Atomic Bonding and Molecules

Chapter 15

Bonding of atoms makes molecules

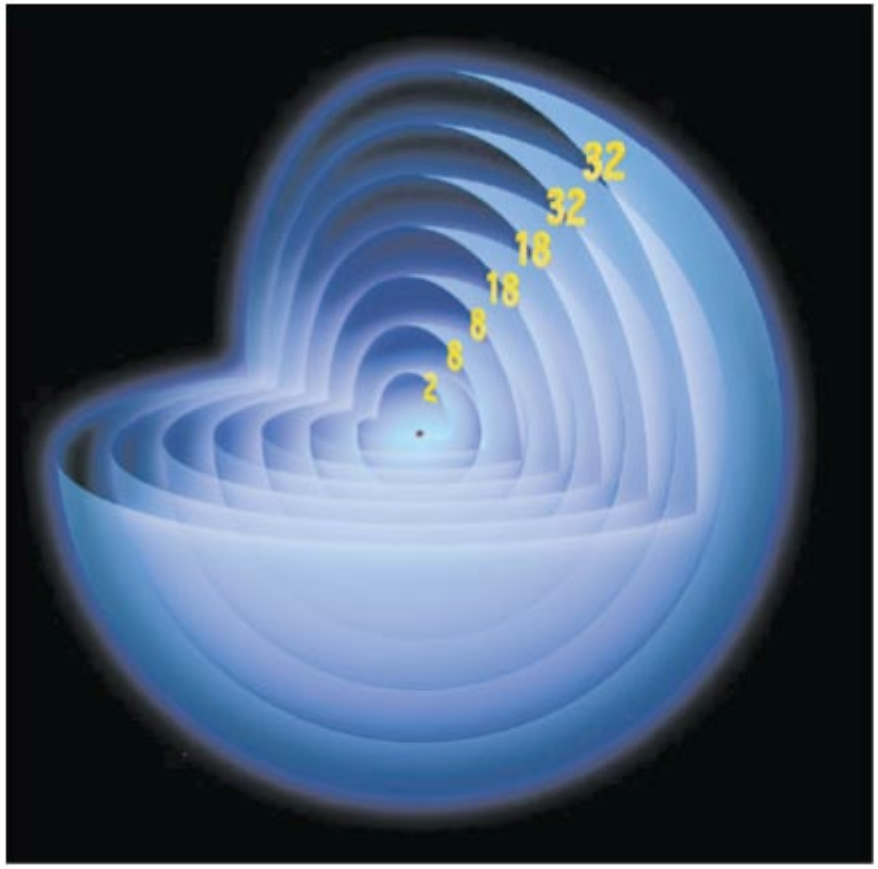
- The Formation of Ions and Ionic Bonds
- Types of bonds
  - Metallic Bonds
  - Covalent Bonds
  - Polar Covalent Bonds
- Molecular Polarity and Molecular Attractions

Causes of bonding

- Atoms bond together through their electrons
- Electrons behave as though they are contained within a series of seven concentric shells
- Outer shell electrons interact with electrons of other atoms
- These are the VALENCE electrons

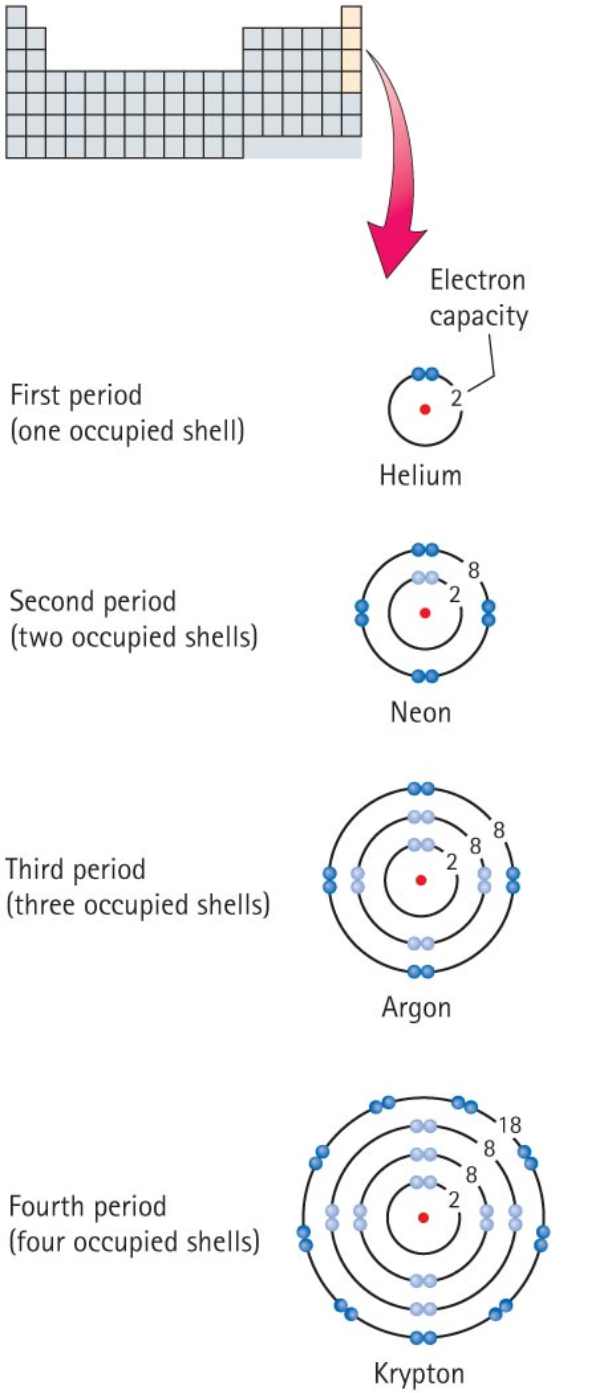
Electron Shells

- Maximum number of electrons in each shell is shown
- Inner shell fills up before next shell begins to get electrons
- Full shells are most stable



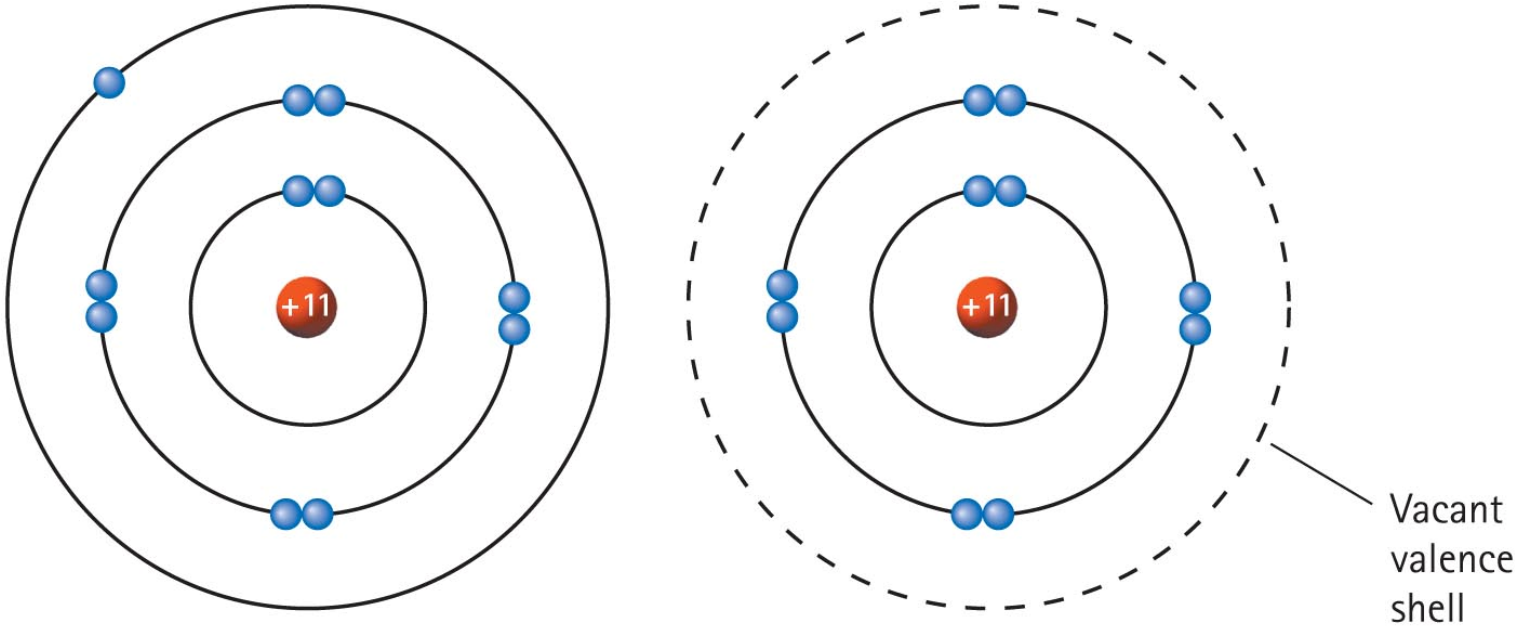
Full electron shells

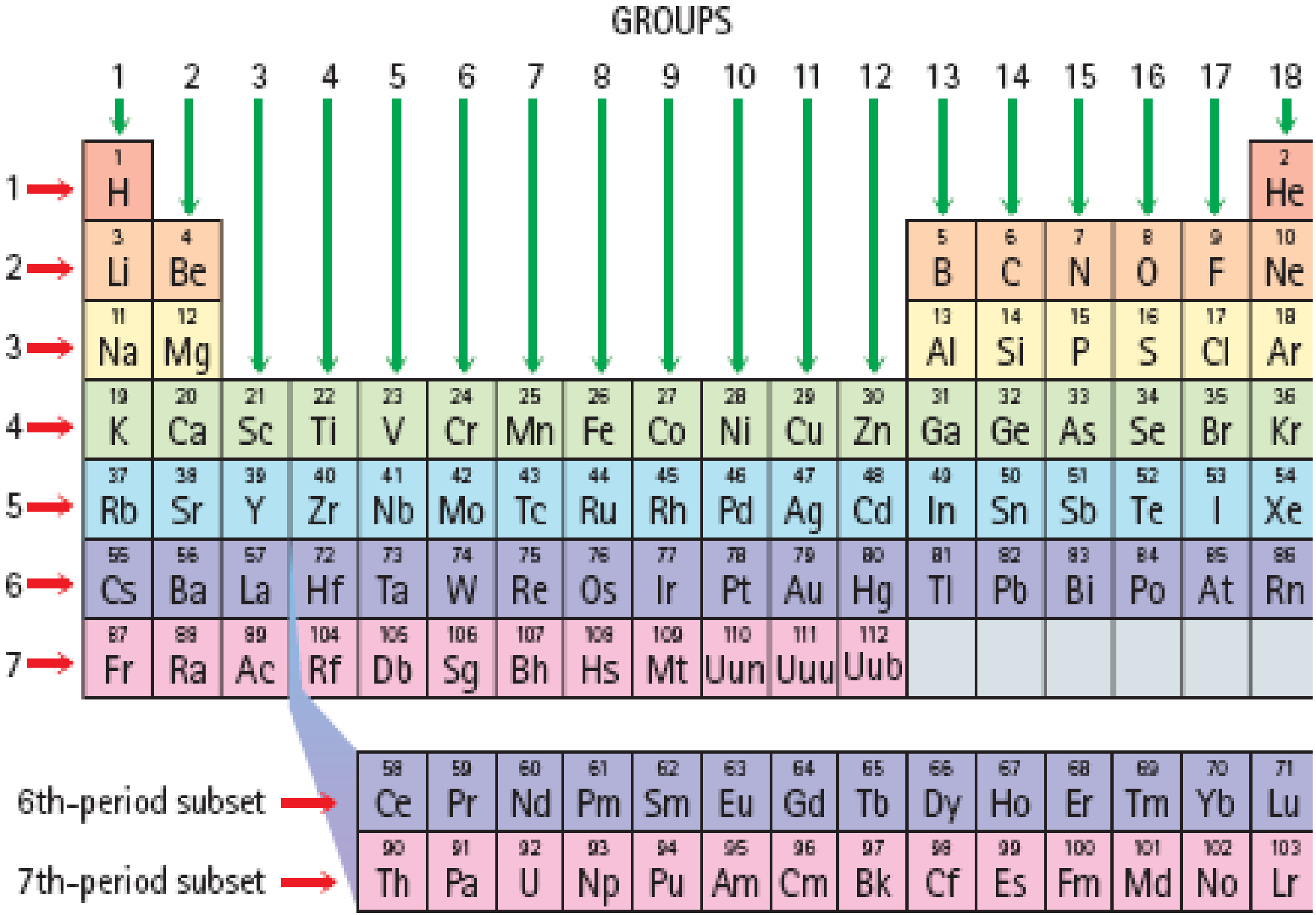
- Outer electron shells of noble gases are full



Sodium Ion Formation

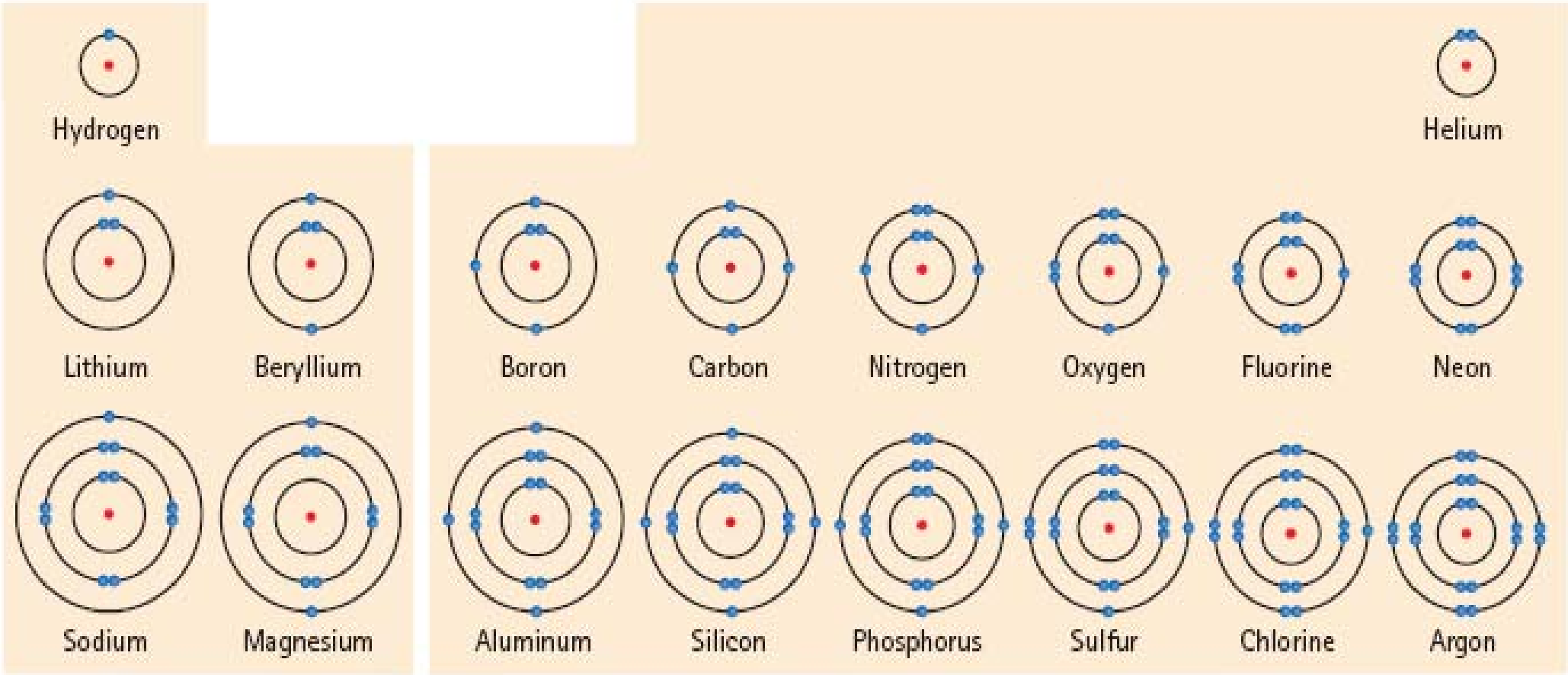
- Ion: An atom that has lost or gained one or more electrons




GROUPS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
1 H He
2 Li Be B C N O F Ne
3 Na Mg Al Si P S Cl Ar
4 K Ca Sc Ti V Cr Mn Fe Co Ni Cu Zn Ga Ge As Se Br Kr
5 Rb Sr Y Zr Nb Mo Tc Ru Rh Pd Ag Cd In Sn Sb Te I Xe
6 Cs Ba La Hf Ta W Re Os Ir Pt Au Hg Tl Pb Bi Po At Rn
7 Fr Ra Ac Rf Db Sg Bh Hs Mt Uun Uuu Uub
6th-period subset
Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu
7th-period subset
Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr

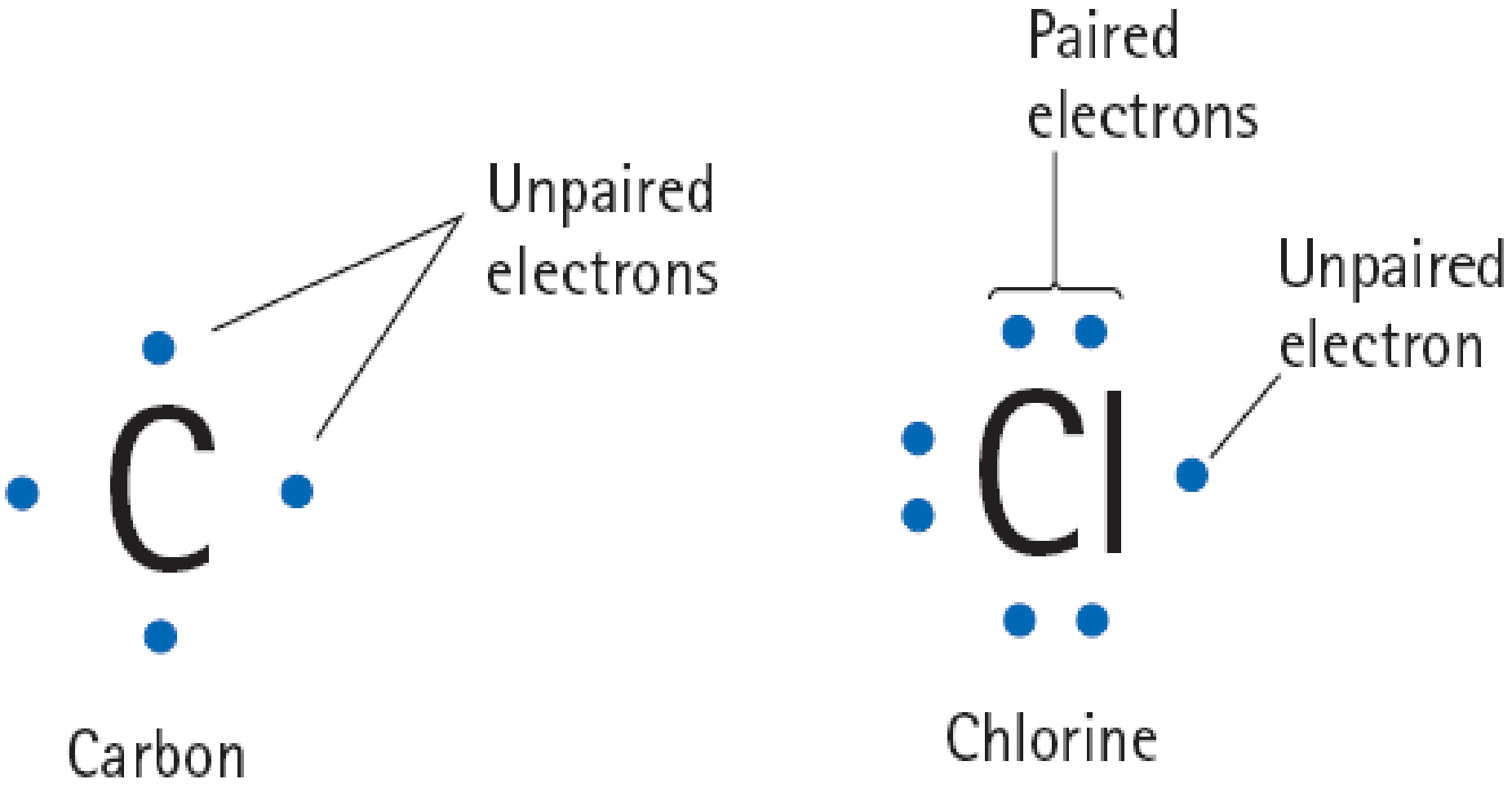
Electrons shells in periodic table

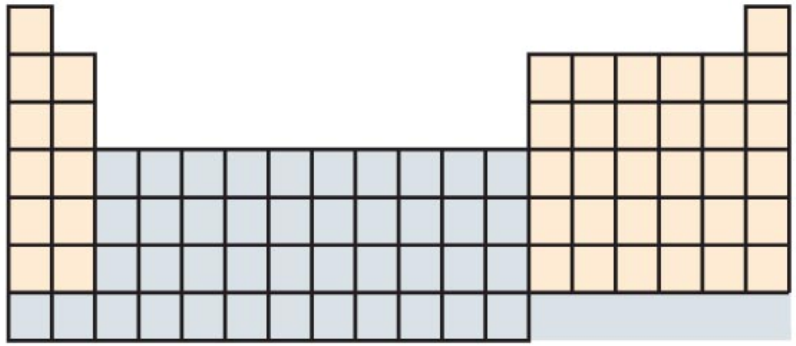
- First three periods



Electron Dot Structure

- A notation showing only the valence electrons surrounding the atomic symbol





Valence Electron dot structure for elements not in transition metal groups

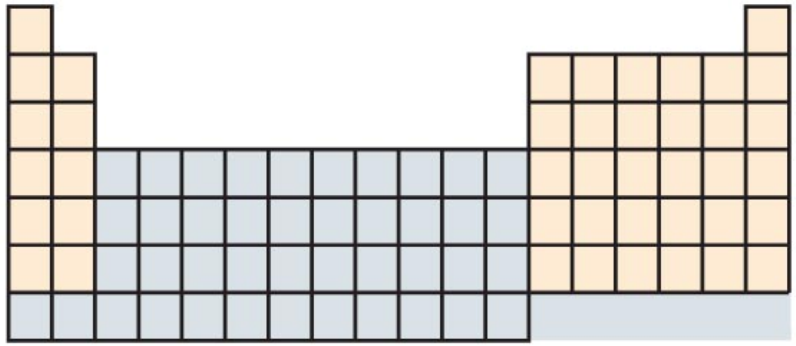
1	2	13	14	15	16	17	18
H ·							He:
Li ·	·Be·	· B ·	· C ·	· N ·	: O ·	: F ·	:Ne:
Na·	·Mg·	·Al·	·Si·	· P ·	: S ·	:Cl·	:Ar:
K ·	·Ca·	·Ga·	·Ge·	·As·	:Se·	:Br·	:Kr:
Rb·	· Sr ·	· In ·	·Sn·	·Sb·	:Te·	: I ·	:Xe:
Cs·	·Ba·	· Tl ·	·Pb·	·Bi·	:Po·	:At·	:Rn:

Ion

- An atom, molecule, or compound with a different number of protons and electrons
- More protons: positive CAT ION
  - THE t looks like a plus sign…
- More electrons: negative AN ION
  - Negative has an N in the prefix
- Both are all one word: anion, cation

Ion formation

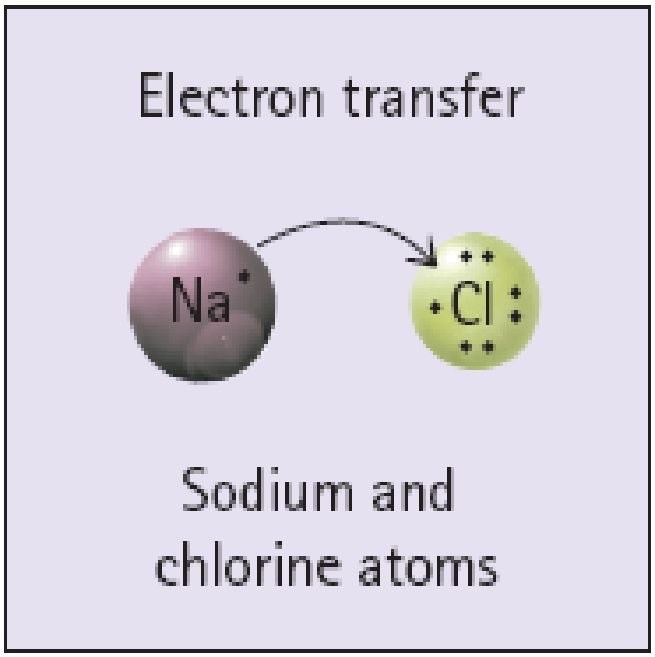
- Lose electrons
  - more protons than electrons
  - positive charge
- Gain electrons
  - More electrons than protons
  - Negative charge
- More than one can be lost or gained
- Determine by position in periodic table

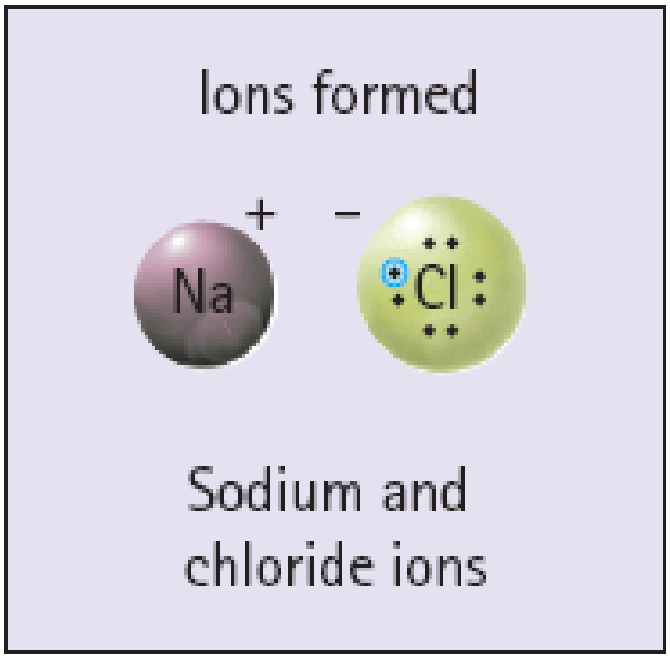


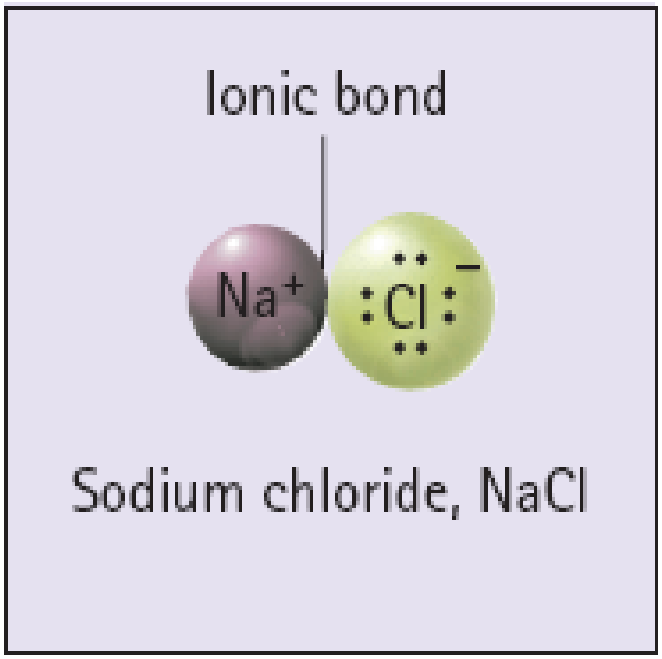
Electron dot structure pattern

1	2	13	14	15	16	17	18
H ·							He:
Li ·	·Be·	· B ·	· C ·	· N ·	: O ·	: F ·	:Ne:
Na·	·Mg·	·Al·	·Si·	· P ·	: S ·	:Cl·	:Ar:
K ·	·Ca·	·Ga·	·Ge·	·As·	:Se·	:Br·	:Kr:
Rb·	· Sr ·	· In ·	·Sn·	·Sb·	:Te·	: I ·	:Xe:
Cs·	·Ba·	· Tl ·	·Pb·	·Bi·	:Po·	:At·	:Rn:

Ionic Bonds



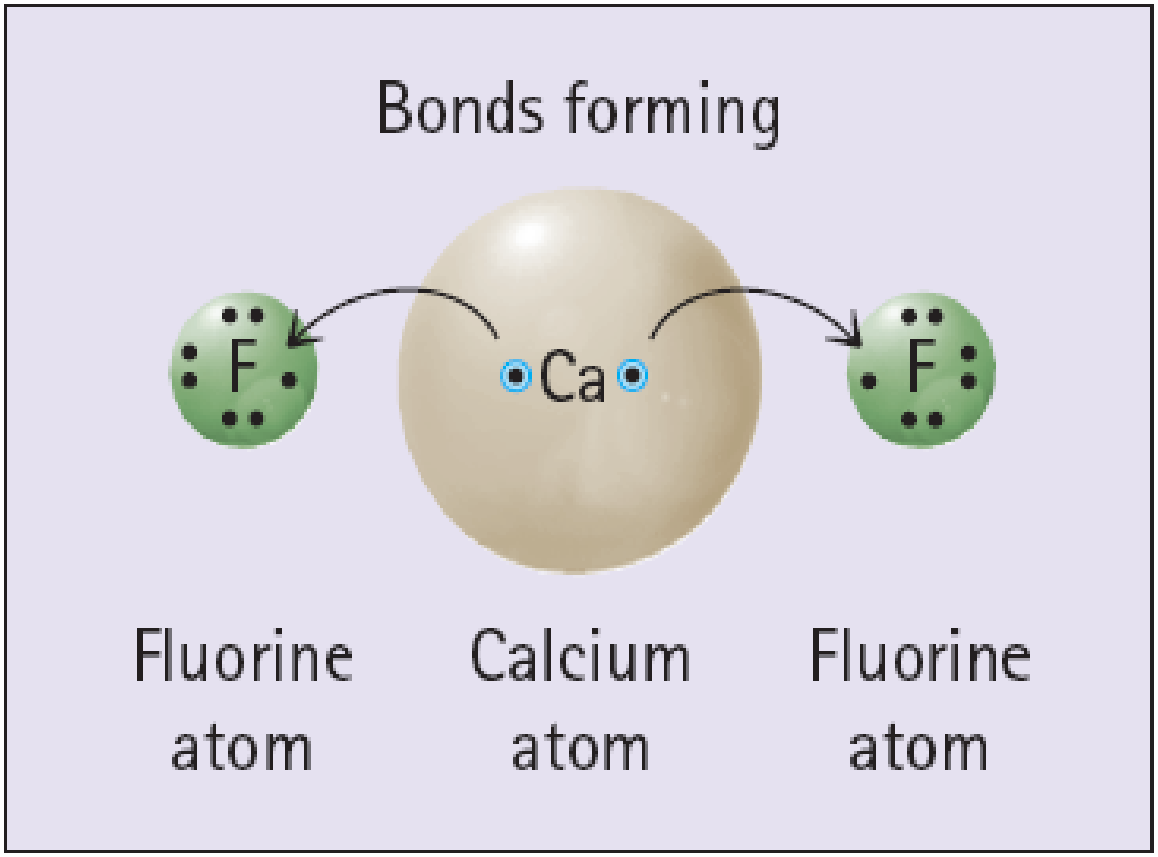


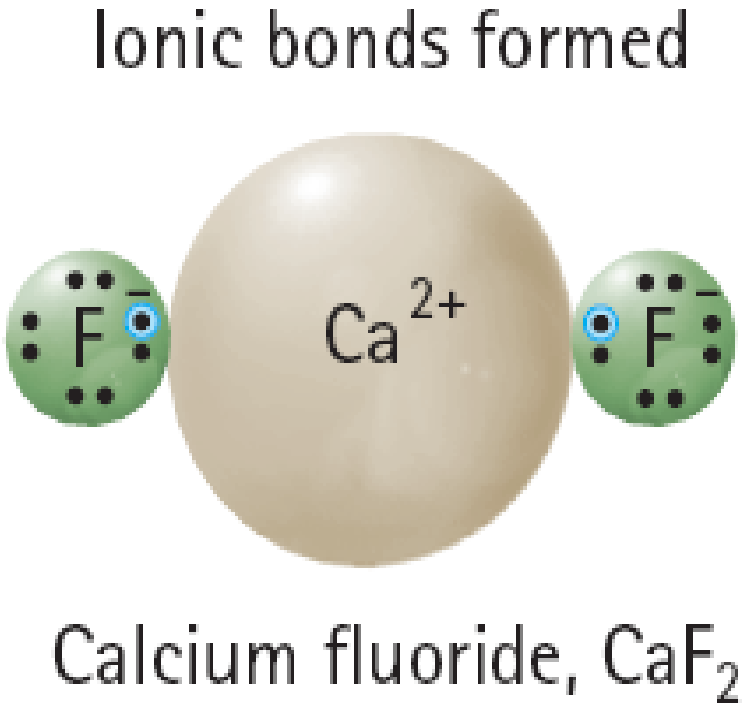


- Electrical force of attraction between oppositely charged ions

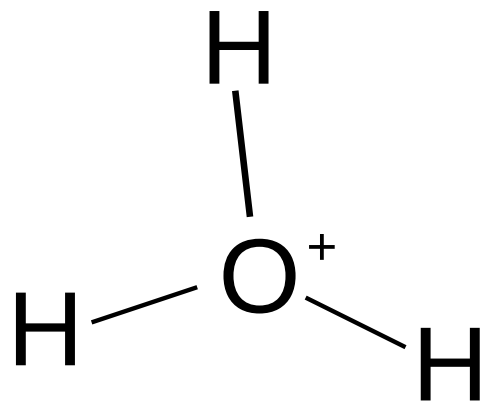
Ionic Bond Ratios

- Compounds form in ratios to neutralize charges





Molecular Ions



Water

Hydronium ion, H_3O^+

H^+

Hydrogen ion

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

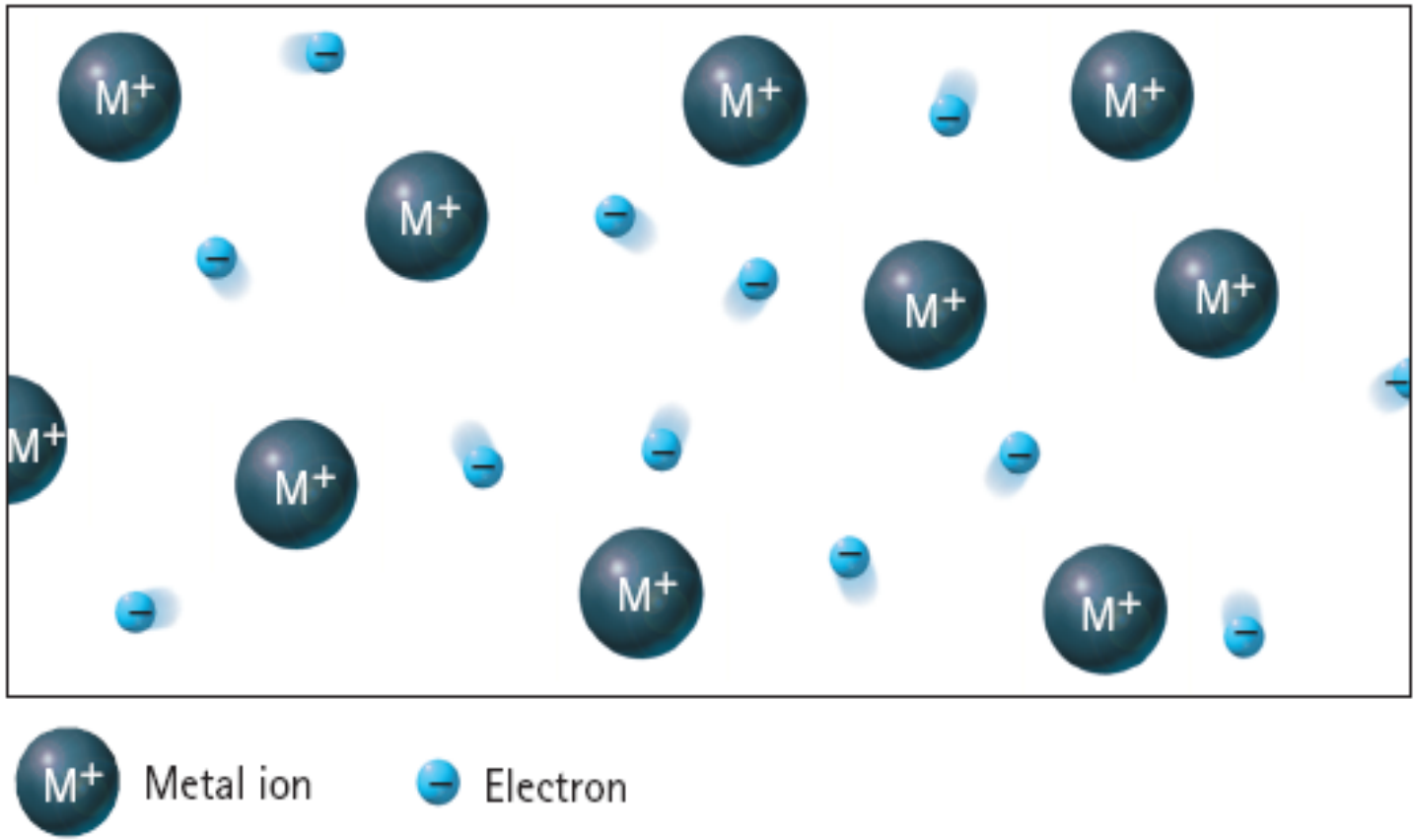
Groups of atoms forming ions

- Molecular ions
- Bonds within group are covalent

Hydronium ion	H_3O^+
Ammonium ion	NH_4^+
Bicarbonate ion	HCO_3^-
Nitrate ion	NO_3^-
Hydroxide ion	OH^-
Carbonate ion	CO_3^{2-}
Sulfate ion	SO_4^{2-}
Phosphate ion	PO_4^{3-}

Metallic Bonds

- Nucleus of metal atoms only weakly hold outer electrons
- Weak attraction allows the electrons to move from one atom to another quite freely



Metallic Properties

Mobility of electrons results in many properties of metals

- Conductive—electrons move freely
- Shiny—electrons vibrate and reflect light
- Malleable—can move with respect to one another without breaking because electrons in constant motion
- Alloys—electrons shared between unlike types of metal atoms

Metallic Alloys

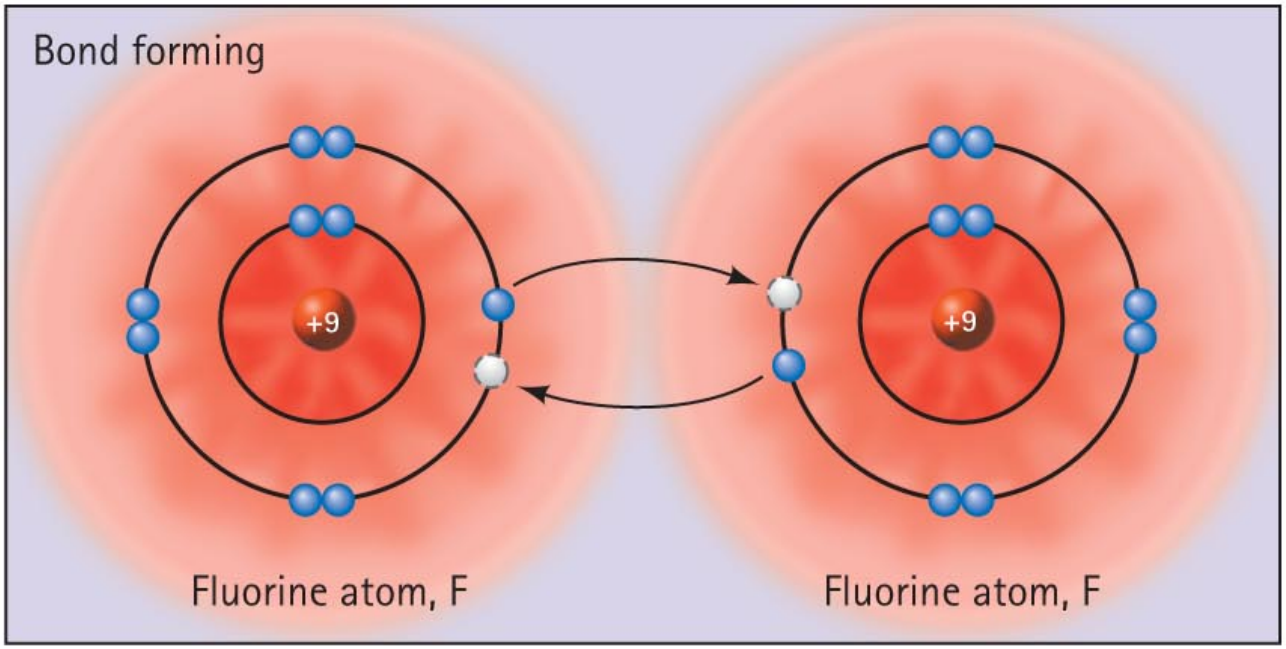
- An alloy is a mixture of metallic elements.

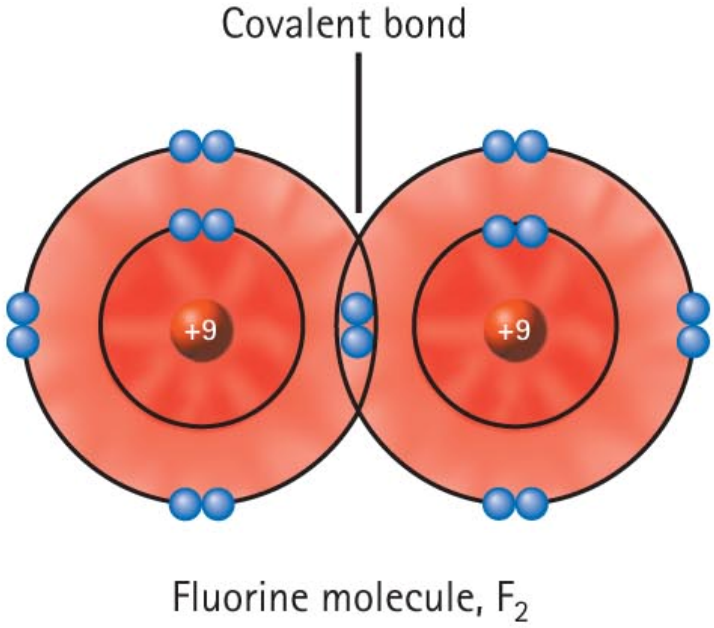
Metal Ores

- Few metals naturally occur as elements
  - Gold, copper, mercury
- Most occur as oxides and sulfides
  - Ionic compounds
  - Concentrations of these are ORE

Covalent Bonds

- Atoms are held together by their mutual attraction for shared electrons

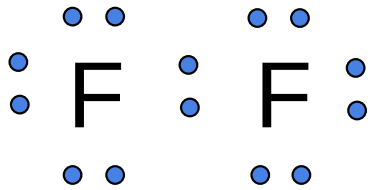




- There are two electrons within a single covalent bond

Covalent Bond Diagrams

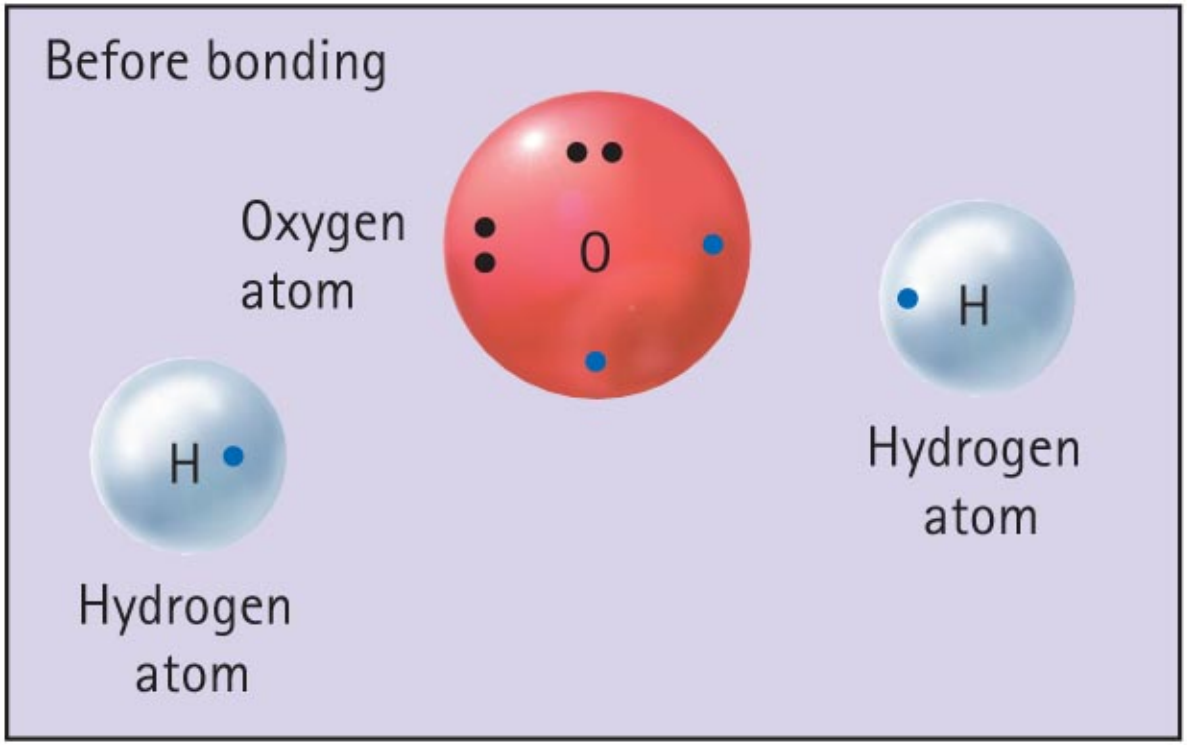
- The covalent bond is represented using a straight line

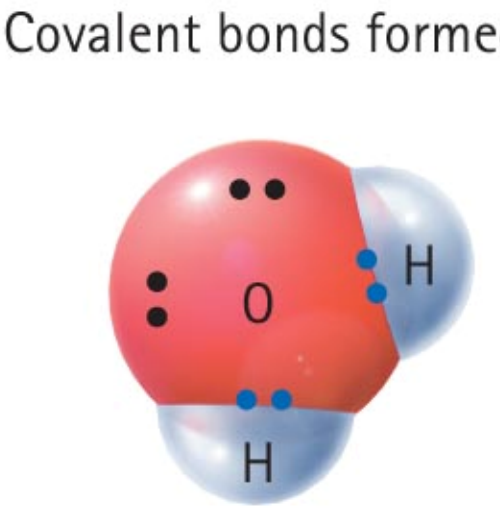


F — F

Covalent Water

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

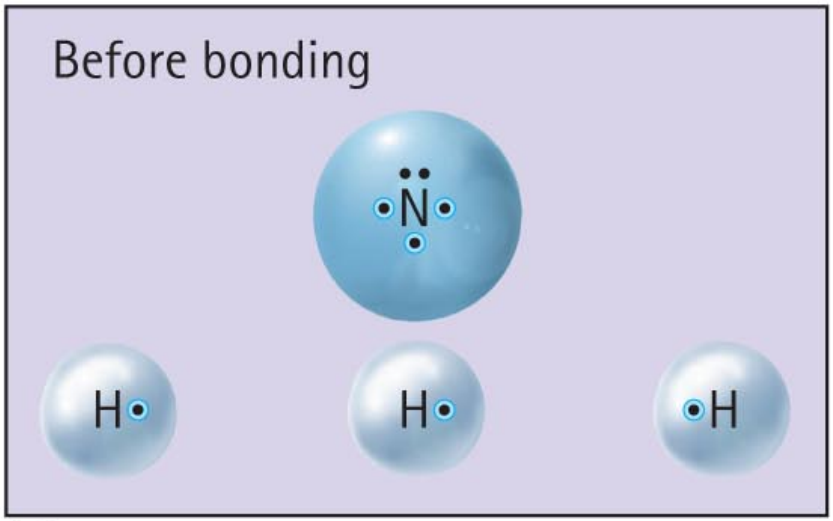




Water molecule, H_2O

Covalent Ammonia

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



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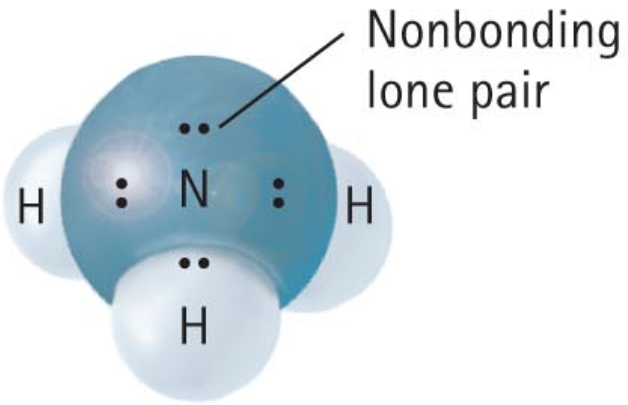
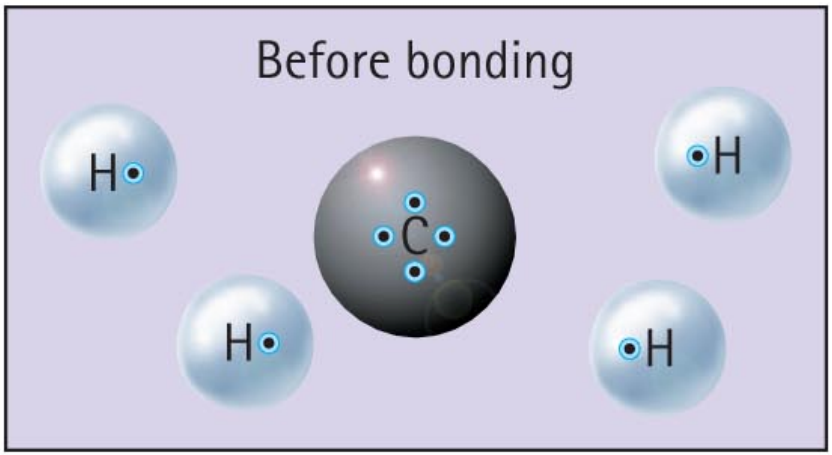


Ammonia molecule, NH_3

Covalent Methane

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



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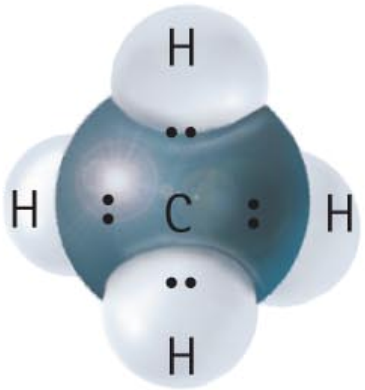
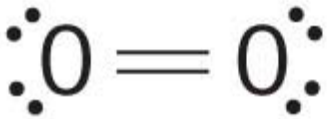


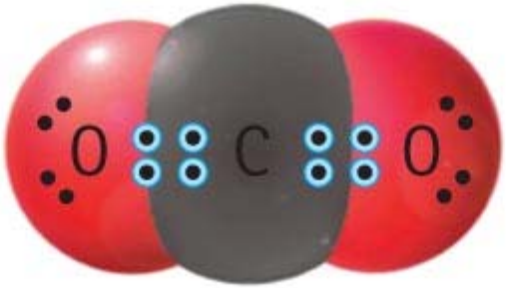
Methane molecule, CH_4

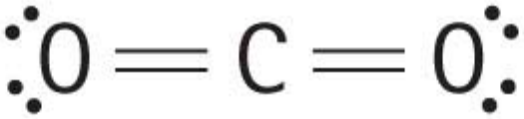
Multiple covalent bonds

- are possible if atom has more than one unpaired valence electron



Oxygen, O_2



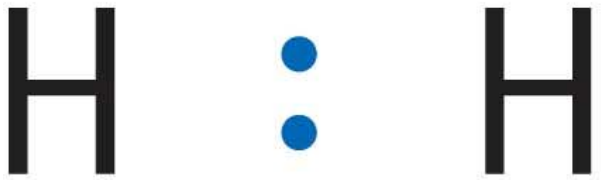


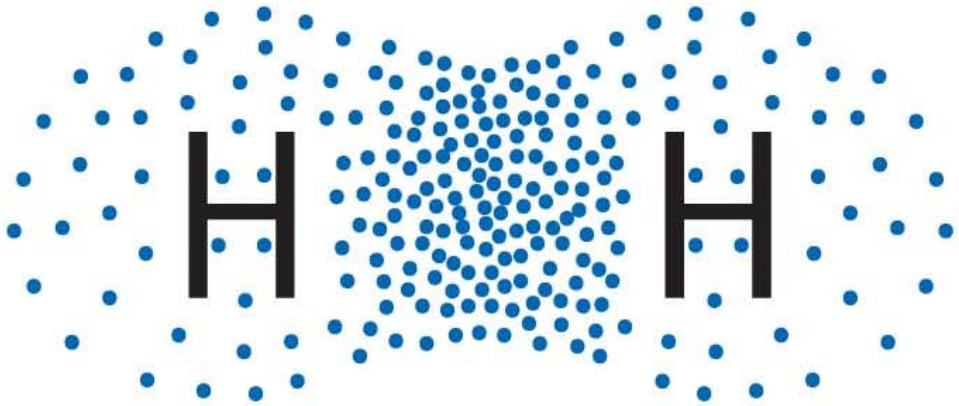
Carbon dioxide, CO_2

Nitrogen, N_2

Nonpolar Covalent Bonds

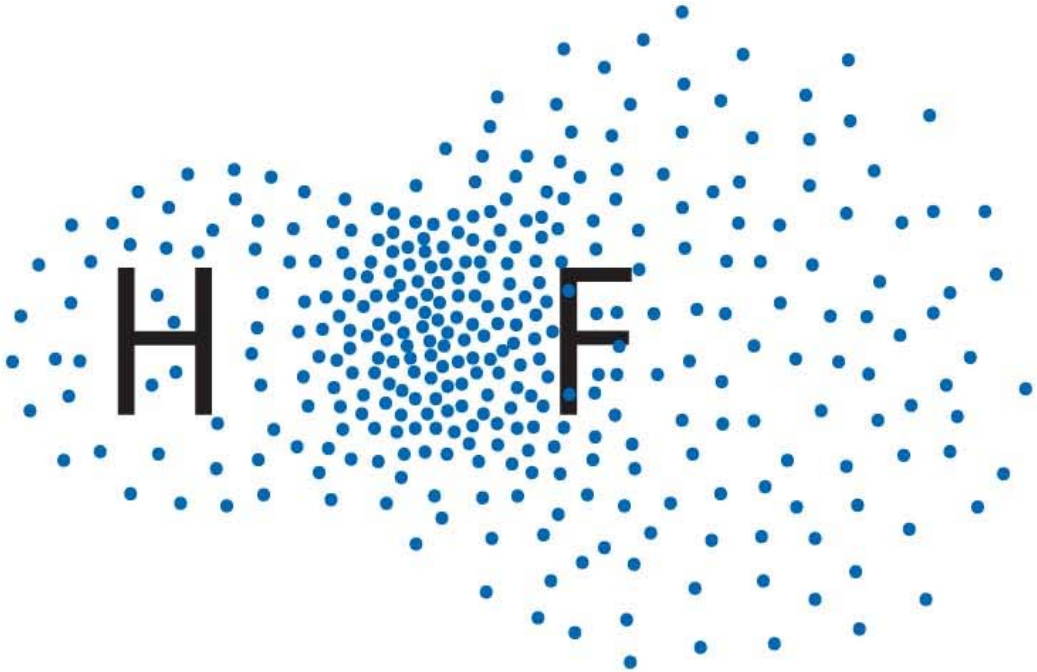
- Electrons are shared evenly when the two atoms are the same element





Polar Covalent Bonds

- Shared *unevenly* when the bonded atoms are different elements



Polar covalent bonds

- Closer together on the periodic table, less polar bond
- Further apart on the periodic table, more polar bond
- Molecules are called ‘dipoles’
- Ionic bonds are extremely polar—but not covalent