

Unit 1, Lesson 12: Intra and Inter-Molecular Forces

Intra-molecular forces of attraction:

- **INTRAMOLECULAR** forces of attraction refer to the forces of attraction **within** molecules
- intra-molecular forces refer to chemical bonds (ionic and covalent)

Inter-molecular forces of attraction (van der Waals forces)

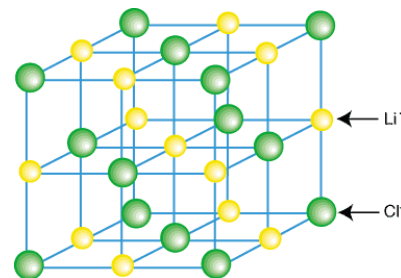
- **INTERMOLECULAR** forces refer to the forces of attraction **between** molecules
- inter-molecular forces of attraction between covalent molecules are also known as “van der Waals” forces, in honour of Johannes van der Waal
- inter-molecular forces are responsible for holding collections of molecules to one another; that is, inter-molecular attractions are responsible for the physical properties of compounds, such as melting point, boiling point and solubility in water
- inter-molecular forces are much weaker than chemical bonds
- the strength of inter-molecular attraction depends on the polarity of the molecules in the substance
- non-polar molecules have very low inter-molecular attractions- they are often gases at SATP
- polar molecules have stronger inter-molecular attractions- they are often liquids at SATP
- ionic compounds have very strong inter-molecular attractions- they are solids at SATP

There are three main types of inter-molecular attraction:

1. ion to ion
2. dipole to dipole (hydrogen bonding is a special example of dipole-dipole attractions)
3. dispersion forces

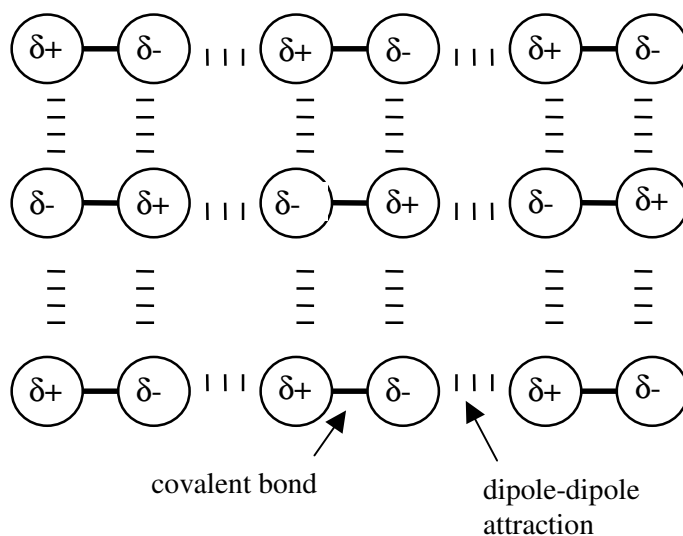
1. Ion to Ion inter-molecular attraction

- occurs in ionic compounds
- negatively charged ions are attracted to positively charged ions
- because this is the attraction of full positive to full negative charges, the inter-molecular attraction is extremely strong
- ionic solids form solid, hard crystal lattice structures
- they have high melting and boiling points
- they dissolve well in water because the charged ions are attracted to the partially charged regions of the water molecule



2. Dipole-dipole inter-molecular attraction

- occurs between polar covalent molecules
- a dipole (“two poles”) refers to any polar molecule that has permanent partial negative (δ^-) and partial positive (δ^+) regions
- the negative and positive dipoles of adjacent polar molecules are significantly attracted to one another
- as the polarity of the molecule increases, the strength of the dipole-dipole interaction also increases
- as the strength of the dipole-dipole attraction increases, melting point and boiling point also increase
- polar molecules will dissolve well in water, because both contain partially charged regions



Hydrogen Bonding (a special case of dipole-dipole attraction)

- occurs in polar molecules that contain hydrogen bonded to fluorine, oxygen or nitrogen
- the electrons are shifted significantly away from the hydrogen by the electronegative element
- there is a substantial positive charge on the hydrogen atom which may then be attracted strongly to the negative portion of another molecule
- hydrogen bonding is an extreme example of the attractions between polar molecules
- hydrogen bonds are, on average, 5 times stronger than regular dipole-dipole attractions
- hydrogen bonding significantly increases such physical properties as melting point and boiling point

Compound	Melting Point °C		Boiling Point °C	
H ₂ Te	-48		-2	
H ₂ Se	-66		-41	
H ₂ S	-86		-61	
H ₂ O	Guess	Actual	Guess	Actual

Tellurium, selenium, sulfur and oxygen are all in group VI in the periodic table. Notice the trends in the melting and boiling points for the compounds H₂Te, H₂Se and H₂S.

- What would the approximate melting and boiling points for water be if they too followed these trends?
- What are the actual melting and boiling points for water?

Notice that the melting and boiling points of water are quite high in comparison to those of other, similar molecular substances. This is attributed to the hydrogen bonding between water molecules. The attractions between water molecules are much stronger than regular dipole-dipole attractions, thus requiring more energy and higher temperatures to overcome them.

3. Dispersion Forces (a.k.a. London Forces)

- occur between **ALL** molecules
- are very weak so they are insignificant in ionic substances

Explanation:

The electrons within a molecule are constantly moving. It is possible that, from time to time, the electron distribution causes a portion of a molecule to become temporarily positive while another portion becomes temporarily negative, even in non-polar molecules. These temporary charges in one molecule can attract unlike charges in other molecules.

Dispersion forces are larger for large molecules since they will contain larger numbers of electrons. Dispersion forces are also larger between molecules which can, because of their shapes, come close together, for example, long chain hydrocarbons such as waxes.

However, because this type of polarity is temporary, dispersion forces are very weak. As a result, substances held together by these forces are soft, easy-to-melt solids or are liquids.

