Non-Chemical Bonds

Metallic Bonding

and

Intermolecular Forces

The Nature of Metals

METALLIC BONDS

Properties of Metals

Chemical Properties

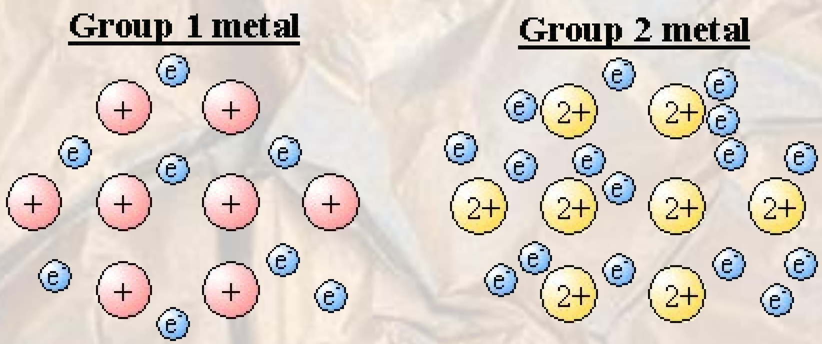
- Tend to lose electrons easily
- Have low ionization energy (energy needed to remove electrons)
- Have low electron affinity (attraction for electrons)
- Form positive ions when combining with other atoms

Physical Properties

- Lustrous - reflect light, shine when they are polished
- Flexible
  - **malleable** **–** can be rolled or hammered into sheets
  - **ductile** **–** can be drawn into wires
- Are solids at room temperature (except for mercury)
- Good conductors of heat and electricity

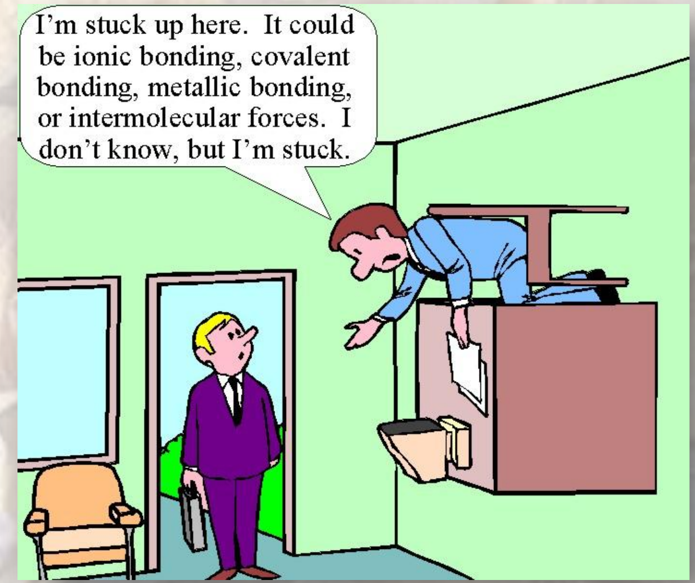
Metallic Bonding

- The metal atoms in a piece of metal lose electrons and become positive ions (cations).
- The cations are attracted to the electrons, but not strongly enough to hold onto them.
- As a result, the electrons are free to move among the cations. They are mobile.
- So, a metallic bond is ***positive ions in a "sea" of mobile electrons***.



Explaining Metal Properties

Property	Explanation
Mostly Solid	The bond between the electrons and the cations is strong.
Conductivity	The electrons are free to move between the cations.
Flexibility	The electrons that bond the cations are mobile.
Luster	The electrons ,which are held loosely, jump up to higher energy levels, and fall back down giving off light.



The Ties that Bind

INTERMOLECULAR FORCES

Dipoles

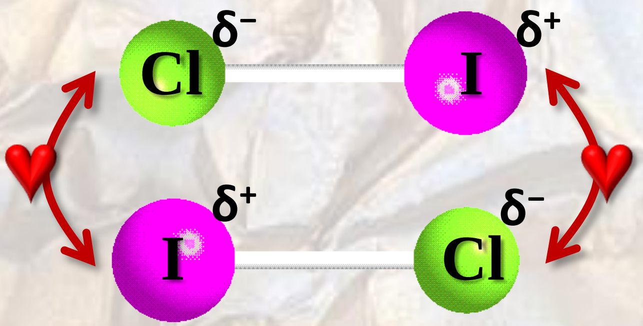
- Iodine monochloride (ICl) is a solid at room temperature.
  - What holds the crystal together?
- Check the electronegativities and the shape of the iodine monochloride molecule.

Atom	Electronegativity
Chlorine	3.2
Iodine	2.7
E.N.D.	0.5

- The molecule is polar.
- Polar molecules are often called ***dipoles*** since they have two poles.

Dipole-Dipole Attraction

- There is an attraction between the oppositely charged ends of the polar iodine monochloride molecules.



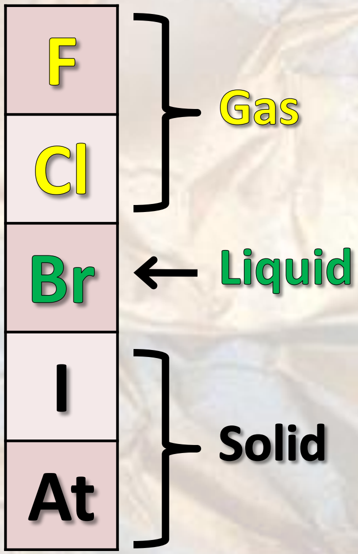
- This attraction is called a ***dipole-dipole attraction***.
- It accounts for the fact that iodine monochloride is solid.

Van der Waals Forces

- Consider iodine (I_2):
  - It is a solid at room temperature.
  - It is a diatomic molecule with nonpolar bonds.
- What holds the iodine crystals together?
- Even though iodine consists of nonpolar, diatomic, neutral molecules:
  - There is still a weak attraction between the electrons of one molecule of iodine and the protons of another.
  - This attraction is called *Van der Waals Forces* or *London Dispersion Forces*.
- Many scientists consider Van der Waals Forces to be caused by temporary dipoles that form as the electrons move.

More on Van der Waals Forces

- Look at the phases of the elements in the halogen family.
- Under normal conditions (STP), fluorine and chlorine are gases, bromine is a liquid, and iodine and astatine are solids.



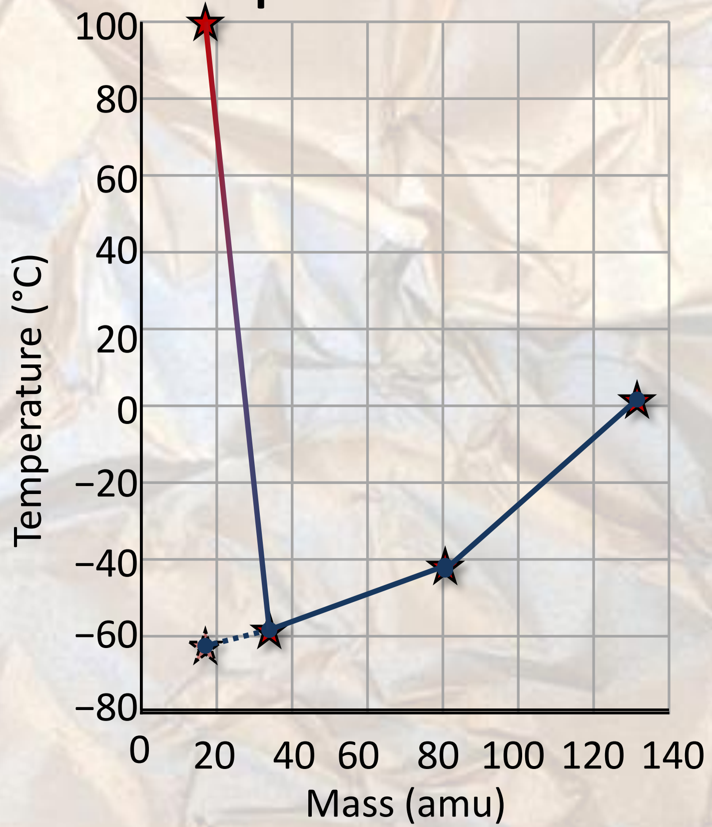
- They are all diatomic, nonpolar molecules. What accounts for the differences in boiling points?

As the size of an atom or molecule increases, so does the Van der Waals force of attraction.

Evidence for Other Bonds

- Consider the following family of compounds:

Compound	Mass (amu)	Boiling Point (°C)
H_2Te	130	1
H_2Se	81	−40.1
H_2S	34	−60.2
H_2O	18	100?



- The boiling points decrease with mass as expected.
- You'd expect water to have the lowest boiling point.
- But it doesn't! Why not!?

Hydrogen Bonds

- Water's high boiling point is evidence for intermolecular forces much stronger than Van der Waals forces. . ., but why?
- Determine the electronegativity differences in the following compounds.
- Water is a very polar molecule.

Compound	Electronegativity		
	Metal	Nonmetal	Difference
H_2Te	2.1	2.1	0.0
H_2Se	2.1	2.6	0.5
H_2S	2.1	2.6	0.5
H_2O	2.1	3.4	1.3

- Water molecules form a strong dipole-dipole attraction called a ***hydrogen bond***.

Forming Hydrogen Bonds

- Hydrogen bonds form between molecules with small electronegative elements such as nitrogen (N), oxygen (O), or fluorine (F), and hydrogen.
- The electropositive hydrogen is strongly attracted to the electronegative nitrogen, oxygen, or fluorine.