WKS
Intermolecular Forces

Name _____
Period _____ Date _____

Introduction: Substances exist in three states of matter: solids, liquids and gases. We know that molecules are... (a) far apart in gases; (b) close together, yet moving in liquids; and (c) held together in orderly structures in solids. At this point, you might be wondering:

– Why do molecules stick together in liquids and solids?
– Why does it take a lot of heat (energy) to change some liquids into gases, while other liquids change into gases at very cold temperatures (low energy)?

Read the attached article and answer the following questions as you go to understand the forces of attraction between molecules in liquids and solids. These forces of attraction hold molecules together in liquids and solids and these forces must be broken when liquids and solids are turned into gases.

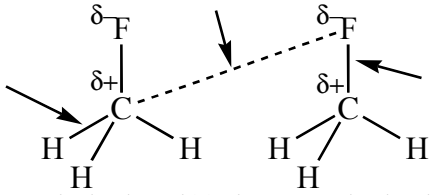
Part A: Intermolecular forces vs. Intramolecular forces

1) Intermolecular forces are the forces of attraction that occur _____ molecules.

2) Intramolecular forces *(or covalent bonds)* are forces that occur _____ molecules.

3) **(Intermolecular, Intramolecular)** forces must be broken when a substance changes from a liquid to a gas.
HINT: molecules must break apart from each other when they change from a liquid to a gas.

4) Look at this diagram below. There are three arrows pointing to where there are forces of attraction. Label each arrow as either an INTERmolecular force or an INTRAmolecular force.

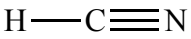


5) In the diagram above, draw a slash through the bond(s) that must be broken to change this substance from a liquid to a gas.

Part B: Dipole-Dipole attractions (This is one type of intermolecular force.)

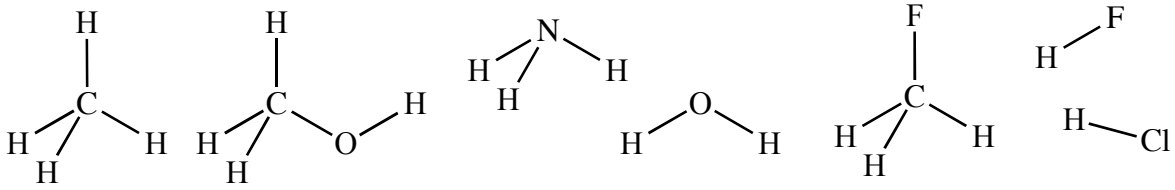
6) Dipole-dipole forces occur between polar molecules. Describe why polar molecules are attracted to each other.

7) The two molecules drawn below are attracted to each other by dipole-dipole attractions. Put in all partial charges and draw a dotted line to show where this dipole-dipole attraction is. (See example diagram in notes.)

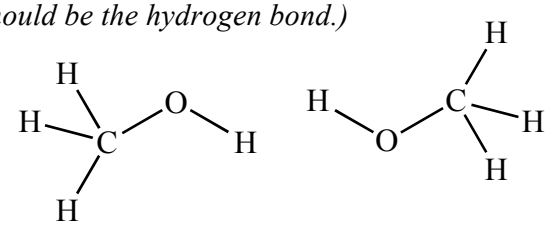


Part C: Hydrogen Bonding *(Another type of intermolecular force)*

8) Look at the molecules drawn below. **Circle the molecules that can hydrogen bond.**
HINT: The molecules must have a hydrogen atom covalently bonded to either a F, O, or N.



9) In the diagram below, I have drawn two of the same molecules which are attracted to each other by hydrogen bonding. **Put in all partial charges and draw a dotted line or lines to show the attraction(s) between molecules**. *(The dotted lines should be the hydrogen bond.)*



10) What are the two main factors that make hydrogen bonds stronger than your typical dipole-dipole attraction?

<u>Part D:</u> Dispersion forces (The last type of intermolecular force.)

11) How is it possible for a temporary (or instantaneous) dipole to form in a noble gas atom or a nonpolar molecule?

12) In your own words, explain how an *instantaneous dipole* can *induce* a similar dipole in a neighboring atom. Why does this happen?

13) Why are dispersion attractions weaker than dipole-dipole attractions and hydrogen bonding?

14) Which of the molecules listed below can form hydrogen bonds? For which of the molecules would dispersion forces be the only intermolecular force? Give reasons for your answers.
a. H_2b. NH_3 c. HCl d. HF

15) **Predicting** Make a prediction about the relative boiling points of the noble gases. Give a reason for your answer.

16) **Thinking Critically** In a methane molecule (CH_4), there are 4 single covalent bonds. In an octane molecule (C_8H_{18}), there are 25 single covalent bonds. How does the number of bonds affect the dispersion forces in samples of methane and octane? Which compound is a gas at room temperature? Which is a liquid?