CH353 – Physical Chemistry I
Spring 2013, Unique 52575

Homework, Week 7

1. Sketch the phase diagram for oxygen using the following data: triple point, 54.3 K and 1.129 x 10^{-3} bar; critical point, 154.6 K and 42.86 bar; standard melting point, -218.4 ˚C; and standard boiling point, -182.9 ˚C. Does oxygen melt as pressure increases?

2. The molar enthalpy of vaporization of water is 40.65 kJ mol^{-1} at its normal boiling point. Determine the vapor pressure of water at 110˚C. How does this compare with the experimental value (1075 Torr)?

3. The vapor pressure of dichloromethane (CH_2Cl_2) is 24.1˚C at 53.3 kPa, and its enthalpy of vaporization is 28.7 kJ mol^{-1}. Estimate the temperature at which is vapor pressure is 70.0 kPa.

4. Calculate the melting point of ice under a pressure of 50 atm. Assume that the density of ice under these conditions is approximately 0.92 g cm^{-3} and that the density of liquid water is 1.0 g mL^{-1}.

5. Before the discovery that freon-12 (CF_2Cl_2) was harmful to the Earth's ozone layer, it was frequently used as the dispersing agent in spray cans for hair spray and other dispersed aerosols. Its enthalpy of vaporization at its normal boiling point of -29.2˚C is 20.25 kJ mol^{-1}. Estimate the pressure that a can of hair spray using freon-12 had to withstand at 40˚C, a temperature it would experience sitting in sunlight. Assume that over the temperature range involved, ΔH_{vap} is a constant equal to its value at -29.2˚C.

6. The enthalpy of fusion of Hg is 2.292 kJ mol^{-1} at its normal freezing temperature of 234.3 K. The molar volume of Hg changes 0.517 cm^{-3} mol^{-1} on melting. At what temperature will the bottom of a column of a 10.0 m column of liquid mercury (density of 13.6 g cm^{-3}) be expected to freeze.

7. A cell bilayer membrane separates two solutions: the cytosol (inside the cell) and the extracellular matrix (outside the cell). Transmembrane proteins located throughout the bilayer periodically open and close channels that allow molecular species such as ions and water to pass through. The thermodynamics of this transport process are studied in the laboratory by suspending a bilayer over a small hole in a rigid piece of plastic, then reconstituting a transmembrane protein in the bilayer. An electric potential can then be applied to the system to cause the protein to open or close a channel or pore inside the model membrane. (Google "black lipid membrane" if you are having difficulty visualizing this.)

This system can be modeled simply as a two-compartment vessel. The entire vessel is enclosed with rigid, adiabatic, impermeable walls, and the barrier between the two compartments (the membrane) is initially also rigid, adiabatic, and impermeable. The two compartments are separately filled with either cytosolic or extracellular solutions, and each compartment comes to equilibrium. An electric field is then applied to the system, and pores open up in the barrier, making it rigid, adiabatic, and permeable. Determine a general expression for the change in entropy of the system when this process occurs. You may assume the system is held at constant temperature, volume, and pressure, and that the cytosolic and extracellular solutions are not in equilibrium with each other.