Hewitt/Lyons/Suchocki/Yeh

Conceptual Integrated Science

Chapter 12
THE NATURE OF CHEMICAL BONDS

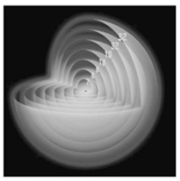
Electron Shells

- Atoms bond together through their electrons. To learn about bonding, therefore, we need to know something about how the electrons within an atom are organized.

Electron Shells

- Electrons behave as though they are contained within a series of seven concentric shells.

The numbers indicate the maximum number of electrons each shell may contain.



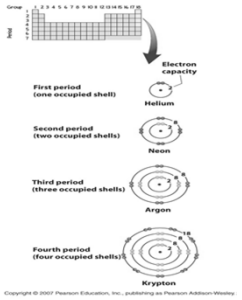
Note:

This is a "conceptual model" and not a representation of what an atom "looks like." Rather, it helps us to understand how the electrons within atoms behave.

Electron Shells

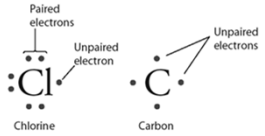
The shells are more easily drawn in two dimensions.

Each atom has its own configuration of electrons. Elements in the same group have similar configurations, which is why they have similar properties.



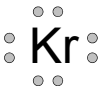
Electron Shells

- Valence electrons: Electrons in the outermost shell of an atom. These are the ones that can participate in chemical bonding.
- Electron-dot structure: A notation showing the valence electrons surrounding the atomic symbol.

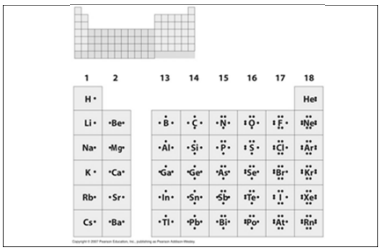


Special Note on Valence Electrons

- For heavier atoms, some valence electrons are more available than others.
- Krypton, for example, has 18 valence electrons, but only eight of these are typically shown within an electron-dot structure.



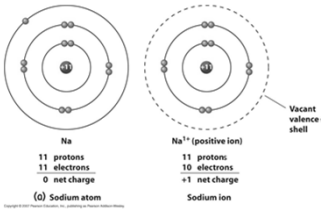
Electron Shells



The Ionic Bond

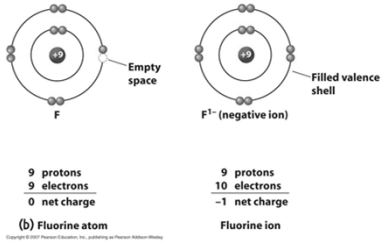
- Ion: An atom that has lost or gained one or more electrons.

An Example – Positive Ion



The Ionic Bond

An Example – Negative Ion



The Ionic Bond

- Ionic Bond: The electrical force of attraction between oppositely charged ions.
- The completed bond will have a balance of electrical charges.
- In this case, sodium (Na) and fluorine (F) will make NaF or Sodium Fluoride.

Na^+ F^-

The Ionic Bond

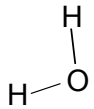
- Another Example: In this case, calcium (Ca) and fluorine (F) will make CaF_2 or Calcium Fluoride.

F^-

Ca^{+2}

F^-

The Ionic Bond



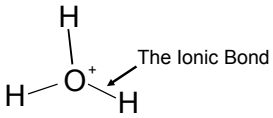
Water

H^+

Hydrogen ion

- Molecular ion: Typically formed by the loss or gain of a hydrogen ion, H^+.

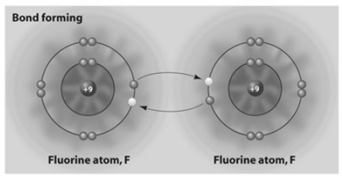
The Ionic Bond

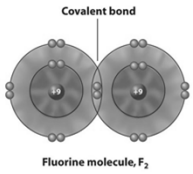


Hydronium ion, H_3O^+

The Covalent Bond

- The type of electrical attraction in which atoms are held together by their mutual attraction for shared electrons.





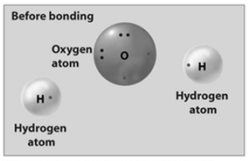
The Covalent Bond

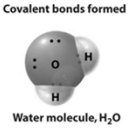
- There are two electrons within a single covalent bond.
- The covalent bond is represented using a straight line.

F — F

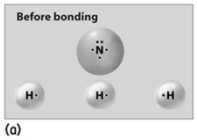
The Covalent Bond

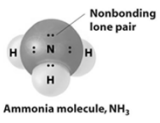
- The number of covalent bonds an atom can form equals its number of unpaired valence electrons.

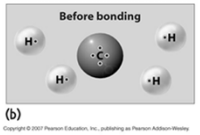




The Covalent Bond

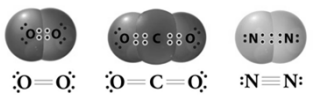






The Covalent Bond

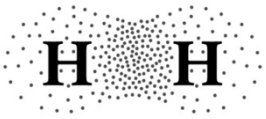
- Multiple covalent bonds are possible.



Polar Bonds and Polar Molecules

- Electrons within a covalent bond are shared evenly when the two atoms are the same.

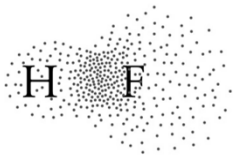
H : H



Polar Bonds and Polar Molecules

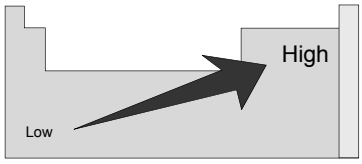
- They may be shared *unevenly*, however, when the bonded atoms are different.

H : F



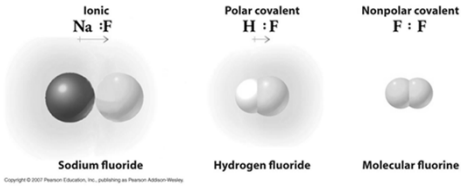
Polar Bonds and Polar Molecules

- Electronegativity: The ability of a bonded atom to pull on shared electrons. Greater electronegativity means greater "pulling power."



Polar Bonds and Polar Molecules

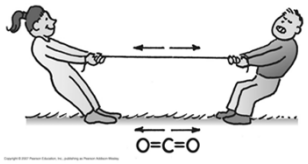
- This may lead in some cases to polar covalent molecules that are more negative on one end than the other.



Polar Bonds and Polar Molecules

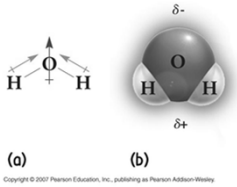
- But if polar bonds within a molecule are facing in equal and opposite directions…

…then the polarity may cancel itself out.



Polar Bonds and Polar Molecules

- The polarity may, however, may not cancel itself out.

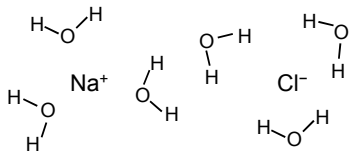


The polarity of water leads to certain properties.

Interparticle Attractions

- *Ion–dipole*

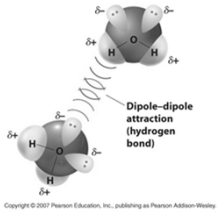
  The attraction between an ion and a dipole.
  Example: NaCl in water.



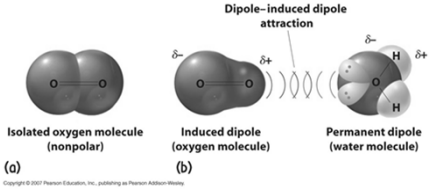
Interparticle Attractions

- *Dipole–dipole*

  The attraction between two dipoles.
  Example: cohesive forces within water.



Interparticle Attractions



Dipole–induced dipole

The attraction between a dipole and an induced dipole.

Integrated Science—Physics

What do the ions of these elements have in common?

Sodium
Calcium
Magnesium
Fluorine
Iron
Potassium
Chlorine
Lead
Mercury
Cadmium

To different extents, they are commonly found in drinking water.

Mixtures

- *Pure substance*

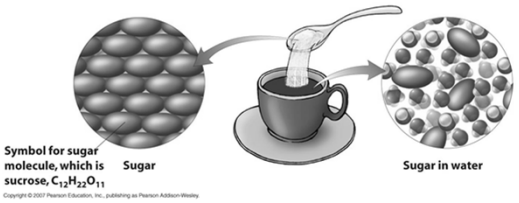
  A material consisting of only one type of element or compound.

- *Mixture*

  A collection of two or more pure substances.
  - homogeneous (single phase)
  - heterogeneous (multiple phases)

Solutions

- Solution: A homogenous mixture consisting of ions or molecules



Solutions

- Solution: A homogenous mixture consisting of ions or molecules
- Solvent: The major component of a solution.
- Solute: The minor components of a solution.
- Saturated: Said of a solution in which no more solute will dissolve.

Solutions

- Concentration: A measure of the amount of solute dissolved in solution.

$$\text{Concentration} = \frac{\text{Solute}}{\text{Solution}}$$

"dilute"

Solutions

- Mole: A large number, 6.02×10^{23}, used to measure numbers of atoms or molecules, a.k.a. Avogadro's number.

The formula mass of a substance expressed in grams contains one mole.

Substance	Formula Mass
Carbon, C	12
Oxygen, O_2	32
Carbon dioxide, CO_2	44
Sucrose, $C_{12}H_{22}O_{11}$	342

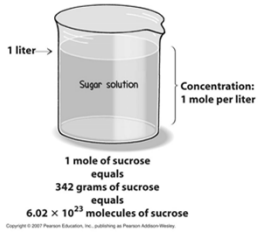
Solutions

- Molarity:

A unit of concentration expressed in moles solute per liter of solution.

$$\text{Molarity} = \frac{\text{Moles of Solute}}{\text{Liters of Solution}}$$

Solutions



A 1 Molar Solution (1 M) contains Avagadro's number of atoms or molecules of solute per liter of solution.

Sucrose, $C_{12}H_{22}O_{11}$ = 342 g/mole

Solutions

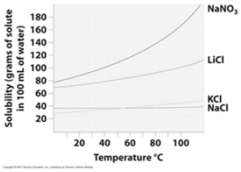
- ppm ("parts per million):

A unit of concentration expressed in milligrams of solute per liter of solution.

$$1 \text{ ppm} = \frac{1 \text{ part solute}}{1{,}000{,}000 \text{ parts solution}} = \frac{1 \text{ milligram solute}}{1 \text{ liter solution}}$$

Solubility

- Solubility: The ability of a solute to dissolve in a solvent; temperature and material dependent.
- Soluble: Said of a solute that has appreciable solubility.



Solubility

- Precipitate: Solute that comes out of solution.