Name: ____KEY_____ Section: _____

Chapter 10 Practice Worksheet:
Liquids, Solids, and Phase Changes

1. Circle all of the molecules below that are polar:

a. CH_3Cl
b. CH_4
c. CCl_4
d. SO_2
e. CO_2
f. H_2O
g. NH_3
h. $CH_3–CH_3$
i. $CH_2=CH_2$
j. CH_3OH
k. CH_3NH_2

2. Define each type of intermolecular force below. Give an example of each and describe what characteristic that example has that results in each type of intermolecular force.

a. Ion-dipole: _attractive forces between an ion and a polar molecule _____

b. Dipole-dipole: _attractive forces between polar molecules (pure substance or mixture)___

c. London dispersion forces: _attractive forces between all molecules (induced dipoles → uneven electron distribution _
d. Hydrogen bonding: _ attractive forces between hydrogen and nitrogen, oxygen, or fluorine __

3. List the intermolecular forces that exist between molecules (or formula units) in each of the following. Circle the strongest force that will determine physical properties (e.g., boiling points) for each substance.

CH_3Cl __London, **dipole-dipole**_____

H_2 _**London**_____

HCl __London, **dipole-dipole**_____

Ne __**London**_____

NH_3 ___London, dipole-dipole, **hydrogen**_____

HF __London, dipole-dipole, **hydrogen**_____

CH_3OH __London, dipole-dipole, **hydrogen**_____

C_2H_4 ___**London**_____

CO_2 ___**London**_____

CO ___London, **dipole-dipole**_____

4. Explain the intermolecular forces that compete to determine whether or not an ionic substance will dissolve in water. Which force must be strongest in order for an ionic substance to dissolve?

In order for an ionic solid to dissolve, there is competition between the ion-ion forces within the compound and ion-dipole forces between ions and water molecules. If the ion-dipole forces are stronger, the solid will dissolve in water.

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5. How are boiling points affected by intermolecular forces?

Stronger intermolecular forces between molecules make it more difficult for those molecules to be pulled apart. Therefore, stronger intermolecular forces result in higher boiling points.

6. Define surface tension and viscosity. How do intermolecular forces affect these properties (i.e., as intermolecular forces increase, what happens to each property?)?

Surface tension is the resistance of a liquid to spread out. Viscosity is a measure of a substance's resistance to flow. As the strength of IMF's increase, surface tension and viscosity increase. Molecules are more strongly attracted to each other and will be less likely to spread apart or to flow.

7. List the 6 types of phase changes.

Solid → liquid: __melting_____ Reverse: ___freezing_____

Liquid → gas: ___boiling_____ Reverse: ___condensing_____

Solid → gas: ___sublimation_____ Reverse: ___deposition_____

8. List the following substances in order of increasing boiling points: $BaCl_2$, H_2, CO, HF, Ne, CO_2

$H_2 < Ne < CO_2 < CO < HF < BaCl_2$

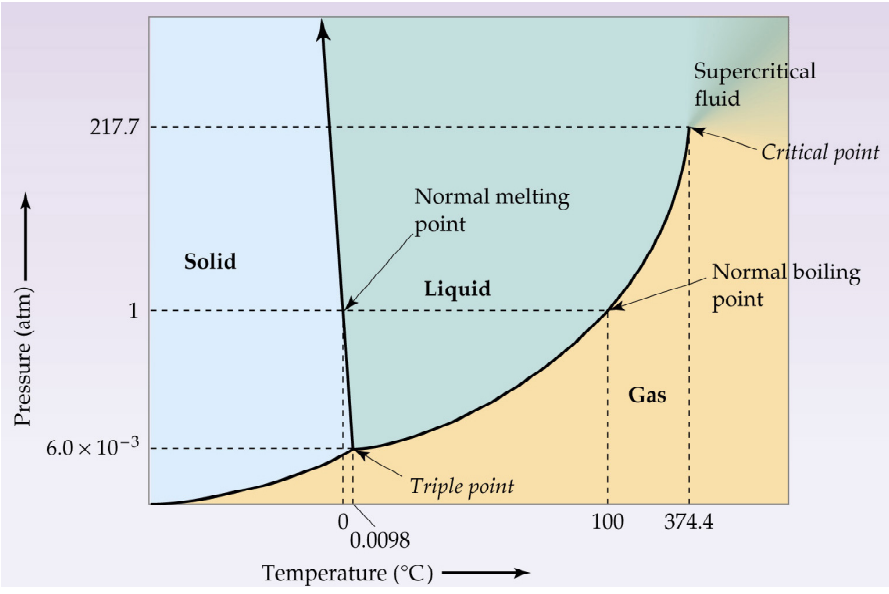
9. Why are heats of vaporization always larger than heats of fusion?

Heats of vaporization define the boiling point and heats of fusion define the melting point of a substance. Melting requires considerably less energy than boiling because IMF's do not need to be completely overcome. In order for a substance to boil, molecules must go into the gas phase which requires that there are no IMF's acting on the molecules (IMF's completely broken).

10. What is meant by **normal** boiling point and **normal** melting point?

Normal boiling and melting points occur at 1 atm of pressure.

12. a) Draw the phase diagram for water. Label each section and the phase changes that occur at each line (equilibria). Identify the normal boiling point and normal freezing point for water.



b) What does the negative slope of water's solid/liquid equilibrium line indicate? Why is carbon dioxide's positive?

The negative slope for water indicates that as you increase pressure on solid ice, the solid will turn into the liquid phase (melt). This is unusual because most substances (including CO_2) will transition from liquid to solid (freeze) as you increase pressure.

c) What happens to the melting and boiling points of water as pressure is decreased?

As pressure decreases, the melting point of water will increase but water's boiling point will decrease.

12. What are the four types of crystalline solids? Briefly describe each type.

Ionic: solid structure composed of ions arranged in a 3D structure and held together by ionic bonds (e.g., $CaCl_2$);
Molecular: solid structure composed of covalent molecules held together by intermolecular forces (e.g., ice);
Covalent network: solid structure made up of covalently bonded atoms in a 3D arrangement (e.g., diamond);
Metallic: 3D arrangement of metallic atoms held together by a cloud of electrons over the array of atoms (e.g., steel)