BONDING

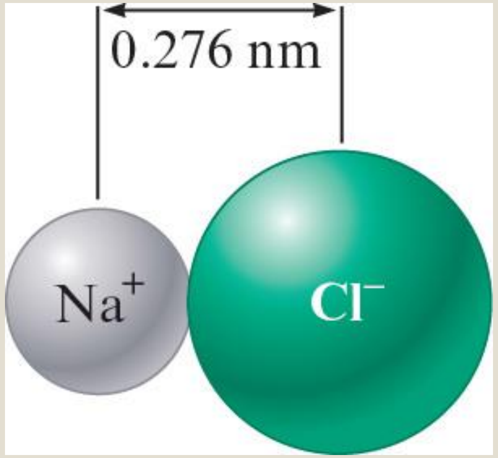
General concepts

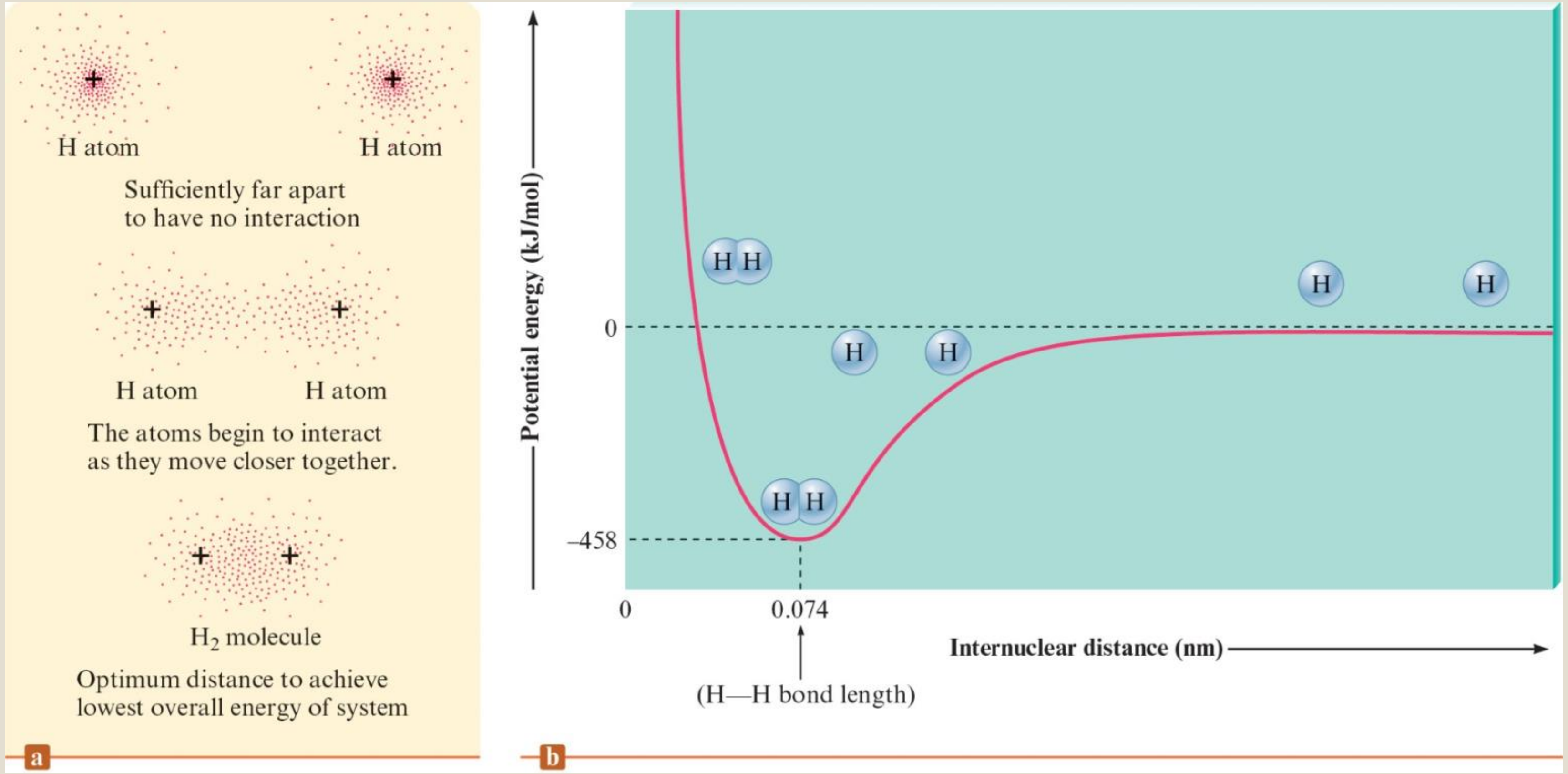
Bonding concepts

- Bonding involves models – constructs to make sense of physical phenomena
- Bonding – forces that cause groups of atoms to behave as units
- Bonding – results from tendency of system to move towards lowest potential energy
- THEREFORE – the formation of bonds always RELEASES energy and the breaking of bonds always TAKES energy

Bonding basics

- **Bond energy** - Energy needed to break a bond
- **Driving force** = lowering of potential energy of system
- **Potential energy** = energy of position
- Potential energy = sum of electromagnetic **attractions** and **repulsions** among charged particles





Notice:

1) Zero point set arbitrarily at internuclear distance = ∞
2) Energy of minimum point (bottom of dip) = bond dissociation E
3) Internuclear distance of min. point = bond length
4) **Bond length** = distance at which potential energy is lowest

Coulomb's law (again)

- In terms of energy:

$$E = k\,\frac{q_1 q_2}{r}$$

- In terms of force:

$$F = k\,\frac{q_1 q_2}{r^2}$$

Energy = ability to do work

Work = F • distance

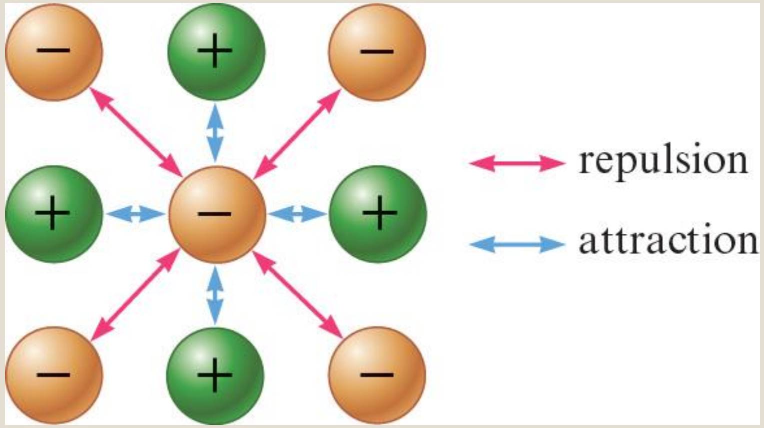
F = E/distance

Bond types

- Ionic
- Polar covalent
- (non-polar) covalent
- Metallic
- Covalent network

Ionic

- Electrons given and taken by atoms
- Full charges on atoms result
- Oppositely charged IONS (charge atoms) attract
- Crystalline structure to minimize potential energy
- See Ionic bonding presentation

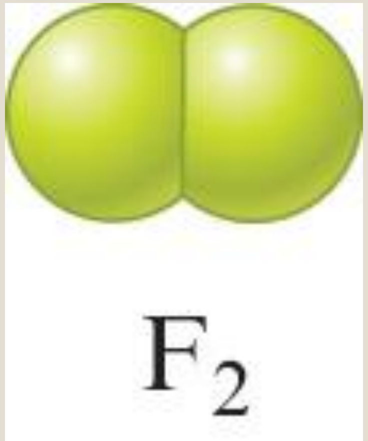


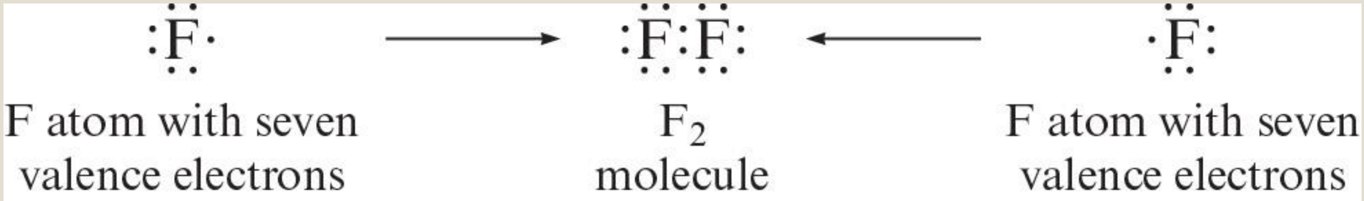
ELECTRONEGATIVITY

Evaluating bond character

Non-polar covalent

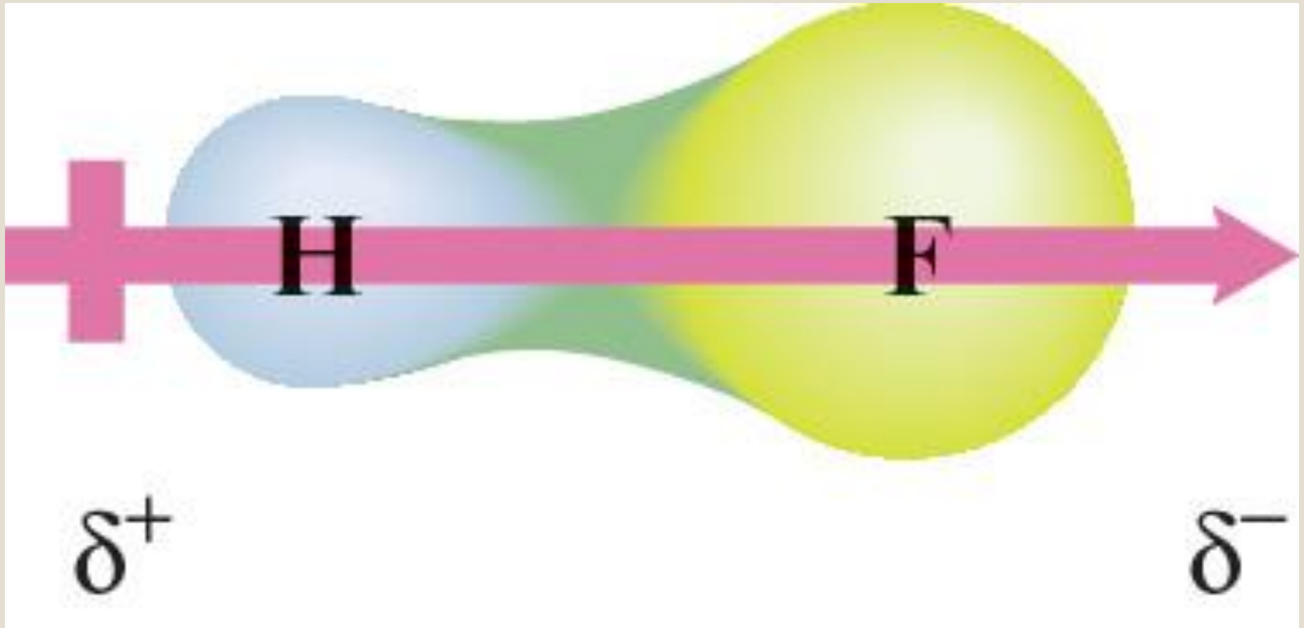
- Attraction of one atomic nucleus for another atom's electrons and vice versa
- The two attractions are very close in magnitude
- Electrons shared in pairs between atoms





Polar covalent

- Unequal sharing of electron pairs
- Partial charges result
- Remember notation



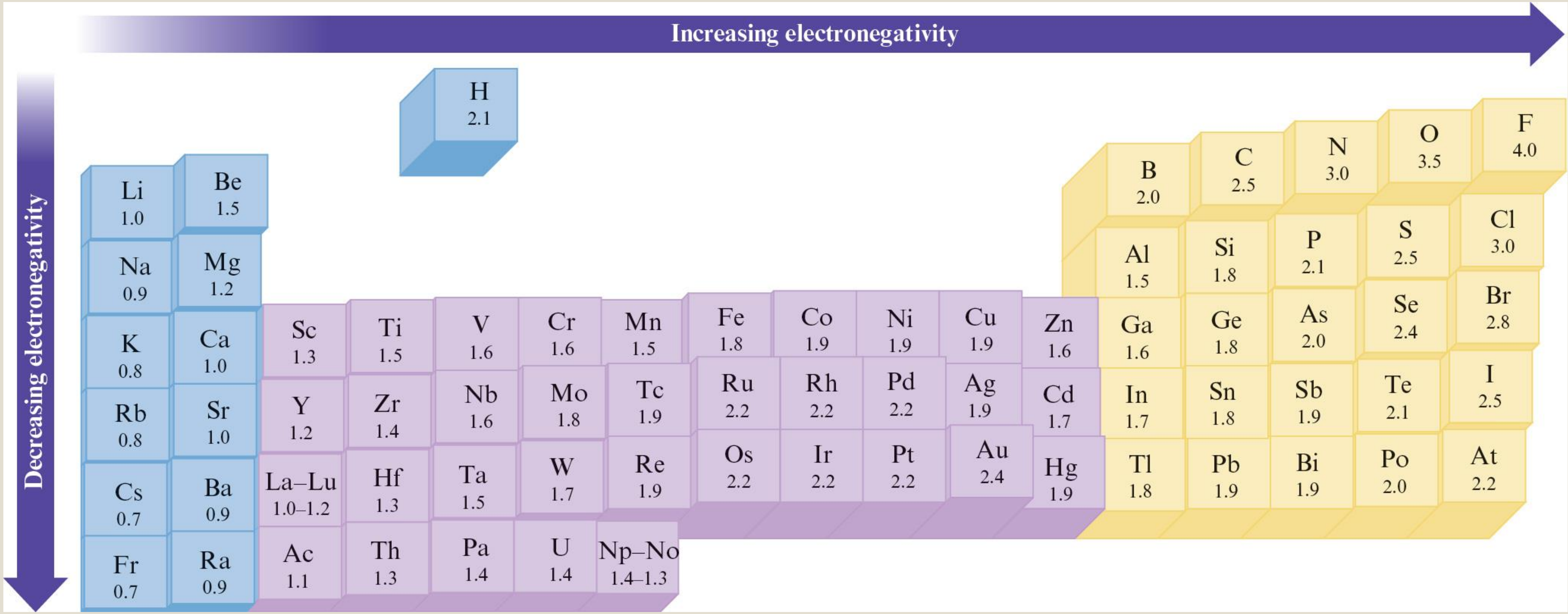
Electronegativity

- Quantify (put a number to) how “grabby” an atom is for electrons
- Construct to understand that bond type is continuum, not discrete

TABLE 8.1 | **The Relationship Between Electronegativity and Bond Type**

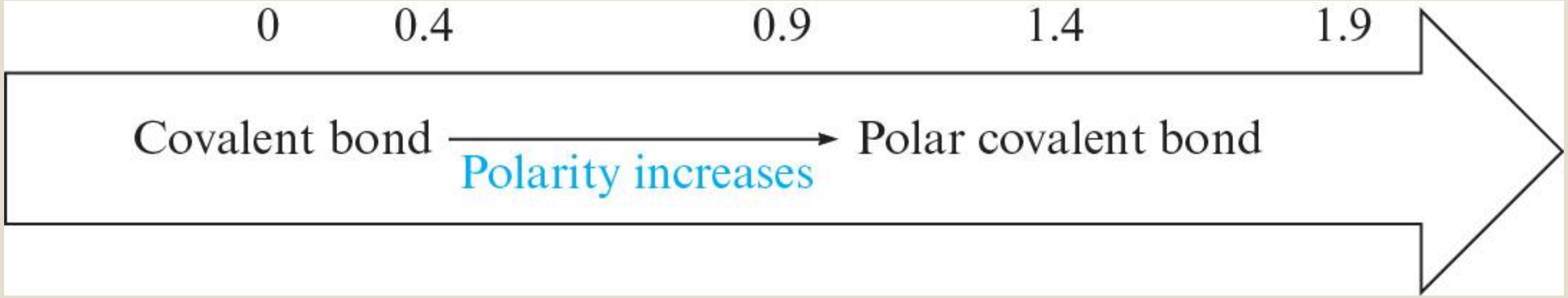
Electronegativity Difference in the Bonding Atoms	Bond Type	
Zero	Covalent	Covalent character
↓	↓	
Intermediate	Polar covalent	
↓	↓	
Large	Ionic	Ionic character

Trends in electronegativity



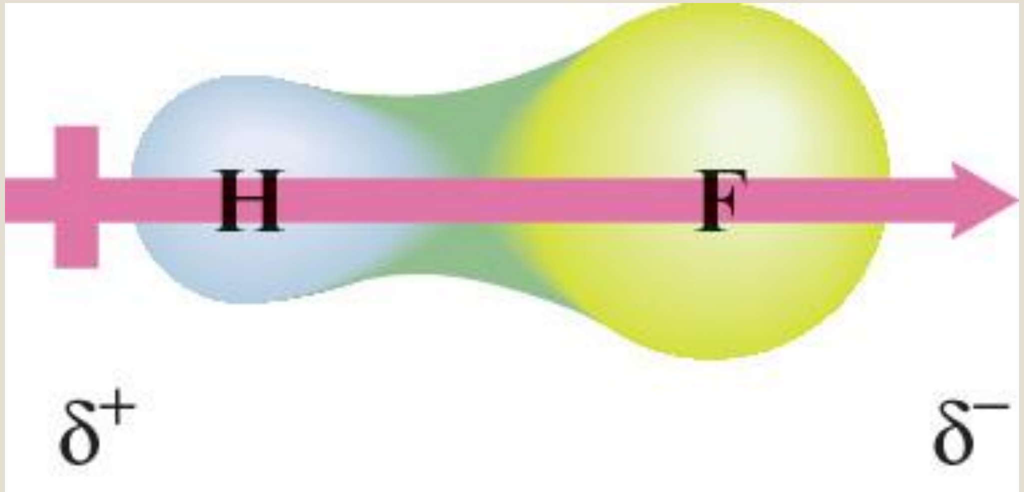
Bond polarity

- Predict/explain with electronegativity (e-n) differences



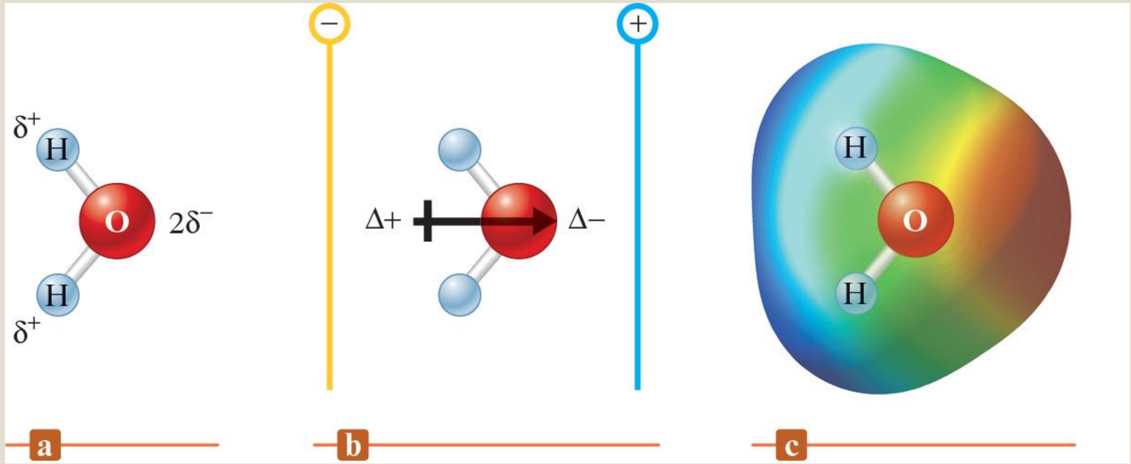
Bond polarity

- Two centers of charge δ^+ and δ^-
- Polarity measured as **dipole moment**
- **Dipole moment** = Q • d
  - Q = charge at either end
  - d = distance between charges
- ↑ e-n difference, ↑ Q, ↑ bond polarity
- ↑ distance, ↑dipole moment, ↑ bond polarity

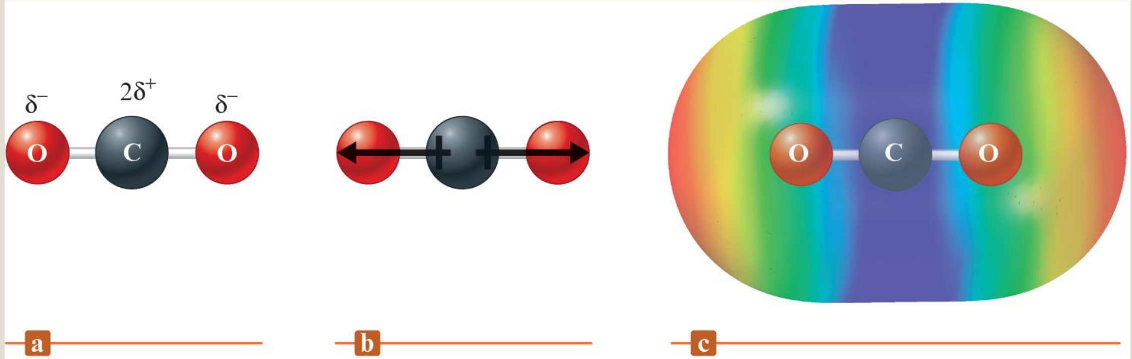


Molecule polarity

- Molecule dipole moment
  - Must have polar bonds
  - That don’t cancel out



water – polar



carbon dioxide – non-polar

Octet rule generalization

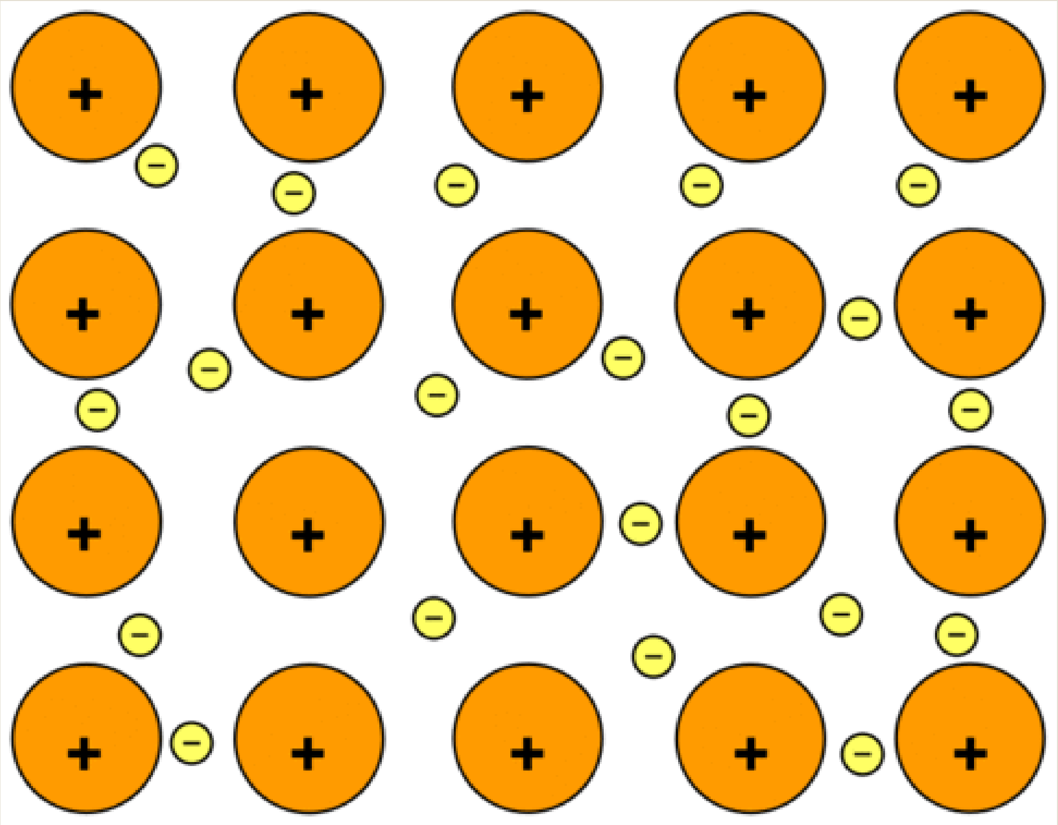
- Two *non-metals* share electrons so both atoms end up with noble gas configurations (ns^2p^6) **covalent**

- A *non-metal* and *representative group metal* take and give electrons, respectively, so each atom ends up with noble gas configuration (ns^2p^6) **ionic**

METALLIC

Socialism in chemistry!

Electrons shared by all



- Orange represents **cations** of a metallic element
  - Each cation is the nucleus AND all the inner electrons of the metallic atom
- Yellow represents **electrons**
  - These electrons are the **valence** (outer) electrons from all the metallic atoms
- **REMEMBER** the metal still has an overall neutral charge. None of the electrons have been lost and so there are still as many protons as neutrons

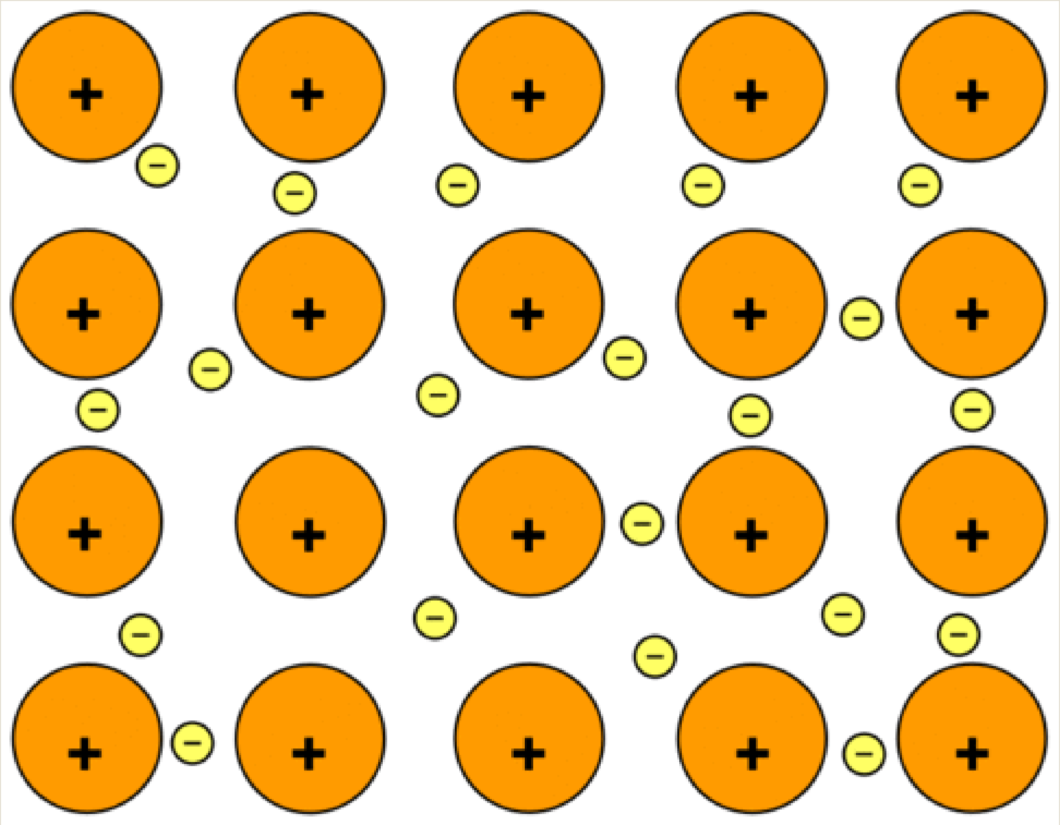
Observed characteristics

Metallically bonded substances

- Conduct electricity as solids and as liquids
- Conduct heat easily
- Can be beaten into sheets (malleable) and pulled into wire (ductile)
- Require relatively high temperatures for melting
- Tend to be shiny

Alloys

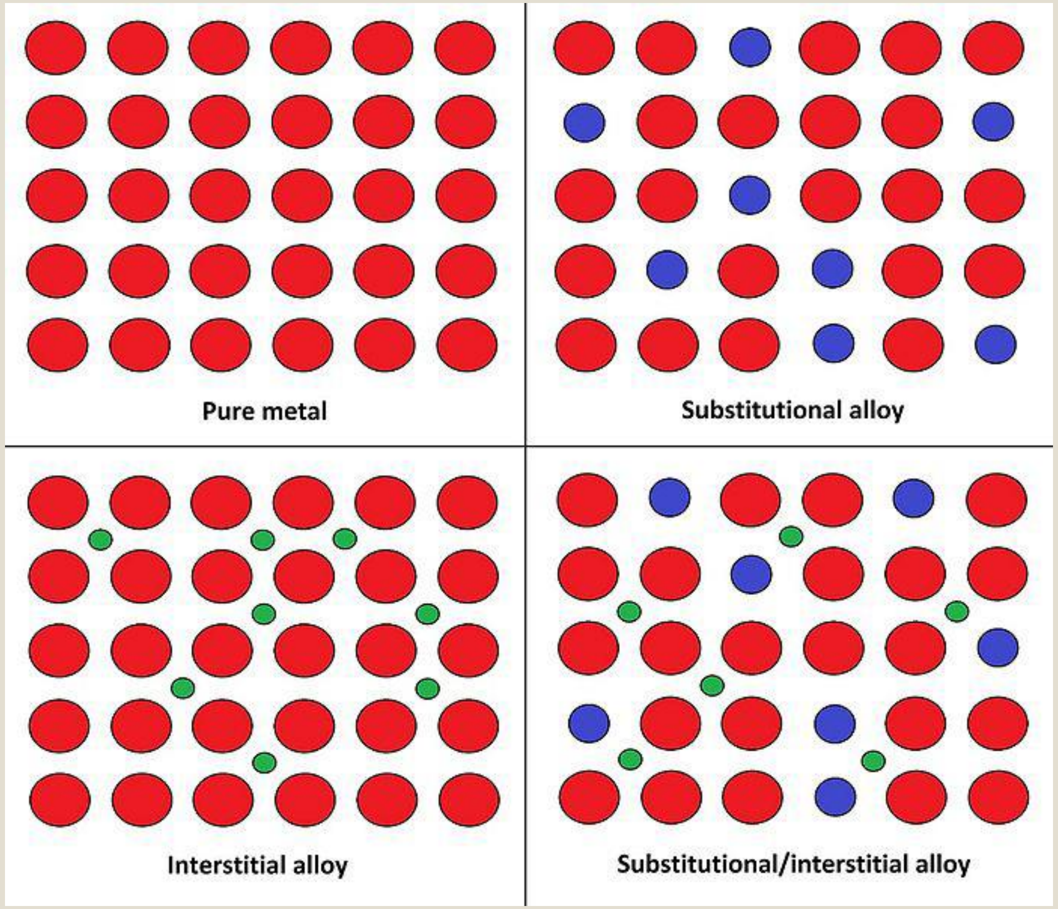
- Two or more elements combined with metallic bonding
- This means the orange cations would not all be the same element
- But the valence electrons are still all delocalized and thus shared by all the atoms present



Examples alloy types

- **Substitutional –** metal atoms of similar size & electronegativity Ex: brass (Zn & Cu), bronze (Sn & Cu)
- **Interstitial –** much smaller atoms inserted into spaces within metal cation lattice

  Ex. Steel (Fe with little C atoms in spaces)
- **Both –** Ex. Stainless steel (Fe & Cr with little C atoms)



NOTE: delocalized electrons NOT shown

Alloy advantages

Components can be chosen to give desired characteristics

- Can be made harder
- Can be made to hold an edge (think about swords)
- Can manipulate melting point (like in solder or fuses)
- Can deter oxidation