Chemistry 101 Name: _____
Homework Problem Set # 9
Due Monday, November 17 Section (circle): 01 02 03

These questions are based on chapters 10 and 8 of the textbook: Timberlake, K. *General, Organic and Biological Chemistry: Structures of Life (Platinum Edition).* Specifically, see sections 10.4, 10.9-10.11, 8.1-8.5.

1. Timberlake, problem 10.28 (page 333). Consider the following acids and their dissociation constants:

$$HPO_{4\ (aq)}^{2-} + H_2O\ _{(l)} \rightleftharpoons H_3O^+_{(aq)} + PO_{4\ (aq)}^{3-} \qquad K_a = 2.2 \times 10^{-13}$$

$$HCOOH^{2-}_{(aq)} + H_2O\ _{(l)} \rightleftharpoons H_3O^+_{(aq)} + HCOO^-_{(aq)} \qquad K_a = 1.8 \times 10^{-4}$$

   (a) Which is the weaker acid, HPO_4^{2-} or HCOOH?
   HPO_4^{2-} - it has the smaller K_a
   (b) What is the conjugate base of HPO_4^{2-}?
   PO_4^{3-} - note, there was a typo in the problem, on the problem it was PO_3^{3-}
   (c) Which acid has the weaker conjugate base? (Hint: see bottom of page 328)
   stronger acid = weaker conjugate base, so HCOOH
   (d) Which acid has the stronger conjugate base?
   weaker acid = stronger conjugate base, so HPO_4^{2-}
   (e) Which acid produces more ions?
   stronger acid = more ions, so HCOOH

2. Timberlake, problem 10.66 (page 352). Acetic acid has a K_a of 1.8×10^{-5}. What is the pH of a buffer solution containing 0.15 M CH_3COOH (acetic acid) and 0.15 M CH_3COO^-.

$$K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$

$$[H_3O^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]} = \frac{(1.8 \times 10^{-5})(0.15\ M)}{0.15\ M} = 1.8 \times 10^{-5}$$

$$pH = -\log[H_3O^+] = -\log 1.8 \times 10^{-5} = 4.74$$

3. Use Table 10.3 (Timberlake) to identify the stronger acid in each of the following pairs. (circle the stronger acid)

   (a) H_2CO_3 or HF? *HF*
   (b) CH_3COOH or H_2CO_3? *CH_3COOH*
   (c) HNO_2 or HCN? *HNO_2*
   (d) HCN or $H_2PO_4^-$? *$H_2PO_4^-$*

4. Timberlake, problem 10.80 (page 357). What is the molarity of the acid in each of the following titrations?

   (a) A 20.0 mL sample of HCl solution that is titrated with 8.0 mL of 6.0 M NaOH solution.

$$HCl + NaOH \longrightarrow H_2O + NaCl$$

$$0.008\ L \times 6.0M = 0.048\ moles\ NaOH$$

$$0.048\ moles\ NaOH \times \frac{1\ moleHCl}{1\ mole\ NaOH} = 0.048\ moles\ HCl$$

$$\frac{0.048\ moles\ HCl}{0.020\ L} = 2.4M$$

(b) A 10.0 mL sample of H_2SO_4 solution that is titrated with 25.0 mL of 0.50 M NaOH solution.

$$H_2SO_4 + 2NaOH \longrightarrow 2H_2O + Na_2SO_4$$

$$0.0250\ L \times 0.50M = 0.0125\ moles\ NaOH$$

$$0.0125\ moles\ NaOH \times \frac{1\ mole H_2SO_4}{2\ mole\ NaOH} = 0.00625\ moles\ H_2SO_4$$

$$\frac{0.00625\ moles\ H_2SO_4}{0.010\ L} = 0.625\ M$$

(c) A 30.0 mL sample of HCl solution that is titrated with 18.0 mL of 3.0 M NaOH solution.

$$H_3PO_4 + 3NaOH \longrightarrow 3H_2O + Na_3PO_4$$

$$0.0180\ L \times 3.0M = 0.054\ moles\ NaOH$$

$$0.054\ moles\ NaOH \times \frac{1\ mole H_3PO_4}{3\ mole\ NaOH} = 0.018\ moles\ H_3PO_4$$

$$\frac{0.018\ moles\ H_3PO_4}{0.030\ L} = 0.60\ M$$

5. Complete the following dilution problems:

(a) What is the final molarity of a solution when 20.0 ml of a 3.0 M KCl solution is diluted to 250.0 mL?

$$M_2 = \frac{M_1V_1}{V_2} = \frac{(3.0\ M)(20.0\ mL)}{250.0\ mL} = 0.24\ M$$

(b) What is the final molarity of a solution when 100.0 ml of a 1.55 M NaBr solution is diluted to 4.00 L?

$$M_2 = \frac{M_1V_1}{V_2} = \frac{(1.55\ M)(0.100\ L)}{4.00\ L} = 0.0388\ M$$

(c) How much (volume) of a 5.34 M HCl solution must be used to make 2.00 L of a 0.10 M HCl solution?

$$V_1 = \frac{M_2V_2}{M_1} = \frac{(0.10\ M)(2.00\ L)}{5.34\ M} = 0.037\ M$$

(d) How much (volume) of a 0.127 M $CaCl_2$ solution must be used to make 500 mL of a 0.020 M $CaCl_2$ solution?

$$V_1 = \frac{M_2V_2}{M_1} = \frac{(0.020\ M)(500\ mL)}{0.127\ M} = 0.079\ M$$

6. Perform the following temperature conversions:

(a) Convert 24.6°C into Kelvin:
24.6 + 273.15 = 297.7K

(b) Convert -2.2°C into Kelvin:
-2.2 + 273.15 = 270.9K

(c) Convert 310 K into °C:
310 - 273.15 = 37°C

(d) Convert 85°Finto Kelvin:
(85-32)/(1.8) + 273.15 = 303K

7. A sample of N_2 gas has a volume of 2.5 L at a pressure of 1.00 atm. What is the new pressure if the volume is increased to 3.5 L?

$$P_1V_1 = P_2V_2$$

$$P_2 = \frac{P_1V_1}{V_2} = \frac{(1.00\ atm)(2.5\ L)}{3.5\ L} = 0.71\ atm$$

8. A small tank of O_2 gas has a volume of 3.0 at a pressure of 11.0 atm. What would the volume of the gas be if the pressure was only 1.00 atm?

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{P_1V_1}{P_2} = \frac{(11.00\ atm)(3.0\ L)}{1.00\ atm} = 33\ L$$

9. A balloon with a volume of 1.85 L is at room temperature (25°C). If the balloon is submerged in a bucket of ice water (0°C), what would you expect the volume to be?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$V_2 = \frac{V_1T_2}{T_1} = \frac{(1.85\ L)(273\ K)}{(298\ K)} = 1.69\ L$$

10. A car tire is inflated to 25.4 Psi on a cold day when the temperature is 10°F. What is the pressure of the tire when the temperature rises to 85°F?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$P_2 = \frac{P_1T_2}{P_1} = \frac{(25.4\ psi)(302.6\ K)}{(260.9\ K)} = 29.5\ psi$$

11. A particular cylinder of CO_2 gas has a pressure of 100.0 atm inside the laboratory which is at 20.0 °C. When the tank is moved to the loading dock, where the temperature warmer, the pressure rises to about 106 atm. What is the temperature on the loading dock?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

$$T_2 = \frac{P_2T_1}{P_1} = \frac{(106\ atm)(293\ K)}{(100\ atm)} = 310\ K = 38°C$$