due Wed. April 6

Chemistry 342

Problem Set 8

1. Pure water is saturated with a 2:1 mixture of hydrogen and oxygen at a total pressure of 5 atm. The water is then boiled to remove all the gases. Calculate the percent composition of the gases driven off (i.e., the composition of the gases after removing water vapor from the gases). Use data from the table below.

partial pressure, atm	Henry's Law Constant ($k \times 10^{-4}$)		
	N_2 at 19.4°C	O_2 at 23°C	H_2 at 23°C
1.18	8.24	4.58	
2.63	8.32	4.59	7.76
3.95	8.41	4.60	7.77
5.26	8.49	4.68	7.81
6.58	8.59	4.73	7.89
7.90	8.74	4.80	8.00
9.20	8.86	4.88	8.16

2. When 2 g of nonvolatile hydrocarbon containing 94.4% C is dissolved in 100 g benzene at 20 °C is lowered from 74.66 mm Hg to 74.01 mm Hg. Calculate the molecular formula of the hydrocarbon.

3. Suppose you wish to prepare your own windshield washing solution for use in the winter. Calculate the weight of (a) methanol and (b) ethylene glycol, which when dissolved in 4 L of water, would just prevent the formation of ice at -10°C.

4. When cells of the skeletal vacuole of a frog were placed in a series of NaCl solutions of different concentrations, it was observed microscopically that they remained unchanged in 0.7% of NaCl solution, shrank in more concentrated solutions, and swelled in more dilute solutions. This particular salt solution freezes at -0.406°C. What is the osmotic pressure of the cell cytoplasm at 25°C?

5. Two 10 liter bulbs are connected by a stopcock. One bulb contains 100 g of water and the other bulb contains a gas at 2 atm pressure. Both bulbs are at 25°C. The solubility of the gas in water at 25°C and at 1 atm pressure is 2 moles per 1000 g of water. The vapor pressure of pure water may be taken as 24 mm Hg at 25°C. Calculate the total pressure in the system if the stopcock is opened and equilibrium is established at 25°C. Assume the gas neither dissociates nor associates in solution.

6. At 1 atm pressure of CO_2, 1.7 g of CO_2 will dissolve in 1000 g of water at 20°C, whereas only 1 g will dissolve under 1 atm pressure at 40°C. (a) If a bottle is unsafe with a pressure of over two atmospheres of gas in it, what is the maximum pressure of CO_2 at 20°C that is safe for a bottled beverage that might be exposed to 40°C? (b) What is the mole fraction of CO_2 in the resulting solution? Assume the solution obeys Henry's law.

7. The following boiling points are obtained for solutions of oxygen and nitrogen at 1 atm:

boiling pt., K	77.3	78	79	80	82	84	86	88	90.1
mole % O_2 in liquid	0	8.1	21.6	33.4	52.2	66.2	77.8	88.5	100
mole % O_2 in vapor	0	2.2	6.8	12	23.6	36.9	52.2	69.6	100

Draw the T vs. X diagram. If 90% of a mixture containing 20% O_2 and 80% N_2 is distilled, what will be the composition of the residual liquid and its boiling point? Make a plot of activity $\boldsymbol{a}$ vs. mole fraction X diagram from the data.

8. The following data were obtained for the boiling points at 1 atm of solutions of CCl_4 in C_2Cl_4:

Mole fraction CCl_4 in liquid	0	0.1	0.2	0.4	0.6	0.8	1
Mole fraction CCl_4 in vapor	0	0.469	0.67	0.861	0.918	0.958	1
boiling point °C	120.8	108.5	100.8	89.3	83.5	79.9	76.9

If half of a solution 30 mole % in CCl_4 is distilled, what is the composition of the distillate? If a solution 50 mole % in CCl_4 is distilled until the residue is 20 mole % CCl_4, what is the approximate composition of the distillate? Specify whether the distillate is being removed or not.

9. A new antibiotic has been isolated from natural products by a lengthy series of extractions, biological tests, and so forth. A few milligrams are available, and by the ultracentrifuge method, it has been found that the molecular weight is 10,000. It is desired to check this by another methods. Calculate the freezing point depression, boiling point elevation, change in vapor pressure, and osmotic pressure in cm H_2O for such a substance dissolved in water. Assume the temperature is

25°C for the osmotic pressure measurements. In each calculation, assume 1 g of the substance is dissolved in 100 g of pure water. Which method could be most easily carried out on the basis of your calculations?

10. The heat capacity of liquid zinc from 419.5°C to 907°C can be represented by

$$C_p(\text{Zn, liquid}) = 7.09 + 1.15\times10^{-3}T$$

Zinc forms a monatomic gas with $C_p(\text{Zn, gas}) = (5/2)R$. The normal boiling point of zinc is 907°C. Calculate the vapor pressure of zinc at 500°C, assuming it to be an ideal gas. What would be the result of the calculation if you neglected the variation of the heat of vaporization with T?