Intermolecular Forces Worksheet

1) Each of the following statements describes an intermolecular force. For each statement indicate if it describes London Forces (L), dipole forces (D) or hydrogen bonding (H).

L Occurs in all molecules
H is the strongest intermolecular force
D occurs in polar molecules
L occurs when a temporary dipole is formed
L strength of the force depends on the size in the of the molecule (ie # of protons and electrons)
H occurs in molecules where hydrogen is covalently bonded to O, N, or F

2) Rank the following from strongest to weakest:

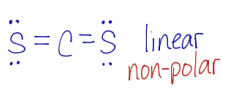
i. Covalent Bond
ii. Dipole-dipole force
iii. Hydrogen bond
iv. Ionic Bond
v. London Dispersion force

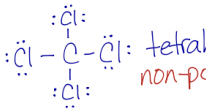
Weakest 5 2 3 4 1 Strongest

3) For each of the following pairs of compounds, identify which one would have the higher boiling point, giving a reason for your answer.

a) CS_2 or SiH_4

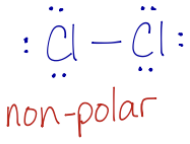
CCl4 – Since both are non-polar, the compound that has the stronger London (dispersion) forces will have the higher MP/BP. London (dispersion) forces get stronger as the molecular mass increases.

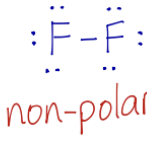




b) Cl_2 or F_2

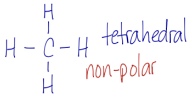
Cl2 – Since both are non-polar, the compound that has the stronger London (dispersion) forces will have the higher MP/BP. London (dispersion) forces get stronger as the molecular mass increases.

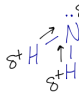




c) CH_4 or NH_3

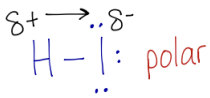
NH3 – NH3 has hydrogen bondi
while CH4 possesses weaker Lo
(dispersion) forces.

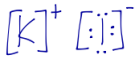




d) HI or KI

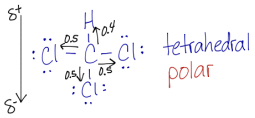
KI – KI has ionic bonds while HI possesses weaker dipole-dipole forces.

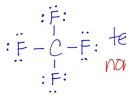




e) $CHCl_3$ or CF_4

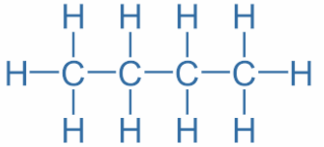
CHCl3 – CHCl3 has dipole-dipole forces while CF4 possesses weaker London (dispersion) forces.

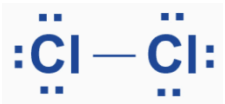




4) Suggest, with a reason, why the boiling point of Cl_2 is -35°C and the boiling point of C_4H_{10} is -0.50°C.

Both are non-polar. C_4H_{10} has stronger London forces because of it's shape.





5) The industrial production of ammonia, NH_3, from H_2 and N_2 is called the Haber process, named for Fritz Haber, the German chemist who developed it just before World War I. During the process, in a gaseous mixture of all three substances, NH_3 must be separated from H_2 and N_2. This is done by cooling the gaseous mixture so as to condense only the NH3. This leaves the elemental nitrogen and hydrogen as gases to be recycled and produce more ammonia. Why does only the ammonia liquefy upon cooling, but not the H_2 or N_2?

Since hydrogen bonds exist between ammonia molecules but only London (dispersion) forces exist between diatomic molecules of nitrogen and hydrogen, the ammonia has a higher boiling point and therefore liquefies (condenses) at a higher temperature than nitrogen and hydrogen that remain in the gaseous phase upon cooling.

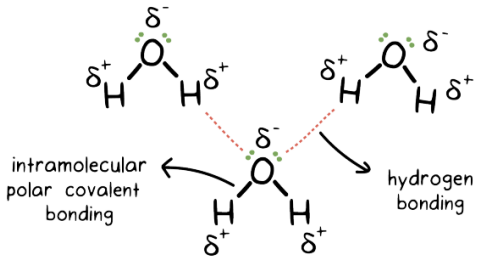
6) Rank the following from weakest intermolecular forces to strongest. Justify your answers.

H_2Se, H_2S, H_2Po, H_2Te

$H_2S < H_2Se < H_2Te < H_2Po$ These compounds are all the same shape. Although H_2S is slightly more polar than the others, it is not very polar so it has very weak dipole-dipole forces. Therefore, the difference in dispersion forces are more important for these compounds. H2Po is the largest and, therefore, has the strongest dispersion forces.

7) Surface tension is the ability of a fluid to act as a thin elastic membrane at its surface. Explain why non-polar molecules usually have much lower surface tension than polar ones.

Surface tension results when the molecules at a surface attract each other to be able to form a thin, elastic membrane. For example, H_2O (due to their hydrogen bonding) has surface tension since the positive hydrogen pole of one water molecule is attracted to the negative oxygen pole of a neighbouring water molecule. Since non-polar molecules are not attracted to each other as much as in polar molecules, these molecules are much less likely to have high surface tension



8) Ionic compounds such as NaCl have very high melting points because a great deal of energy is required to overcome the many attractive forces between the oppositely charged ions in an ionic crystal lattice. NaCl melts at 801°C, yet its ions will readily separate from each other at room temperature when the solid is added to water. Explain this by discussing the predominant force that allows an ionic compound to dissolve in water.

Although the ionic bonds holding a crystal lattice together are strong, when the surface of that lattice is in contact with water, each ion on that surface will attract the oppositely charged end of polar water molecules near them. That attraction between an ion and a polar molecule is called an ion-dipole force. These attractive forces soon overcome those existing between the ions themselves and so the crystal structure begins to break down and the ionic compound dissolves. As the ions move away from the lattice surface, they immediately become surrounded or enclosed in what chemists call a hydration shell. Ion-dipole forces are the primary force responsible for the solubility of ionic compounds in water.