**Quiz 9**

# Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work. Where appropriate answers should be boxed for clarity, written to the correct number of significant figures, and, include the proper units.

1. Why are intramolecular forces so much stronger than intermolecular forces (3 points)?

Intramolecular forces are much stronger than intermolecular forces because they act over much smaller distances.

1. Name the phase change in each of these events (4 points):
   1. Dew appears on a lawn in the morning. \_\_\_\_\_\_condensation
   2. Icicles change into liquid water. \_\_\_\_\_\_fusion
   3. Wet clothes dry on a summer day. \_\_\_\_\_\_vaporization
   4. Mothballs in a bureau drawer disappear over time. \_\_\_\_\_\_sublimation
2. A water molecule can engage in as many as four hydrogen bonds. Explain (3 points).

A single water molecule can form four hydrogen bonds. The two hydrogen atoms each form one hydrogen bond to the oxygen atoms on neighboring water molecules. The two lone pairs on the oxygen atom form hydrogen bonds with hydrogen atoms on two neighboring molecules.

1. The dipole moment of CH2F2 (1.93 debyes) is larger than that of CH2Cl2 (1.60 debyes), yet the boiling point of CH2Cl2 (40 °C) is much higher than that of CH2F2 (-52 °C). Why (5 points)?

The substance with the higher boiling point will be that which has the largest sum of intermolecular forces. In this case, the greater dispersion forces of CH2Cl2 add to the dipole-dipole interactions to give stronger intermolecular forces between the CH2Cl2 molecules compared to those of CH2F2 molecules. Also, the molar mass of CH2Cl2 is higher than that of CH2F2 so it requires more energy to vaporize.

1. Arrange the following in order of increasing boiling point: CH4, CH3CH3, CH3CH2Cl, and CH3CH2OH. Explain your reasoning (5 points).

CH4 < CH3CH3 < CH3CH2Cl < CH3CH2OH

The first two molecules only exhibit dispersion forces, so the boiling point will increase with molar mass. The third molecule has a dipole force, which are stronger than dispersion forces. The fourth molecule exhibits hydrogen bonding, which is the strongest intermolecular force, giving it the highest boiling point.