

1. (8 points) **SHOW ALL WORK.** Concentrated hydrochloric acid,  $\text{HCl}_{(\text{aq})}$ , has a density of 1.19 g/mL and is 37.0 % HCl by weight. Determine the *molar concentration* of HCl in the solution. (Formula masses:  $\text{H}_2\text{O} = 18.0$  g/mole;  $\text{HCl} = 36.5$  g/mole)

2. (4 points) Consider the aqueous solutions labeled A - E as follows.

A: pure  $\text{H}_2\text{O}$

B: 1.0 m  $\text{HNO}_2$

C: 1.0 m  $\text{KNO}_2$

D: 1.0 m glucose,  $\text{C}_6\text{H}_{12}\text{O}_6$

E: 1.0 m  $\text{K}_2\text{SO}_4$

Arrange these in order of increasing boiling point, lowest to highest.

*Write only the letters of the solutions in the blanks below.*

\_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_ < \_\_\_\_\_  
lowest bp highest bp

3. (2 points) (a) The conjugate base of  $\text{H}_2\text{PO}_4^-$  is \_\_\_\_\_.  
(b) \_\_\_\_\_ is the conjugate acid of  $\text{P}_2\text{H}_4$ .

4. (2 points) **Circle** any of the following common substances that are colloidal dispersions.

fog      sand      table salt      milk      antifreeze      Jell-O

5. (2 points) The vapor pressure of water is 23.8 torr at 25 °C. If 2.0 moles of a non-volatile solute are dissolved in 8.0 moles of water at that temperature, the vapor pressure of the resulting solution should be \_\_\_\_\_ torr.

6. (7 points) **SHOW ALL WORK.** For the following reaction,  $K_c = 64$ . A quantity of HI is placed in an empty container and the system is allowed to reach equilibrium. At that point, the *total pressure* in the container is found to be 3.00 atm. Calculate the partial pressure of  $\text{H}_2$  (in atm) at equilibrium.



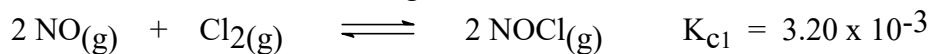
7. **SHOW ALL WORK.** Glycerol,  $C_3H_5(OH)_3$  (92.0 g/mole) is a non-dissociating, non-volatile liquid that is very soluble in water. A certain aqueous solution of glycerol has a boiling point of 105.5 °C. Determine the quantities in parts (a) and (b) below, related to this solution. [Some constants for  $H_2O$  (18.0 g/mole):  $K_b = 0.51 \text{ }^\circ\text{C/m}$  and  $K_f = 1.86 \text{ }^\circ\text{C/m}$ ]

(a) (7 points) The freezing point of the solution in °C.

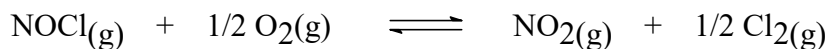
(b) (7 points) The weight percent of glycerol in the solution.

8. (3 points) At a pressure of 380 torr, the solubility of  $O_2$  gas in water is  $6.50 \times 10^{-4}$  M. If the pressure is increased to 25 atm, the solubility of  $O_2$  should be \_\_\_\_\_ M.
9. (4 points) The heat of solution ( $\Delta H^\circ_{\text{soln}}$ ) of an ionic compound in water is approximately equal to the sum of the \_\_\_\_\_ energy of the crystalline solid and the \_\_\_\_\_ energy of the ions in solution.

10. (7 points) **SHOW ALL WORK.** Using the data,



determine the value of  $K_c$  for the following reaction.



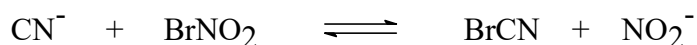
11. In a lab experiment, you are given two aqueous solutions labeled **A** and **B** as follows and asked to determine the molar concentration of  $\text{H}_2\text{SO}_4$  in Solution **B**.

Solution **A**:  $\text{NaOH}$ ,  $M = 0.250$       Solution **B**:  $\text{H}_2\text{SO}_4$ ,  $M = ???$

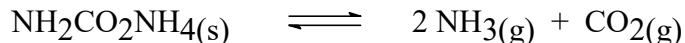
(a) (3 points) Write a balanced, *net ionic equation* for the reaction that occurs when these two solutions are mixed together.

(b) (10 points) **SHOW ALL WORK.** After carefully mixing 100 mL of solution **A** with 100 mL of solution **B**, you determine that the resulting solution has a pH of 12.63 at 25 °C. Calculate the molar concentration of the original  $\text{H}_2\text{SO}_4$  solution (**B**).

12. (12 points) Consider the following reaction from the viewpoint of the Lewis acid-base concept. Write *Lewis electron dot formulas* (including formal charges and/or resonance forms if needed) for all four species in this reaction. *Clearly indicate which reactant is the Lewis acid and which is the Lewis base.* Use arrow(s) to illustrate the formation and/or breaking of any chemical bond(s) during the reaction.



13. A 3.00 g sample of solid  $\text{NH}_2\text{CO}_2\text{NH}_4(\text{s})$  (78.1 g/mole) was placed in an *empty* 1.00-L container and heated to 400 K until the following equilibrium is established. The mass of solid  $\text{NH}_2\text{CO}_2\text{NH}_4(\text{s})$  remaining at equilibrium was found to be 1.75 g.  
 [From other experiments, the reaction is known to be endothermic with  $\Delta H^\circ = 665 \text{ kJ}$ .]



- (a) (5 points) How will the equilibrium amount of  $\text{CO}_2(\text{g})$  be affected by each of following changes? Indicate your answer by writing the appropriate letter.

[I = increase, D = decrease, N = no change]

Change	moles $\text{CO}_2(\text{g})$
add some $\text{NH}_3(\text{g})$	
add a catalyst	
decrease the volume	
remove some $\text{NH}_2\text{CO}_2\text{NH}_4(\text{s})$	
increase the temperature	

- (b) (2 points) If the temperature of the above equilibrium system is reduced, the actual value of  $K_c$  should (circle one):      increase      decrease      stay the same
- (c) (8 points) **SHOW ALL WORK.** Determine the equilibrium constant ( $K_c$ ) at 400 K for this reaction using the data provided above.

14. (7 points) **SHOW ALL WORK.** At 50 °C the value of  $K_w$  is  $5.6 \times 10^{-14}$ . Determine the pH of a solution made by dissolving 1.50 g of  $\text{Ba}(\text{OH})_2$  (171 g/mole) in enough water to make 500 ml of solution at this temperature.