Chem 2 AP Homework #4-7: Problems pg. 153 #4.26, 4.27, 4.29, 4.30, 4.32, 4.34; pg. 155 #4.82, 4.83, 4.84, 4.86, 4.88

26 **Give Arrhenius's and Brønsted's definitions of an acid and a base. Why are Brønsted's definitions more useful in describing acid-base properties?**
Arrhenius acids dissociate in water to form H^+ and Brønsted acids donate protons (H^+); Arrhenius bases dissociate in water to form OH^- and Brønsted bases accept protons. Brønsted definitions are more general (all Arrhenius acids and bases are also Brønsted acids and bases, but not the converse).

27 **Give an example of a monoprotic acid, a diprotic acid, and a triprotic acid.**
Monoprotic acid: HNO_3, HCl; Diprotic acid: H_2SO_4, H_2CO_3; Triprotic acid: H_3PO_4, H_3AsO_4

29 **What factors qualify a compound as a salt? Specify which of the following compounds are salts: CH_4, NaF, NaOH, CaO, $BaSO_4$, HNO_3, NH_3, KBr?**
To qualify as a salt, a compound must contain a cation other than H^+ and an anion other than O^{2-} or OH^-; they are also electrolytes. Salts: NaF, $BaSO_4$, KBr; Not salts: CH_4, CaO, NaOH, HNO_3, NH_3. Note: CaO, NaOH, HNO_3 are strong electrolytes even though they are not *salts* since they dissociate [CaO forms $Ca(OH)_2$], and NH_3 is a weak base, hence a week electrolyte.

30 **Identify the following as a weak or strong acid or base:**
(a) **NH_3**: weak base; (b) **H_3PO_4**: weak acid; (c) **LiOH**: strong base; (d) **HCOOH**: weak acid; (e) **H_2SO_4**: strong acid; (f) **HF**: weak acid; (g) **$Ba(OH)_2$**: strong base.

32 **Identify each of the following species as a Brønsted acid, base, or both:**
(a) **PO_4^{3-}** in water can accept a proton to become HPO_4^{2-}, and is thus a **Brønsted base**.
(b) **ClO_2^-** in water can accept a proton to become $HClO_2$, and is thus a **Brønsted base**.
(c) **NH_4^+** dissolved in water can donate a proton H^+, thus behaving as a **Brønsted acid**.
(d) **HCO_3^-** can either accept a proton to become H_2CO_3, thus behaving as a **Brønsted base**. Or, HCO_3^- can donate a proton to yield H^+ and CO_3^{2-}, thus behaving as a **Brønsted acid**. HCO_3^- is said to be *amphoteric* because it possesses both acidic and basic properties.

34 **Balance the following equations and write the corresponding ionic and net ionic equations (if appropriate):**

(a) CH_3COOH is a weak acid: $CH_3COOH(aq) + KOH(aq) \longrightarrow CH_3COOK(aq) + H_2O(l)$
Ionic: $CH_3COOH(aq) + K^+(aq) + OH^-(aq) \longrightarrow CH_3COO^-(aq) + K^+(aq) + H_2O(l)$
Net ionic: $CH_3COOH(aq) + OH^-(aq) \longrightarrow CH_3COO^-(aq) + H_2O(l)$

(b) H_2CO_3 is a weak acid: $H_2CO_3(aq) + 2NaOH(aq) \longrightarrow Na_2CO_3(aq) + 2H_2O(l)$
Ionic: $H_2CO_3(aq) + 2Na^+(aq) + 2OH^-(aq) \longrightarrow 2Na^+(aq) + CO_3^{2-}(aq) + 2H_2O(l)$
Net ionic: $H_2CO_3(aq) + 2OH^-(aq) \longrightarrow CO_3^{2-}(aq) + 2H_2O(l)$

(c) HNO_3 is a strong acid: $2HNO_3(aq) + Ba(OH)_2(aq) \longrightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$
Ionic: $2H^+(aq) + 2NO_3^-(aq) + Ba^{2+}(aq) + 2OH^-(aq) \longrightarrow Ba^{2+}(aq) + 2NO_3^-(aq) + 2H_2O(l)$
Net ionic: $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$

82 **How does an acid-base indicator work?**
The indicator changes color when a proton is either removed or added.

83 A student carried out two titrations to standardize a NaOH solution of unknown concentration. She used two similar masses of KHP, but one was dissolved in 20.00 mL of distilled water and the other in 40.00 mL. Assuming no experimental error, would she obtain the same result for the concentration of the NaOH solution?

Yes, she should obtain the same result for the concentration of the NaOH solution. The amount of NaOH needed should be proportional to the amount of acid, which is known for both titrations, and independent of the amount of solvent present.

84 Would the volume of a 0.20 *M* NaOH solution needed to titrate 25.0 mL of a 0.10 *M* HNO_2 (a weak acid) solution be different from that needed to titrate 25.0 mL of a 0.10 *M* HCl (a strong acid) solution?

No, the volume of 0.10 M NaOH needed would not be different if you titrated with 25.0 mL of 0.10 M of HNO_2 (weak acid) or with 25.0 mL of 0.10 M HCl (strong acid). The equivalence point is the point at which the moles of OH^- is equal to the moles of H^+. In this case, the moles of H^+ are the same for both of the acids.

86 Calculate the concentration (in molarity) of a NaOH solution if 25.0 mL of the solution are needed to neutralize 17.4 mL of a 0312 *M* HCl solution.

$$HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaCl(aq)$$

$$?\ mol\ NaOH = 17.4\ mL\ HCl \times \frac{0.312\ mol\ HCl}{1000\ mL\ \text{soln}} \times \frac{1\ mol\ NaOH}{1\ mol\ HCl} = 5.43 \times 10^{-3}\ mol\ NaOH$$

$$\textbf{\textit{M} of NaOH} = \frac{5.43 \times 10^{-3}\ mol\ NaOH}{25.0\ mL\ \text{soln}} \times \frac{1000\ \text{mL}}{1\ \text{L}} = \boxed{\textbf{0.217 } \textbf{\textit{M}}}$$

88 What volume of a 0.500 *M* HCl solution is needed to neutralize each of the following?

(a) 10.0 mL of a 0.300 *M* NaOH solution

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$$

$$?\ mol\ HCl = 10.0\ mL \times \frac{0.300\ mol\ NaOH}{1000\ mL\ of\ solution} \times \frac{1\ mol\ HCl}{1\ mol\ NaOH} = 3.00 \times 10^{-3}\ mol\ HCl$$

$$\textbf{volume of HCl} = 3.00 \times 10^{-3}\ mol\ HCl \times \frac{1000\ \text{mL}}{0.500\ \text{mol}} = \boxed{\textbf{6.00 mL}}$$

(b) 10.0 mL of a 0.200 *M* $Ba(OH)_2$ solution

$$2HCl(aq) + Ba(OH)_2(aq) \longrightarrow BaCl_2(aq) + 2H_2O(l)$$

Notice that the mole ratio between acid and base is 2:1:

$$?\ mol\ HCl = 10.0\ mL \times \frac{0.200\ mol\ Ba(OH)_2}{1000\ mL\ of\ solution} \times \frac{2\ mol\ HCl}{1\ mol\ Ba(OH)_2} = 4.00 \times 10^{-3}\ mol\ HCl$$

$$\textbf{volume of HCl} = 4.00 \times 10^{-3}\ mol\ HCl \times \frac{1000\ \text{mL}}{0.500\ \text{mol}} = \boxed{\textbf{8.00 mL}}$$