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. The last two pages can be torn off for reference.

1. The phosphorous in the Lewis structure for PCl₃ 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 PCl₃ 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 (H₂) boils at -253 °C and fluorine (F₂) boils at -188 °C. The best explanation for this difference in boiling point is:
   a. H₂ is able to hydrogen bond.
   b. F₂ has smaller dispersion forces.
   c. F₂ is polar and thus has dipole-dipole forces which H₂ does not.
   d. Both have dipole-dipole forces, but those of F₂ are stronger than those of H₂.
   e. H₂ has smaller dispersion forces.

4. Which of the following molecules has hydrogen bonding as its only intermolecular force?
   a. C₆H₁₃NH₂
   b. H₂O
   c. HF
   d. C₃H₁₁OH
   e. None, all also have dispersion forces.
5. Which intermolecular forces are present in CH$_3$OH?
   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. C$_2$H$_6$
   b. C$_2$F$_6$
   c. C$_2$Cl$_6$
   d. C$_2$Br$_6$
   e. C$_2$I$_6$

7. Which of the compounds will have the highest freezing point?
   a. C$_2$H$_6$
   b. C$_2$F$_6$
   c. C$_2$Cl$_6$
   d. C$_2$Br$_6$
   e. C$_2$I$_6$

8. Which of the following statements is true of CBr$_4$ and CCl$_4$?
   a. CBr$_4$ will have a lower boiling point than CCl$_4$.
   b. CBr$_4$ will have a higher viscosity than CCl$_4$.
   c. CBr$_4$ will have a lower surface tension than CCl$_4$.
   d. CBr$_4$, in addition to dispersion forces, has dipole-dipole forces.
   e. CBr$_4$ will have a higher vapor pressure than CCl$_4$ 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. 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 solutes and nonpolar solvents dissolve polar solutes
   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
Short answer and problems. Show your work to receive full credit. Point totals are listed in the parentheses to the right of each problem number. The last two pages you may tear off – they have some useful information.

16. (10 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 completely dissolved and, if not, which have precipitated on the bottom of the beaker?

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? **Explain your reasoning.**
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.

b. Find the ppm of KCl.

c. Find the mole fraction of KCl.

d. Find the molality of the KCl.

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

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

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

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

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