1. (2 pts) Use the vapor pressure diagram on the right to estimate the boiling point of ethyl alcohol at 400 torr.

\[ \sim \frac{65 \degree C}{65 \degree C} \]

2. (2 pts) Use the same vapor pressure diagram to estimate the vapor pressure of water at 60 \degree C.

\[ \sim 150 \ \text{torr} \]

3. (4 pts) Use the phase diagram at the right to describe the behavior of a sample of CO\(_2\) initially at a temperature of 50 \degree C and 50 atm which is then allowed to cool at the same pressure to 70 \degree C.

The gas cools to \( \sim 20 \degree C \), where it condenses to give liquid, which then cools to \( \sim 50 \degree C \), where it freezes to solid, which cools to \( \sim 20 \degree C \).

4. (6 pts) Consider the unit cell shown on the right with calcium (corners), oxygen (faces) and titanium (center) in it.

a) For each of the atoms, indicate its location, the number at that location(s) and its net contribution to the unit cell.

\[ \text{Ca} \] 8 corners \( \times \frac{1}{8} \) = 1 (Ca atom) \n \[ \text{Ti} \] 11/2 corners \( \times \frac{1}{11/2} \) = 1 (Ti atom)

O: 6 faces \( \times \frac{1}{2} \) = 3 (O atoms)

b) What is the chemical (empirical) formula for the compound?

\[ \text{CaTiO}_3 \]

c) How would you classify this unit cell (primitive, face centered, or body centered cubic)?

5. (6 pts) Aluminum crystallizes in a cubic close-packed structure (face-centered cubic cell).

a) How many aluminum atoms are in a unit cell?

\[ 1 \text{ (corners)} + 3 \text{ (faces)} = 4 \ \text{atoms} \]

b) Assume the atoms are represented as spheres with a radius of 1.34 \( \text{\AA} \). What is the length of the side of the unit cell? (1 \( \text{\AA} \) = \( 1 \times 10^{-10} \text{ cm} \))

\[ a = \frac{h}{\sqrt{2}} = \frac{1.34 \text{\AA}}{\sqrt{2}} \]

\[ h = \frac{a^2}{h} = \frac{(1.34 \text{\AA})^2}{h} \]

\[ a = 3.79 \text{\AA} \]

c) What is the density of aluminum? Its atomic weight is 26.98. It's OK to keep the density in units of amu/\( \text{\AA}^3 \).

\[ \rho = \frac{m}{V} = \frac{(4)(26.98 \text{amu})}{(3.79 \text{\AA})^3} = 1.98 \text{ amu/\AA}^3 = \text{density} \]
1. (2 pts) Use the phase diagram on the right to identify each region and specify what happens along curve segments C-A, A-B and A-D.

   C - A = solid → gas equilibrium
   A - B = liquid → gas
   A - D = solid → solid

2. (2 pts) Use the same diagram to identify the point A and to indicate what will happen if one starts with a gas at a temperature greater than A and a pressure less than A, then allows the material to cool at the same temperature.

   Gas cools, then when it reaches the A - C line it deposits a solid, which may cool further.

3. (4 pts) In the zinc blende structure shown at the right, the Zn$^{2+}$ ions are shown at the corners and faces of the unit cell, while there are four sulfide ions imbedded as shown in four of the eight quadrants within the cube.

   a) How many zinc ions and how many sulfide ions are in the unit cell? Be sure to identify the contribution from each kind of location.

   Zn$^{2+}$ (8 corners × $\frac{1}{8}$) + (6 faces × $\frac{1}{2}$) = 4 Zn$^{2+}$ ions

   S$^{2-}$ (4 inside × 1) = 4 S$^{2-}$ ions

   b) What is the classification of this cubic unit cell?

   Face-centered cubic

4. (8 pts) A certain form of AgI adopts the zinc blende structure. Assume the unit cell length, a, is 6.49 Å.

   a) What is the density of AgI in g/cm$^3$? The atomic weights for Ag and I are 107.9 and 126.9, respectively. Recall also that 1 amu = 1.661 x 10$^{-24}$ g and that 1 Å = 10$^{-8}$ cm.

   \[ d = \frac{m}{V} = \frac{4(107.9 + 126.9 \text{ amu})}{(6.49 \text{ Å})^3} \times \left(\frac{1.661 \times 10^{-24} \text{ g}}{1 \text{ amu}}\right) \left(\frac{10^{-8} \text{ cm}}{1 \text{ Å}}\right)^3 = 5.70 \text{ g/cm}^3 \]

   b) If you examine the upper left quadrant of the cell, you'll see the sulfide is located in the center of that quadrant. Use this information along with the unit cell length, a, given above to determine the closest distance between a silver ion and a iodide ion.

   Note: This distance between (center of) atoms?

   \[ d = \sqrt{\frac{1}{3} \left(\frac{a}{2}\right)} \]

   And, closest distance = \[ \frac{1}{2} d = \frac{1}{2} \sqrt{\frac{1}{3} \left(\frac{a}{2}\right)} = \frac{1}{2} \sqrt{\frac{1}{3} (6.49 \text{ Å})} = 5.62 \text{ Å} \]

5. (4 pts) The normal BP of carbon tetrachloride (CCl₄) is higher than that of chloroform (CHCl₃), both of which are above room temperature.

   a) Which will be more volatile at room temperature?

   The one with the lower normal BP - CHCl₃

   b) Which will have the higher vapor pressure at room temperature?

   The one with the lower normal BP - CHCl₃