CHEM 132
Problem Set Ch.15

Key Begins on Page 3.

1. For each of the following, identify the **acids** and **bases** involved in both the forward and reverse directions

a) $HOBr + H_2O \rightleftharpoons H_3O^+ + OBr^-$

b) $HSO_4^- + H_2O \rightleftharpoons H_3O^+ + SO_4^{-2}$

c) $HS^- + H_2O \rightleftharpoons H_2S + OH^-$

d) $C_6H_5NH_3^+ + OH^- \rightleftharpoons C_6H_5NH_2 + H_2O$

2. Use table 15.2 in your text to determine whether the species on the **left** or those on the **right** are favored by the reaction.

a) $NH_4^+ + CO_3^{-2} \rightleftharpoons NH_3 + HCO_3^-$

b) $HCO_3^- + H_2S \rightleftharpoons H_2CO_3 + HS^-$

c) $CN^- + H_2O \rightleftharpoons HCN + OH^-$

d) $CN^- + H_2CO_3 \rightleftharpoons HCN + HCO_3^-$

3. Calculate the **$[H^+]$** and **$[OH^-]$** for each of the following solutions.

	$[H^+]$	**$[OH^-]$**
a) 0.0060 M HCl	_____	_____
b) 0.082 M NaOH	_____	_____
c) 4.2×10^{-3} M HNO_3	_____	_____

4. The following are solution concentrations. State whether each is **acidic, neutral** or **basic.**

a) 2×10^{-4} M OH^- _____ c) 6×10^{-10} M OH^- _____

b) 2×10^{-6} M H^+ _____ d) 6×10^{-10} M H^+ _____

5. Obtain the **pH** corresponding to the following concentrations.

a) 1.0×10^{-4} M H^+ _____ c) 2.3×10^{-5} M OH^- _____

b) 2.91×10^{-11} M H^+ _____ d) 3.2×10^{-10} M OH^- _____

6. A sample of wine was found to have a pH of 3.85. Calculate the **$[H^+]$** and **$[OH^-]$**.

$[OH^-]$ = _____

$[H^+]$ = _____

7. List the following compounds in order of **increasing** acidity. **Explain your reasoning.**

$HBrO_2$ $HClO_2$ $HBrO$

8. Predict whether each of the following aqueous solutions is **acidic, basic,** or **neutral**.

a) KCl _____ c) NH_4NO_3 _____

b) $NaNO_2$ _____ d) NaI _____

9. A 1.00 L aqueous solution containes 6.78 g of Barium hydroxide, $Ba(OH)_2$. What was the **pH** of the solution at 25°C?

pH = _____

10. A 2.500-g sample of a mixture of sodium chloride and sodium carbonate is dissolved in 25.00 mL of 0.798 M HCl. Some acid remains after the treatment of the sample.

a) Write a **net ionic equation** for the complete reaction of sodium carbonate with hydrochloric acid.

b) If 28.7 mL of 0.108 M NaOH were required to titrate the excess hydrochloric acid, **how many moles** of sodium carbonate were present in the original sample?

KEY

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1. For each of the following, identify the **acids** and **bases** involved in both the forward and reverse directions

a) $\underset{\text{ACID}}{HOBr} + \underset{\text{BASE}}{H_2O} \rightleftharpoons \underset{\text{ACID}}{H_3O^+} + \underset{\text{BASE}}{OBr^-}$

b) $\underset{\text{ACID}}{HSO_4^-} + \underset{\text{BASE}}{H_2O} \rightleftharpoons \underset{\text{ACID}}{H_3O^-} + \underset{\text{BASE}}{SO_4^{-2}}$

c) $\underset{\text{BASE}}{HS^-} + \underset{\text{ACID}}{H_2O} \rightleftharpoons \underset{\text{ACID}}{H_2S} + \underset{\text{BASE}}{OH^-}$

d) $\underset{\text{ACID}}{C_6H_5NH_3^+} + \underset{\text{BASE}}{OH^-} \rightleftharpoons \underset{\text{BASE}}{C_6H_5NH_2} + \underset{\text{ACID}}{H_2O}$

2. Use table 15.2 in your text to determine whether the species on the **left** or those on the **right** are favored by the reaction.

a) $\underset{\text{ACID}}{NH_4^+} + CO_3^{-2} \rightleftharpoons \underset{\text{ACID}}{NH_3} + HCO_3^-$ SINCE $NH_4^+ > HCO_3^{-1}$

b) $\underset{\text{ACID}}{HCO_3^- + H_2S} \rightleftharpoons \underset{\text{ACID}}{H_2CO_3} + HS^-$ SINCE $H_2CO_3 > H_2S$

c) $\underset{\text{ACID}}{CN^- + H_2O} \rightleftharpoons \underset{\text{ACID}}{HCN} + OH^-$ SINCE $HCN > H_2O$

d) $CN^- + \underset{\text{ACID}}{H_2CO_3} \rightleftharpoons \underset{\text{ACID}}{HCN + HCO_3^-}$ SINCE $H_2CO_3 > HCN$

3. Calculate the $[H^+]$ and $[OH^-]$ for each of the following solutions.

	$[H^+]$	$[OH^-]$
a) 0.0060 M HCl	0.006	1.67×10^{-12}
b) 0.082 M NaOH	1.22×10^{-13}	0.082
c) 4.2×10^{-3} M HNO_3	0.0042	2.38×10^{-12}

4. The following are solution concentrations. State whether each is **acidic, neutral** or **basic.**

a) 2×10^{-4} M OH^- (pH = 10.3) BASIC

b) 2×10^{-6} M H^+ (pH = 5.7) ACIDIC

c) 6×10^{-10} M OH^- (pH = 4.8) ACIDIC

d) 6×10^{-30} M H^+ (pH = 9.2) BASIC

5. Obtain the **pH** corresponding to the following concentrations. $pH = -\log[H^+] = -\log\frac{1\times10^{-14}}{[OH^-]}$

a) 1.0×10^{-4} M H^+ 4

c) 2.3×10^{-5} M OH^- 9.4

b) 2.91×10^{-11} M H^+ 10.5

d) 3.2×10^{-10} M OH^- 4.5

6. A sample of wine was found to have a **pH** of 3.85. Calculate the **$[H^+]$** and **$[OH^-]$**

$pH = 3.85$

$[H^+] = 10^{-3.85} = 1.41 \times 10^{-4}$ **$[OH^-]$** = 7.1×10^{-11}

$[OH^-] = \frac{1.0\times10^{-14}}{[H^+]} = \frac{1\times10^{-14}}{1.41\times10^{-4}} = 7.1\times10^{-11}$ **$[H^+]$** = 1.41×10^{-4}

7. List the following compounds in order of **increasing** acidity. **Explain your reasoning.**

$HBrO_2$ $HClO_2$ $HBrO$

LOWEST STRONGEST

$HBrO < HBrO_2 < HClO_2$

LESS e⊖ WITH OXYGENS — LESS ELECTRONEG. — MOST ELECTRONEGATIVE

8. Predict whether each of the following aqueous solutions is **acidic, basic,** or **neutral**.

a) KCl SKIP THIS QUESTION

c) NH_4NO_3 WILL BE COVERED IN CH. 16.

b) $NaNO_2$

d) NaI

9. A 1.00 L aqueous solution containes 6.78 g of Barium hydroxide, $Ba(OH)_2$. What was the **pH** of the solution at 25°C?

$6.78\,g\ Ba(OH)_2 \left(\frac{1\ mol}{171.3\ g}\right)\left(\frac{2\ mol\ OH^-}{1\ mol\ Ba(OH)_2}\right) = 0.0792\ mol\ OH^-$ IN 1.0 L

$[OH^-] = 0.0792\ M$ THEN $[H^+] = \frac{1.0\times10^{-14}}{.0792} = 1.26\times10^{-13}$

$pH = -\log(1.26\times10^{-13})$

pH = 12.9

10. A 2.500-g sample of a mixture of sodium chloride and sodium carbonate is dissolved in 25.00 mL of 0.798 M HCl. Some acid remains after the treatment of the sample.

a) Write a **net ionic equation** for the complete reaction of sodium carbonate with hydrochloric acid.

$$CO_3^{-2} + 2H^+ \longrightarrow H_2CO_3$$

b) If 28.7 mL of 0.108 M NaOH were required to titrate the excess hydrochloric acid, **how many moles** of sodium carbonate were present in the original sample?

TOTAL HCl used = $(0.0252\ L)(0.798\ \frac{mol}{L}) = 0.01995$ mol HCl TOTAL

EXCESS HCl = moles NaOH used to titrate excess = $(0.0287\ L)(0.108\ M) = 0.00310$ mol HCl LEFT-OVER

SUBTRACT 0.01685 mol HCl REACTED

$(0.01685\ mol\ HCl_{reacted})\left(\frac{1\ mol\ Na_2CO_3}{2\ mol\ HCl}\right) = 0.00843\ mol\ Na_2CO_3$ PRESENT