CH301H – Principles of Chemistry I: Honors
Fall 2011, Unique 51040
Homework, Week 14

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. Draw the phase diagram for water, indicating regions of solid, liquid, and vapor. Make the values of *P* and *T* on your axis reasonable based on what you know about the melting and boiling temperatures of water at 1 bar.

3. In class, we began discussing the following problem: because the melting temperature of water decreases with increasing pressure, a commonly repeated hypothesis is that an ice skater is able to move across the surface of solid ice by exerting enough force on the ice to temporarily melt the ice to water, thus dramatically reducing the coefficient of friction. Assume that the above hypothesis is true if the skater is able to exert enough force to lower the melting temperature of ice by 0.1 K. Also assume that the ice is maintained at 0˚C, that the density of ice is approximately 0.92 g cm^{-3}, and that the density of liquid water is 1.0 g mL^{-1}. $\Delta H_{fus}(H_2O)$ = 6.01 kJ mol^{-1} at 273 K. You may approximate the force of gravity as 10 N kg^{-1}.

a) Is this a reasonable hypothesis for a person weighing 70 kg who is wearing ice skating blades that are 30 cm long and 3 mm wide? Justify your answer.

b) To achieve the conditions of the above hypothesis, how much would this skater have to weigh (if wearing the same blades described above)?

c) Provide an alternative hypothesis for how skating across solid ice may be possible.

4. The average surface temperature and pressure of Earth is found near the triple point of H_2O (273 K and 10^3 Pa). Neptune's moon Titan is the only moon in our solar system with a fully developed atmosphere that consists of other than just trace gases. When the *Voyager 1* space craft arrived at Neptune in 1980, it observed Titan's atmosphere to be ~7 as dense as Earth's (compensating for its smaller size), that it seemed covered in a dense haze, and that Titan's average surface temperature is approximately 94 K, the temperature of the triple point of methane (CH_4). Based on this single observation, astronomers hypothesized that that the atmosphere of titan must contain significant quantities of methane. This hypothesis has since been confirmed, and we now know that Titan's atmosphere is 96.4% $N_2(g)$ and 1.6% $CH_4(g)$. Based on these observations, your general knowledge of Earth's climate, justify this hypothesis, and suggest the role of CH_4 in regulating the climate of Titan.

5. 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.

6. At a camp high in the Andes, water boils at 90˚C. Using the phase diagram for water in your text book, estimate the atmospheric pressure at the altitude of the camp and fraction of the earth's atmosphere that is below the altitude of the camp.

7. Provide a physical interpretation to explain the observation that ice melts as pressure is applied. It might be useful to think about the dominant intermolecular forces in water.