CHEM 1154

LIQUIDS, SOLIDS, and SOLUTIONS PROBLEMS

You should be able to do these questions without a calculator.

1. What is the relationship between intermolecular forces in liquids and their boiling points? **[See your class notes]**

2. The vapor pressure of a hypothetical liquid is four times greater at 127°C than it is at 27°C. Calculate the heat of vaporization of this liquid. **[about 14 kJ/mol]**

3. For a certain substance the heat of fusion is 6.0 kJ/mol and the heat of sublimation is 35.0 kJ/mol. Calculate the heat of vaporization of this substance. **[29 kJ/mol]**

4. The heat of fusion of a substance is typically much less than its heat of vaporization. Explain why this is so. **[See your class notes]**

5. Use the following data to sketch the phase diagram of carbon dioxide.

   Triple point: 216 K and 5.1 atm
   Critical temperature and pressure: 304 K and 73 atm
   Melting point at the critical pressure: 218 K
   Vapor pressure of the solid at 195 K: 1.0 atm

6. Does a substance such as liquid CO_2 have a normal boiling point? EXPLAIN. **[No! Because the triple point is above a pressure of 1 atm.]**

7. The normal boiling point of substance A is 60°C and its heat of vaporization is 25 kJ/mol. At what pressure is the boiling point 127°C? **[about 4 to 5 atm]**

8. Calculate the % volume occupied by the atoms in a face-centered-cubic (fcc) unit cell. **[74%]**

9. Potassium crystallizes in one of the two cubic crystal structures we have discussed in class. The length of potassium unit cell is 5.25×10^{-8} cm and the density of potassium is 0.899 g/cm^3. Calculate how many atoms/unit cell potassium has and this should tell you which of the two cubic crystals structures is correct for potassium solid also calculate the atomic radius of a K atom. **[2 atoms/unit cell; bcc; about 2.3×10^{-8} cm]**

10. An 40% by mass aqueous solution of NaOH (Molar mass = 40 g/mol) has a density of 1.43 g/mL. Calculate the approximate molarity and molality for this solution. **[about 14 *M* and 16 m]**

11. A one molal solution of HCl in benzene has a freezing point of 0.4°C. Is HCl an electrolyte in benzene? EXPLAIN showing the appropriate calculations. **[No, because i = 1]**

    K_f(benzene) = 5.1°C/molal and T_f(benzene) = 5.5°C

12. On dissolving 0.128 g of naphthalene ($C_{10}H_8$) in 10.0 g of camphor, the normal melting point of camphor was lowered by 4.0°C. When 1.00 g of a second substance was dissolved in 10.0 grams of camphor, the observed depression of the freezing point of the solution was 10.0°C.
    (a) Calculate the Molal freezing-point depression constant (K_f) for camphor. **[40°C/molal]**
    (b) Calculate the apparent molar mass of the second substance. **[400 g/mol]**

13. A 0.010 molal solution of $TlCl_3$ in water was found to freeze at -0.0744°C. Assuming ideal behaviour, determine
(a) The van't Hoff factor "i". K_f for water is 1.86°C/molal. **[i = 4]**
(b) What species are likely present in the solution? **[Tl^{3+} and 3 Cl^-]**

14. A solution of benzene (C_6H_6) and toluene ($C_6H_5CH_3$) is prepared by thoroughly mixing together equal volumes of the pure liquids at 35°C. At this temperature the density of both liquids are the same. Given the following information:
vapor pressure of pure benzene at 35°C = 100 mmHg
vapor pressure of pure toluene at 35°C= 30 mmHg

(a) Determine the vapor pressure of the resulting solution at 35°C. **[about 68 mmHg]**
(b) Determine the composition of the vapor (as mole fraction) in equilibrium with the solution. **[$X_{benzene}$ = 0.80]**

15. Two liquids, A and B, combine forming an ideal solution. At 50°C, the total vapor pressure for a solution of 1.0 mol of A and 2.0 mol of B is 250 mmHg. On adding another mole of A, the vapor pressure of the solution rises to 300 mmHg. Calculate the vapor pressures of pure A and B. **[For pure A = 450 mmHg and for pure B = 150 mmHg]**