

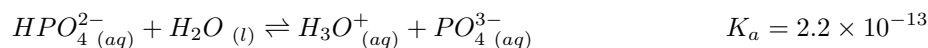
Chemistry 101
Homework Problem Set # 9
Due Monday, November 17

Name: _____

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:



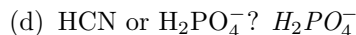
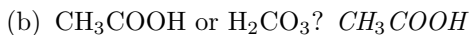
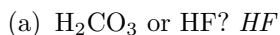
- (a) Which is the weaker acid, HPO_4^{2-} or HCOOH ?
 HPO_4^{2-} - it has the smaller K_a
- (b) What is the conjugate base of HPO_4^{2-} ?
 PO_4^{3-} - note, there was a typo in the problem, on the problem it was PO_3^{3-}
- (c) Which acid has the weaker conjugate base? (Hint: see bottom of page 328)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

$$K_a = \frac{[\text{CH}_3\text{COO}^-][\text{H}_3\text{O}^+]}{[\text{CH}_3\text{COOH}]}$$

$$[\text{H}_3\text{O}^+] = \frac{K_a[\text{CH}_3\text{COOH}]}{[\text{CH}_3\text{COO}^-]} = \frac{(1.8 \times 10^{-5})(0.15 \text{ M})}{0.15 \text{ M}} = 1.8 \times 10^{-5}$$

$$\text{pH} = -\log[\text{H}_3\text{O}^+] = -\log 1.8 \times 10^{-5} = 4.74$$

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



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.

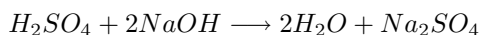


$$0.008 \text{ L} \times 6.0 \text{ M} = 0.048 \text{ moles NaOH}$$

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

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

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

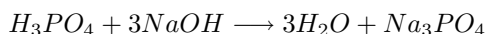


$$0.0250 \text{ L} \times 0.50 \text{ M} = 0.0125 \text{ moles NaOH}$$

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

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

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



$$0.0180 \text{ L} \times 3.0 \text{ M} = 0.054 \text{ moles NaOH}$$

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

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

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?

$$M_2 = \frac{M_1 V_1}{V_2} = \frac{(3.0 \text{ M})(20.0 \text{ mL})}{250.0 \text{ mL}} = 0.24 \text{ M}$$

- (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?

$$M_2 = \frac{M_1 V_1}{V_2} = \frac{(1.55 \text{ M})(0.100 \text{ L})}{4.00 \text{ L}} = 0.0388 \text{ M}$$

- (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?

$$V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.10 \text{ M})(2.00 \text{ L})}{5.34 \text{ M}} = 0.037 \text{ M}$$

- (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?

$$V_1 = \frac{M_2 V_2}{M_1} = \frac{(0.020 \text{ M})(500 \text{ mL})}{0.127 \text{ M}} = 0.079 \text{ M}$$

6. Perform the following temperature conversions:

- (a) Convert 24.6°C into Kelvin:

$$24.6 + 273.15 = 297.7 \text{ K}$$

- (b) Convert -2.2°C into Kelvin:

$$-2.2 + 273.15 = 270.9 \text{ K}$$

- (c) Convert 310 K into °C:

$$310 - 273.15 = 37 \text{ °C}$$

- (d) Convert 85°F into Kelvin:

$$(85 - 32)/(1.8) + 273.15 = 303 \text{ K}$$

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?

$$P_1 V_1 = P_2 V_2$$

$$P_2 = \frac{P_1 V_1}{V_2} = \frac{(1.00 \text{ atm})(2.5 \text{ L})}{3.5 \text{ L}} = 0.71 \text{ atm}$$

8. A small tank of O₂ 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?

$$P_1V_1 = P_2V_2$$
$$V_2 = \frac{P_1V_1}{P_2} = \frac{(11.00 \text{ atm})(3.0 \text{ L})}{1.00 \text{ atm}} = 33 \text{ L}$$

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?

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$
$$V_2 = \frac{V_1T_2}{T_1} = \frac{(1.85 \text{ L})(273 \text{ K})}{(298 \text{ K})} = 1.69 \text{ L}$$

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?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$
$$P_2 = \frac{P_1T_2}{T_1} = \frac{(25.4 \text{ psi})(302.6 \text{ K})}{(260.9 \text{ K})} = 29.5 \text{ psi}$$

11. A particular cylinder of CO₂ 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?

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$
$$T_2 = \frac{P_2T_1}{P_1} = \frac{(106 \text{ atm})(293 \text{ K})}{(100 \text{ atm})} = 310 \text{ K} = 38^\circ\text{C}$$