 12 Practice Problems (with answers at end)**

> Balloonists have an unsurpassed view of the scenery, but there is always the possibility that it may collide with them.
> --H.L. Mencken

**Conjugate acid/base pairs**

1. In each of the following, identify the conjugate acid/base pairs:

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

$H_3O^+ + C_2H_3O_2^- \leftrightarrows HC_2H_3O_2 + H_2O$

$HC_2H_3O_2 + OH^- \rightarrow H_2O + C_2H_3O_2^-$

$2\ H_2O \leftrightarrows H_3O^+ + OH^-$

$NH_3 + OH^- \rightarrow NH_2^- + H_2O$

**$K_w$ and pH**

2. What is the $[H^+]$ in a 0.25 M solution of NaOH (strong). What is $[OH^-]$?

3. Calculate the $[H^+]$ and $[OH^-]$ in a 0.50 M solution of $HNO_3$ (strong).

4. Calculate the $[H^+]$ and $[OH^-]$ in a 0.35 M $HClO_4$ solution (strong).

5. KOH is a strong base. Calculate $[H^+]$ and $[OH^-]$ in a 5.0 M solution.

6. Calculate the pH and pOH of a solution of NaOH (strong base) which is 0.0010 M.

7. Calculate the $[H^+]$ of a solution with a pH of 3.7.

8. Calculate the $[H^+]$ of a solution with a pOH of 4.5

**Acid/Base reactions**

9. The neutralization reactions of each of the following pairs of acids and bases produce soluble salts. If the water were removed from such mixtures, what salts would remain?

sodium hydroxide + sulfuric acid
calcium hydroxide + nitric acid
hydrochloric acid + ammonia
aluminum hydroxide + acetic acid
potassium hydroxide + acetic acid

> The world gets its stimuli from the genius, but it lives on talent.--A. Flexner

**Weak acids and bases, $K_a$ and $K_b$**

10. Calculate $[OH^-]$ for a 0.50 M solution of ammonia.
$K_b = 1.8 \times 10^{-5}$.

11. Calculate $[H^+]$ in a 0.10 M solution of formic acid.
$K_a = 1.7 \times 10^{-4}$.

12. Determine the value of $K_a$ for acetic acid from the following data: 0.10 mol of the acid is dissolved in enough water for a total volume of 1.0 Litre. The resulting $[H^+]$ is $1.35 \times 10^{-3}$.

13. The $K_a$ of HF is $7.1 \times 10^{-4}$. For a solution concentration of 0.150 M, what is the % ionization?

14. Lactic acid, $CH_3CHOCOOH$, gets its name from sour milk, from which it was first isolated in 1780 (L. *lactis*, milk). $K_a$ for lactic acid is $8.4 \times 10^{-4}$. Find the $[H^+]$ in a sample of sour milk containing 0.100 M lactic acid.

15. Many of the common organic acids got their original names from their odors and/or sources. Another case in point is Caproic acid (hexanoic acid), found in the skin secretions of goats (L. *caper*, goat). Caproic acid is $CH_3(CH_2)_4COOH$ and has a structure similar to acetic acid, but with a longer carbon chain. The concentration of $H^+$ in a solution prepared by dissolving 0.030 mol of caproic acid in 1.0 L of water solution was measured and found to be $6.5 \times 10^{-4}$ M. Find $K_a$ for caproic acid.

16. Two solutions are needed in the lab, each with a volume of 10 L (to the nearest 1 Litre) and a pH equal to 11.00. How many moles of each solute would it take if one solution is to be made with NaOH (strong base) and the other with $NH_3$?
($K_b = 1.8 \times 10^{-5}$) (approximate for $NH_3$)

Next to being a great poet
is the power of understanding
one.--Longfellow

**Buffer solutions**

17. A buffer solution contains acetic acid and sodium acetate. The concentration of each substance is 0.50 M. Determine the pH of the solution. $K_a$ = 1.8 x $10^{-5}$. (approximate)

18. Which of the following pairs of solutions could be used to make a buffer solution?
a. NaOH and HCl
b. $HNO_2$ and $NaNO_2$
c. $HNO_2$ and NaOH
d. $Na_3PO_4$ and HCl

19. Blood is buffered mainly by the $H_2CO_3$-$HCO_3^-$ system in which the ratio of [$HCO_3$-] to [$H_2CO_3$] is about 20:1. What would the pH of blood be if this were the only buffer? ($K_a$ for $H_2CO_3$ = 4.2 x $10^{-7}$) (approximate)

**Answers:**

**1. A,B,A,B**
**A,B,A,B**
**A,B,A,B**
**A&B,A,B**
**A,B,B,A**
**2. [$H^+$] = 4.0 x $10^{-14}$ M, [$OH^-$] = 0.25 M**
**3. [$H^+$] = 0.50 M, [$OH^-$] = 2.0 x $10^{-14}$ M**
**4. [$H^+$] = 0.35 M, [$OH^-$] = 2.9 x $10^{-14}$ M**
**5. [$H^+$] = 2.0 x $10^{-15}$ M, [$OH^-$] = 5.0 M**
**6. pH = 11, pOH = 3**
**7. 2.0 x $10^{-4}$ M**
**8. 3.2 x $10^{-10}$ M**
**9. sodium sulfate**
**calcium nitrate**
**ammonium chloride**
**aluminum acetate**
**potassium acetate**
**10. 3.0 x $10^{-3}$ M**
**11. 4.1 x $10^{-3}$ M**
**12. 1.8 x $10^{-5}$**
**13. [quadratic solution required for $H^+$ conc.] 6.7%**
**14. [quadratic solution required] 8.8 x $10^{-3}$ M**
**15. 1.4 x $10^{-5}$**
**16. for NaOH, 0.010 mol; for $NH_3$, 0.56 mol**
**17. pH = 4.74**
**18. only b**
**19. pH = 7.68**