3. Arrange the following compounds in order of decreasing intermolecular ion-ion forces.

\[ \text{BaF}_2, \text{LiF, NaCl, BaO} \]

1. \( \text{BaF}_2 \)
2. \( \text{LiF} \)
3. \( \text{NaCl} \)
4. \( \text{BaO} \)

4. Arrange the following compounds in order of decreasing intermolecular ion-ion forces.

\[ \text{CaI, Al}_2\text{S}_3, \text{Fe}_2\text{S}_3, \text{FeS} \]

1. \( \text{CaI} \)
2. \( \text{Al}_2\text{S}_3 \)
3. \( \text{Fe}_2\text{S}_3 \)
4. \( \text{FeS} \)
As you have seen, electronegativity differences between covalently-bonded atoms in molecules result in a bond dipole.

\[ \delta^+ \quad \delta^- \]

\[ \delta^+ \quad \delta^- \quad \delta^+ \quad \delta^- \]

Two polar molecules are attracted by dipole–dipole forces.

As the polarity of the molecules increases, so will the dipole-dipole forces.

**Example:** \( \text{FBr} > \text{FCI} \)

**Reason:** the electronegativity difference between F and Br is greater than the difference between F and Cl.

Electronegativites:

5. Which compound exhibits stronger dipole-dipole forces: HCl or HBr?

   **HCl** because the difference in EN is greater meaning the dipole is bigger.

6. Which compound exhibits stronger dipole-dipole forces: \( \text{CHF}_3 \) or \( \text{CHBr}_3 \)?

   \( \text{CHF}_3 \) due to larger \( \Delta \text{EN} \) between C and F
Hydrogen bonding is a special kind of dipole–dipole attraction that occurs when a hydrogen atom is covalently bonded to nitrogen, oxygen, or fluorine.

Hydrogen bonding between molecules is the strongest kind of dipole–dipole attraction.

A hydrogen bond is not a "bond" in the classical meaning of the term. It is an intermolecular force of attraction between 2 distinct molecules.

Molecule #1 needs to have: A H atom covalently bonded to an O, N, or F atom.

Molecule #2 needs to have: A lone pair of electrons on an O, N, or F atom.

In the following compounds form hydrogen bonds with another molecule of itself? If so, show two of the molecules (with their structures) and the formation of at least one hydrogen bond between them.

A. NH$_3$

B. CH$_4$

C. H$_2$O

D. HF
8. All of the following compounds can form at least one hydrogen bond to water. Show all of the possible hydrogen bonds between the molecule and water (with their Lewis Structures).

A. CH₃OH

B. CH₃NH₂

C. CH₃COCH₃

D. CH₂COOH
INTERMOLECULAR FORCES
Relative Strengths

It is important to remember the relative strengths of the different intermolecular forces because these strengths relate directly to melting and boiling points.

**Stronger intermolecular forces** = **Higher melting and boiling points**

**Weaker intermolecular forces** = **Lower melting and boiling points**

- **Stronger intermolecular forces**
  - ion-ion
  - hydrogen bonding
  - dipole-dipole
  - dispersion

- **Higher melting and boiling points**

**Weaker intermolecular forces**

**Lower melting and boiling points**

Rank the following substances from strongest to weakest intermolecular forces:

1. NaCl
2. NH₃
3. NF₃
4. He

LDF
H-bond
dipole
dipole

**Strongest**

10. Rank the following substances from strongest to weakest intermolecular forces:

1. HF
2. F₂
3. FCl

H-bond
LDF
dipole
dominant dipole

dipole-dominant

11. Rank the following substances from strongest to weakest intermolecular forces:

- NaCl
- MgCl₂
- AlCl₃
- MgS
- NaBr

[Dominant is ion-ion]

**Smaller than**

12. Rank the following from highest to lowest boiling point:

1. I₂
2. F₂
3. NaF
4. H₂O

LDF:
ion-ion
high BP = high IMF

- LDF = dominant
- Molar mass higher than

1 = highest BP

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