**Intermolecular Forces (IMFs)**

All matter is held together by forces.

The force \_\_\_\_\_\_\_\_\_\_\_\_\_ a molecule is an \_\_\_\_\_\_\_\_\_**molecular force (BONDS)**.

The force \_\_\_\_\_\_\_\_\_\_\_\_\_ molecules is an \_\_\_\_\_\_\_\_\_**molecular force**.

Intermolecular forces are far weaker than intramolecular forces (chemical bonds); however, intermolecular forces still contribute to the properties (and relative strength) of a molecule. The properties of matter result from the properties of the individual molecule (the strength of the chemical bond) and how the molecules act collectively (resulting from intermolecular forces).

**Intramolecular Forces:**

* \_\_\_\_\_\_\_\_\_\_\_\_\_ **Bonding** (attraction between positive and negative ions)
* \_\_\_\_\_\_\_\_\_\_\_\_\_ **Covalent Bonding** (sharing of electrons)
* \_\_\_\_\_\_\_\_\_\_\_\_\_ **Metallic Bonding** (metal atoms)

**Intermolecular Forces** (*weak*)**:**

* \_\_\_\_\_\_\_\_\_\_\_\_\_ **Bonding**
* \_\_\_\_\_\_\_\_\_\_\_\_\_ **-**\_\_\_\_\_\_\_\_\_\_\_\_\_
* **Dispersion forces, London Dispersion**





**Intermolecular Forces**

**Hydrogen Bonding**

* Hydrogen bonding is a strong dipole-dipole interaction that occurs when a highly \_\_\_\_\_\_\_\_\_\_\_\_\_\_ atoms
* Hydrogen bonding exists only in molecules with hydrogen and \_\_\_, \_\_\_, or \_\_\_



**Dipole-Dipole**

* Dipole-dipole interactions occur between \_\_\_\_\_\_\_\_\_\_ molecules that have permanent net \_\_\_\_\_\_\_\_\_\_\_\_
* The partial positive charge on one molecule is electrostatically attracted to the partial negative charge on a neighboring molecule.

**Dispersion forces, London Dispersion, van der Waals**

* Dispersion forces are instantaneous non-permanent dipoles created by random electron motion (electrons are always moving).
* London dispersion forces are present in \_\_\_\_\_\_ molecules.
* Dispersion forces are directly proportional to molecular size. \_\_\_\_\_\_\_\_\_\_\_\_\_ = stronger dispersion force.

**Effects of Intermolecular Forces**

The strength of intermolecular forces present in a substance is related to its boiling and melting points.

Stronger intermolecular forces cause higher melting and boiling points.

**Relative strength of Intermolecular Forces:**

* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ forces are weaker than \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ forces (bonds).
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are the weakest intermolecular force
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ are the strongest intermolecular
* Relative Strength: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ < \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ < \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

*examples*:

CH4 - Methane: has only very weak \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (lowest b.p. & m.p.)

CHCl3 - Chloroform: has \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ interaction and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (moderate b.p. & m.p.)

NH3 - Ammonia: has \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (high b.p. & m.p.)

**Intermolecular Forces**

***Identify the main type of intermolecular force in each compound:***

1) N2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2) carbon tetrachloride \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3) H2S \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4) sulfur monoxide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5) boron trihydride \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6) CH3OH \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7) carbon disulfide \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8) NH3 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9) CH2F2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10) C2H6 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

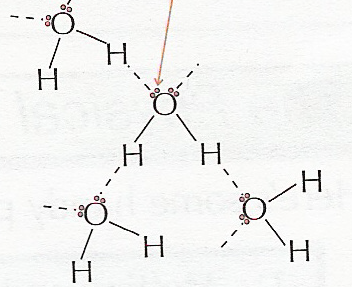
***Rank the following compounds by increasing melting point:***

1) C2H6, C2H5OH, C2H5F

2) H2S, H2O, H2

3) BBr3, BI3, BCl3

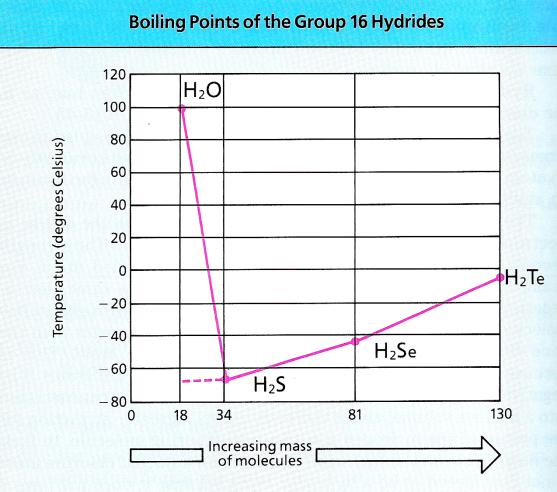
Highlight the difference between the covalent and hydrogen bonds in water:



Circle the molecules that would exhibit hydrogen bonding:

H2O H2S CH4 NO2 CH3OH

Consider the four compounds, H2O, H2S, H2Se, and H2Te. Which one exhibits hydrogen bonding? \_\_\_\_\_\_



Look at this graph of boiling points. What effect does the hydrogen bonding have?

Using the diagram of ice and water to describe why ice (solid) is less dense than water (liquid) and why water expands when frozen. Relate the explanation to *hydrogen bonding*.

