Multiple Choice (2 points each). Circle the letter corresponding to the best answer for each question below. You can write anywhere on these pages you want.

1. The phosphorous in the Lewis structure for PCl$_3$ will have:
   a. two nonbonded electron pairs and three chlorine atoms
   b. one nonbonded electron pair and three chlorine atoms
   c. no nonbonded electron pairs and three chlorine atoms
   d. three nonbonded electron pairs and three chlorine atoms
   e. four nonbonded electron pairs and three chlorine atoms

2. The electron domain geometry and polarity of PCl$_3$ would be expected to be:
   a. trigonal pyramidal and polar
   b. trigonal pyramidal and nonpolar
   c. tetrahedral and polar
   d. tetrahedral and nonpolar
   e. trigonal planar and nonpolar

3. Hydrogen (H$_2$) boils at -253 °C and fluorine (F$_2$) boils at -188 °C. The best explanation for this difference in boiling point is:
   a. H$_2$ is able to hydrogen-bond.
   b. F$_2$ has smaller dispersion forces.
   c. F$_2$ is polar and thus has dipole-dipole forces which H$_2$ does not.
   d. Both have dipole-dipole forces, but those of F$_2$ are stronger than those of H$_2$.
   e. H$_2$ has smaller dispersion forces.

4. Which of the following molecules has hydrogen bonding as its only intermolecular force?
   a. C$_6$H$_{13}$NH$_2$
   b. H$_2$O
   c. HF
   d. C$_3$H$_{11}$OH
   e. None, all also have dispersion forces.
5. Which intermolecular forces are present in CH₃OH?
   a. dispersion
   b. hydrogen bonding and dispersion
   c. hydrogen bonding, dipole-dipole, and dispersion
   d. dipole-dipole and dispersion
   e. hydrogen bonding, ion-dipole, and dispersion

6. Which of the following compounds will have the highest boiling point?
   a. C₂H₆
   b. C₂F₆
   c. C₂Cl₆
   d. C₂Br₆
   e. C₂I₆

7. Which of the compounds will have the highest the lowest freezing point?
   a. C₂H₆
   b. C₂F₆
   c. C₂Cl₆
   d. C₂Br₆
   e. C₂I₆

8. Which of the following statements is true of CBr₄ and CCl₄?
   a. CBr₄ will have a lower boiling point than CCl₄.
   b. CBr₄ will have a higher viscosity than CCl₄.
   c. CBr₄ will have a lower surface tension than CCl₄.
   d. CBr₄, in addition to dispersion forces, has dipole-dipole forces.
   e. CBr₄ will have a higher vapor pressure than CCl₄ at the same temperature.

9. A body-centered cubic cell contains how many atoms in it?
   a. 1
   b. 2
   c. 3
   d. 4
   e. 5
10. In the diagram above, the correct labeling of the regions A, B, and C in order from A→B→C is given as:

a. liquid→solid→vapor  

b. solid→vapor→liquid  

c. solid→liquid→vapor  

d. vapor→liquid→solid  

e. liquid→vapor→solid

11. The critical point on the phase diagram above is represented by point:

a. A  

b. B  

c. C  

d. D  

E

12. The phrase “like dissolves” like refers to the fact that ________________

a. gases can only be dissolved in other gases  

b. solvents can only dissolve solutes of similar molar mass 

c. polar solvents dissolve nonpolar solvents and vice versa  

d. polar solvents dissolve polar solutes and nonpolar solvents dissolve nonpolar solutes  

e. condensed phases can only dissolve in other condensed phases
13. A solution with a concentration higher than the solubility is:
   
   a. is unsaturated
   b. is supercritical
   c. is not possible
   d. is saturated
   e. is supersaturated

14. Which of the following would be most likely to dissolve in the solvent hexane, $C_6H_{14}$?
   
   a. $H_2O$
   b. $NH_3$
   c. $PCl_3$
   d. $C_5H_{12}$
   e. $CHCl_3$

15. Which of the following statements is true of the solubility of gases in relation to temperature and pressure?
   
   a. gases become more soluble as the temperature of a solution increases and the gas pressure decreases
   b. gases become more soluble as the temperature of a solution decreases and the gas pressure above the solution increases
   c. gases become more soluble as the temperature of a solution increases and the gas pressure increases
   d. gases become more soluble as the temperature of a solution decreases and the gas pressure above the solution decreases
   e. gas solubility is not affected by temperature but becomes greater as the gas pressure above the solution increases
16. (8 points) Consider the figure to the right.

a. 20-g each of KNO₃, KClO₃, and K₂Cr₂O₇ are placed in a beaker containing 100-g of water at 60 °C. Initially, are all three solutes dissolved and, if not, which have precipitated on the bottom of the beaker?

All are dissolved initially. Because the amount dissolved is below the solubility.

b. The solution is now cooled to 10 °C. In what order would you see the solutes precipitate and at what temperature would each begin to precipitate?

KClO₃ → K₂Cr₂O₇ → KNO₃
Follow the horizontal arrow from 60 °C to 10 °C.
17. (10 points) 45.0-g of KCl is dissolved in 350-g of water. Determine the following for this solution. Show your work.

a. Find the mass % of KCl.
\[
\text{mass} = \frac{45.0\text{ g KCl}}{45.0\text{ g KCl} + 350\text{ g}} \times 100\% = 11.4\% \]

b. Find the ppm of KCl.
\[
78\text{ ppm} = \frac{45.0\text{ g KCl}}{45.0\text{ g KCl} + 350\text{ g}} \times 10^6 = 1.14 \times 10^5 \text{ ppm} \]

c. Find the mole fraction of KCl.
\[
\text{mol KCl} = \frac{45.0\text{ g}}{74.5\text{ g/mL}} = 0.604 \text{ mol KCl}
\]
\[
\text{mol water} = \frac{350\text{ g}}{18\text{ g/mL}} = 19.4 \text{ mol H}_2\text{O}
\]
\[
\text{mol fraction KCl} = \frac{0.604}{0.604 + 19.4} = 0.03 \approx 3.0 \times 10^{-2}
\]

d. Find the molality of the KCl.
\[
\text{molality} = \frac{\text{mol KCl}}{\text{kg solvent}} = \frac{0.604}{350 \text{ g}} = 1.73 \text{ m}
\]

e. If the density of the solution is 1.05 g/mL, what is the molarity of the solution?

\[
\text{Let's look at our 350 g + 45 g of solution = 395 g solution}
\]
\[
\text{Volume is } \frac{395\text{ g}}{1.05\text{ g/mL}} = 374.6 \text{ mL = } 0.3746 \text{ L}
\]
\[
M = \frac{\text{mol KCl}}{\text{L solution}} = \frac{0.604}{0.3746} = 1.61 \text{ M}
\]
I will not typically give you these equations. However, with the snow days and the recent introduction of this material I thought it might be helpful. Don’t expect these equations on future tests or quizzes.

\[
Molarity = \frac{\text{# mol solute}}{\text{# L solution}}
\]

\[
Molality = \frac{\text{# mol solute}}{\text{# kg solvent}}
\]

\[
\% \text{ by mass} = \frac{\text{mass solute}}{\text{mass solution}} \times 100\%
\]

\[
mole \ fraction = \frac{\# \text{ moles component}}{\# \text{ total moles of all components}}
\]