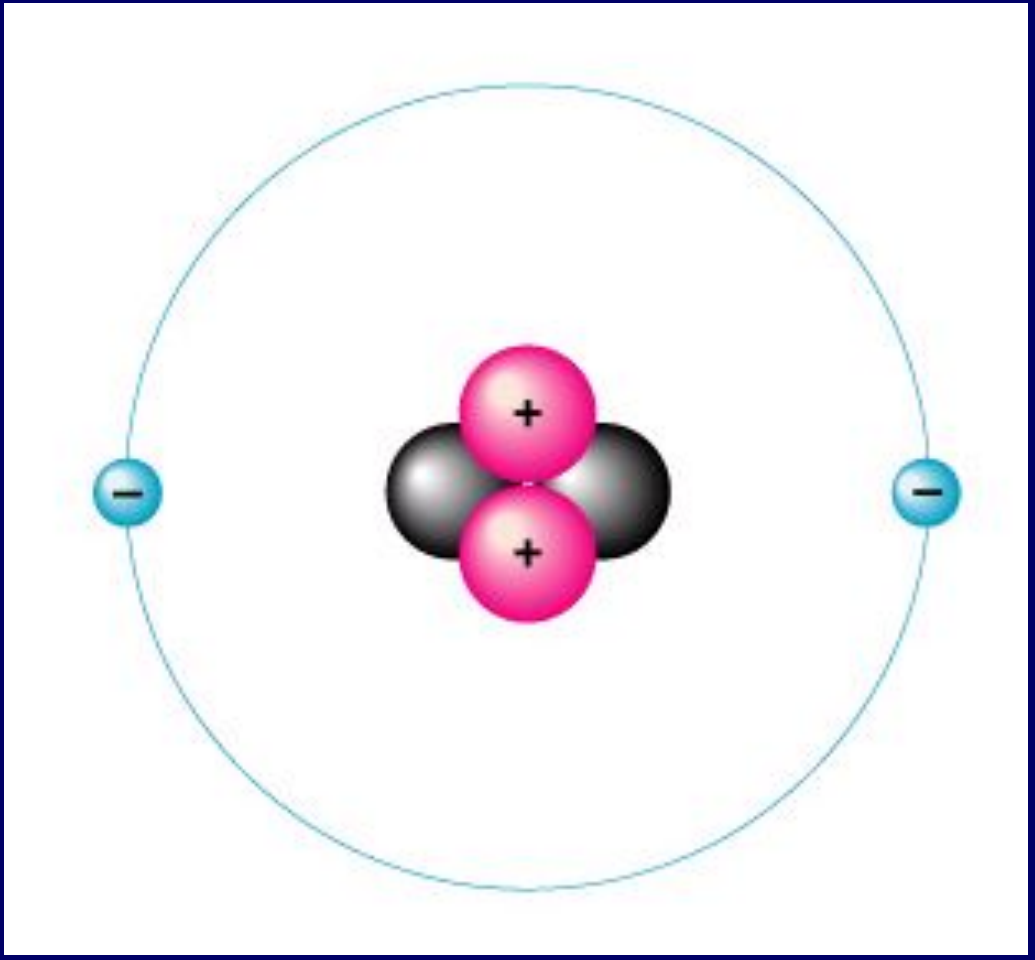

# Chemical Bonds

# Atom – the smallest unit of matter "indivisible"

Helium atom



# electron shells

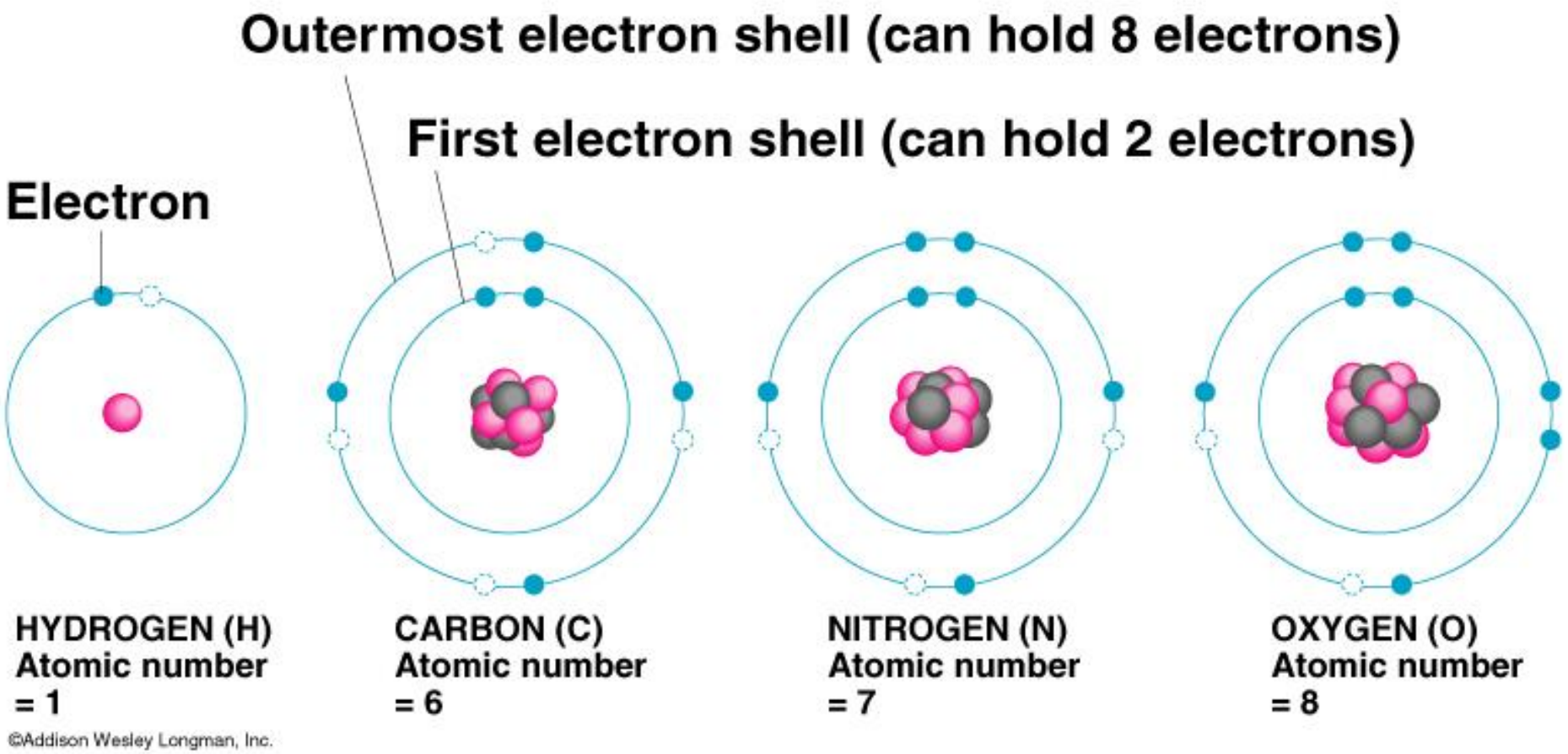
a) Atomic number = number of Electrons

b) Electrons vary in the amount of energy they possess, and they occur at certain energy levels or electron shells.

c) Electron shells determine how an atom behaves when it encounters other atoms

# Electrons are placed in shells according to rules:

1) The 1st shell can hold up to two electrons, and each shell thereafter can hold up to 8 electrons.




Octet Rule = atoms tend to gain, lose or share electrons so as to have 8 electrons

- ✔C would like to Gain 4 electrons
- ✔N would like to Gain 3 electrons
- ✔O would like to Gain 2 electrons

# Why are electrons important?

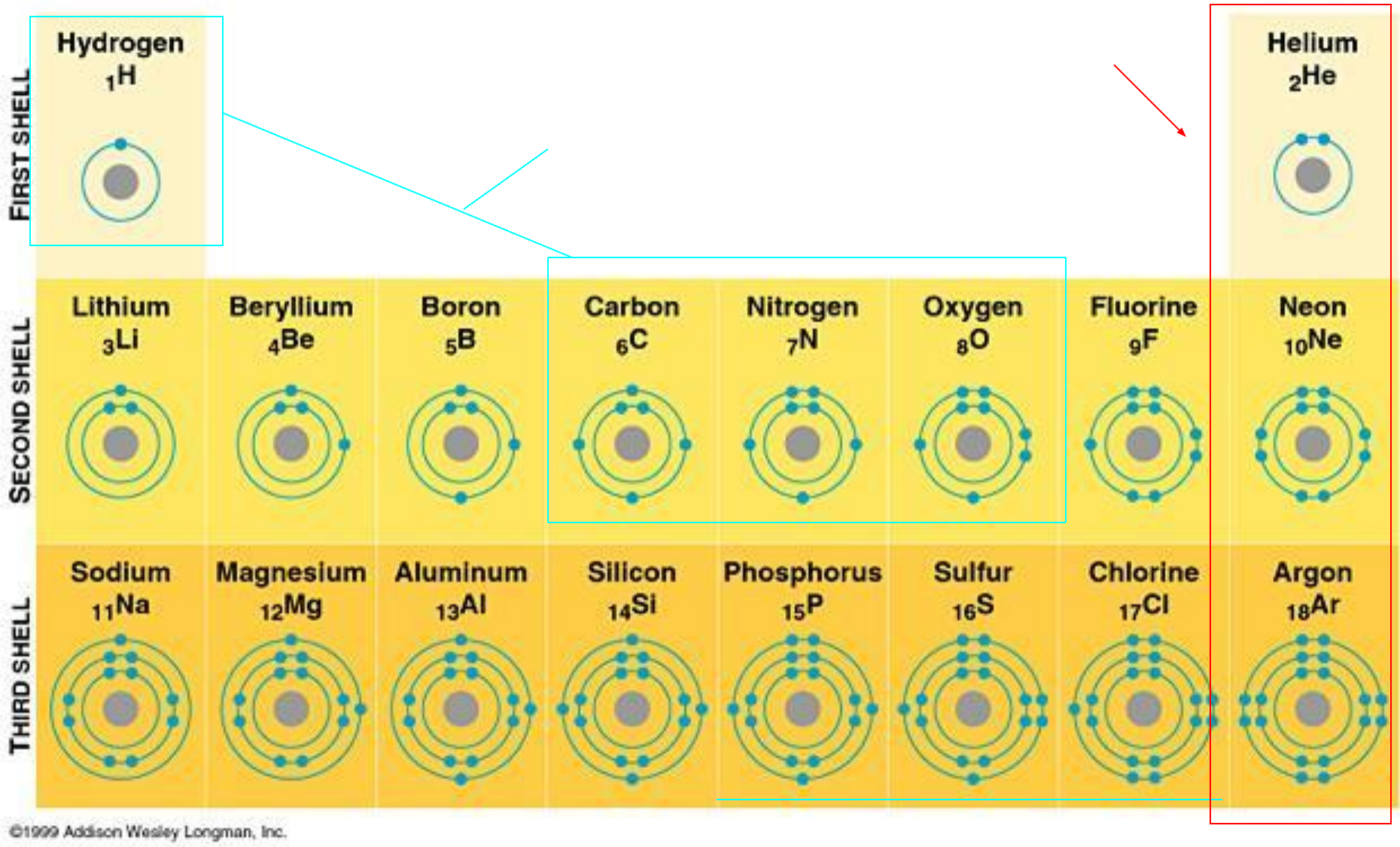
1) Elements have different electron configurations
   - different electron configurations mean different levels of bonding

# Periodic Chart of the Elements

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H | | | | | | | | | | | | | | | | 2 He |
| 3 Li | 4 Be | | | | | | | | | | | 5 B | 6 C | 7 N | 8 O | 9 F | 10 Ne |
| 11 Na | 12 Mg | | | | | | | | | | | 13 Al | 14 Si | 15 P | 16 S | 17 Cl | 18 Ar |
| 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co | 28 Ni | 29 Cu | 30 Zn | 31 Ga | 32 Ge | 33 As | 34 Se | 35 Br | 36 Kr |
| 37 Rb | 38 Sr | 39 Y | 40 Zr | 41 Nb | 42 Mo | 43 Tc | 44 Ru | 45 Rh | 46 Pd | 47 Ag | 48 Cd | 49 In | 50 Sn | 51 Sb | 52 Te | 53 I | 54 Xe |
| 55 Cs | 56 Ba | | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir | 78 Pt | 79 Au | 80 Hg | 81 Tl | 82 Pb | 83 Bi | 84 Po | 85 At | 86 Rn |
| 87 Fr | 88 Ra | | 104 Rf | 105 Db | 106 Sg | 107 Bh | 108 Hs | 109 Mt | 110 Uun | 111 Uuu | 112 Uub | 113 Uut | 114 Uuq | 115 Uup | 116 Uuh | 117 Uus | 118 Uuo |
| 119 ? | 120 ? | | | | | | | | | | | | | | | | |



| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 La | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm | 63 Eu | 64 Gd | 65 Tb | 66 Dy | 67 Ho | 68 Er | 69 Tm | 70 Yb | 71 Lu |
| 89 Ac | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu | 95 Am | 96 Cm | 97 Bk | 98 Cf | 99 Es | 100 Fm | 101 Md | 102 No | 103 Lr |



# Electron Dot Structures

**Symbols of atoms with dots to represent the valence-shell electrons**

| 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: |

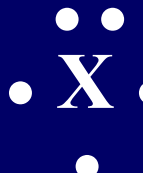
# Chemical bonds: an attempt to fill electron shells

1. Ionic bonds –
2. Covalent bonds –
3. Metallic bonds

# Learning Check

A.  would be the electron dot formula for

1) Na  2) K  3) Al

B.  would be the electron dot formula

1) B  2) N  3) P

# IONIC BOND

**bond formed between two ions by the *transfer* of electrons**

# Formation of Ions from Metals

- **Ionic compounds result when metals react with nonmetals**
- **Metals *lose* electrons to match the *number of valence electrons* of their nearest noble gas**
- ***Positive ions* form *when* the number of electrons are less than the number of protons**

**Group 1 metals $\longrightarrow$ ion $^{1+}$**

**Group 2 metals $\longrightarrow$ ion $^{2+}$**

- **Group 13 metals $\longrightarrow$ ion $^{3+}$**

# Formation of Sodium Ion

**Sodium atom** **Sodium ion**

$Na^{\cdot} - e^{-} \longrightarrow Na^{+}$

**2-8-1** **2-8 ( = Ne)**

| | |
|---|---|
| 11 $p^{+}$ | 11 $p^{+}$ |
| 11 $e^{-}$ | 10 $e^{-}$ |
| 0 | $1^{+}$ |

# Formation of Magnesium Ion

**Magnesium atom** **Magnesium ion**

$Mg^{\cdot}_{\cdot}$ – $2e^-$ ⟶ $Mg^{2+}$

**2-8-2** **2-8 (=Ne)**

$12\ p^+$ $12\ p^+$

$12\ e^-$ $10\ e^-$

**0** $2^+$

# Some Typical Ions with Positive Charges (Cations)

| Group 1 | Group 2 | Group 13 |
| --- | --- | --- |
| $H^+$ | $Mg^{2+}$ | $Al^{3+}$ |
| $Li^+$ | $Ca^{2+}$ | |
| $Na^+$ | $Sr^{2+}$ | |
| $K^+$ | $Ba^{2+}$ | |

# Learning Check

A. Number of valence electrons in aluminum

1) 1 $e^-$ 2) 2 $e^-$ 3) 3 $e^-$

B. Change in electrons for octet

1) lose 3$e^-$ 2) gain 3 $e^-$ 3) gain 5 $e^-$

C. Ionic charge of aluminum

1) 3- 2) 5- 3) $3^+$

# Solution

A. Number of valence electrons in aluminum

3) 3 $e^-$

B. Change in electrons for octet

1) lose 3$e^-$

C. Ionic charge of aluminum

3) $3^+$

# Learning Check

**Give the ionic charge for each of the following:**

**A. 12 $p^+$ and 10 $e^-$**

**1) 0 2) 2+ 3) 2-**

**B. 50$p^+$ and 46 e-**

**1) 2+ 2) 4+ 3) 4-**

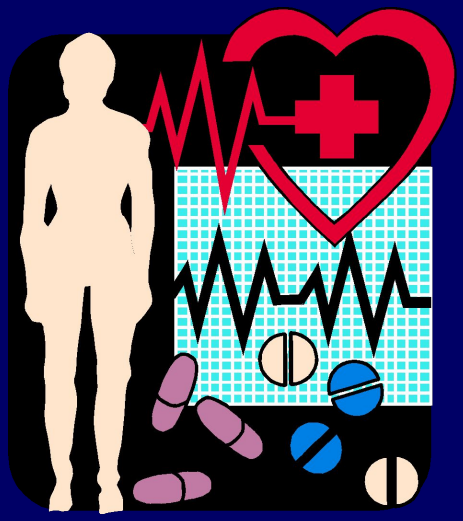
**C. 15 $p^+$ and 18e-**

**2) 3+ 2) 3- 3) 5-**

# Ions from Nonmetal Ions

- In ionic compounds, nonmetals in 15, 16, and 17 gain electrons from metals
- Nonmetal add electrons to achieve the octet arrangement
- Nonmetal ionic charge:

  3-, 2-, or 1-



# Fluoride Ion

**unpaired electron** **octet**


**2-7** **2-8 (= Ne)**

**9 p+** **9 $p^+$**

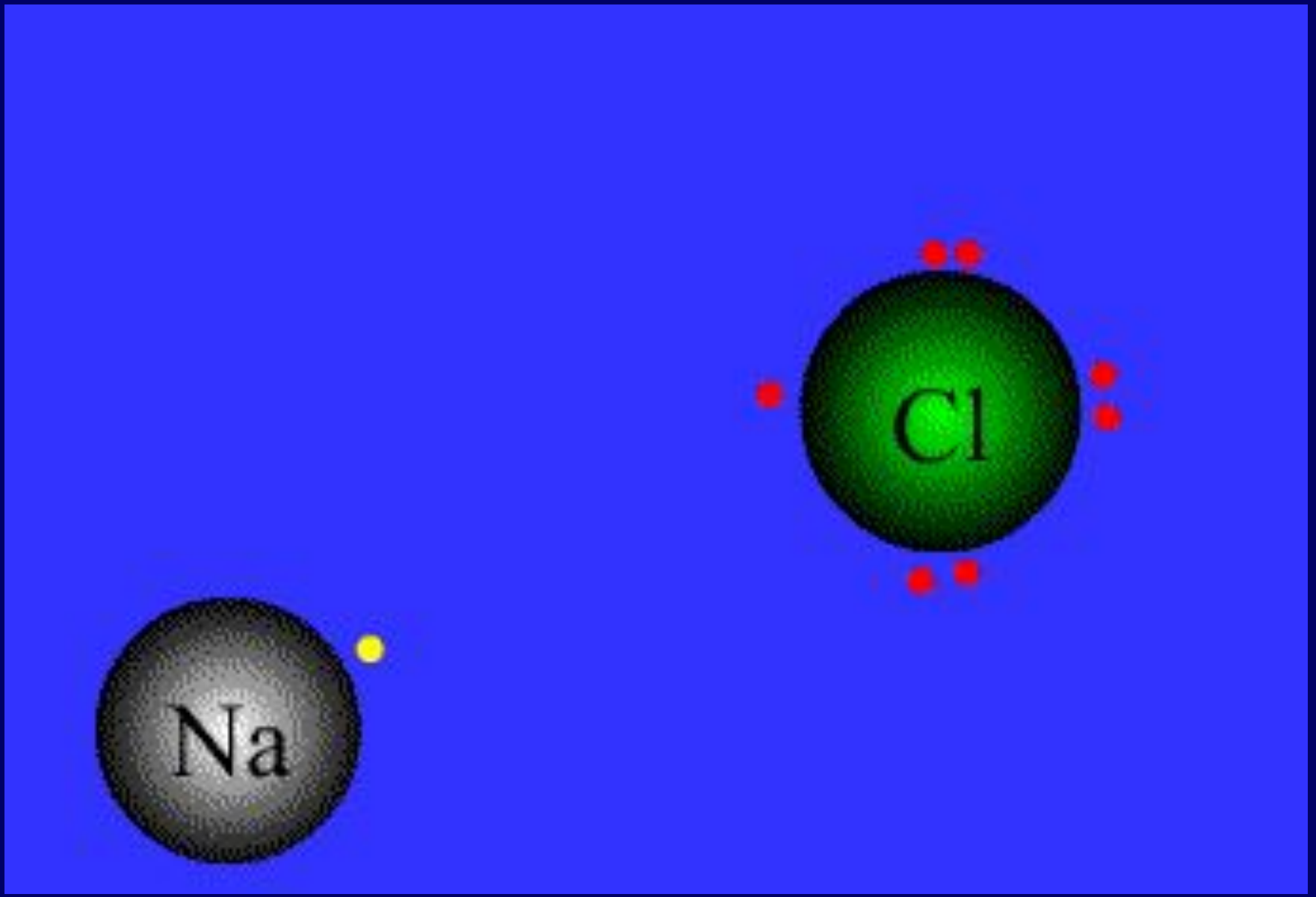
**9 e-** **10 e-**

**0** **1 -**

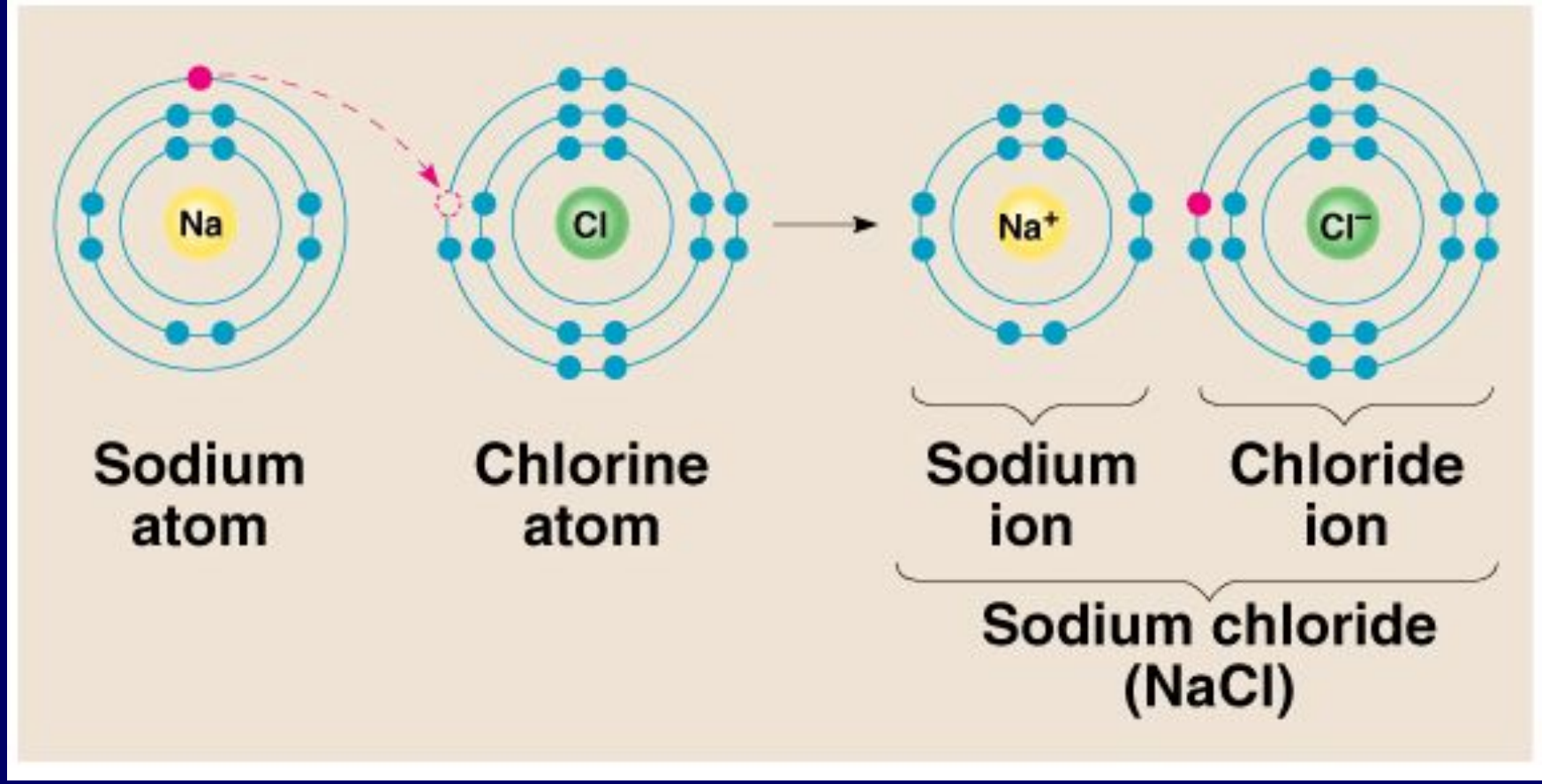
**ionic charge**

# Ionic Bond

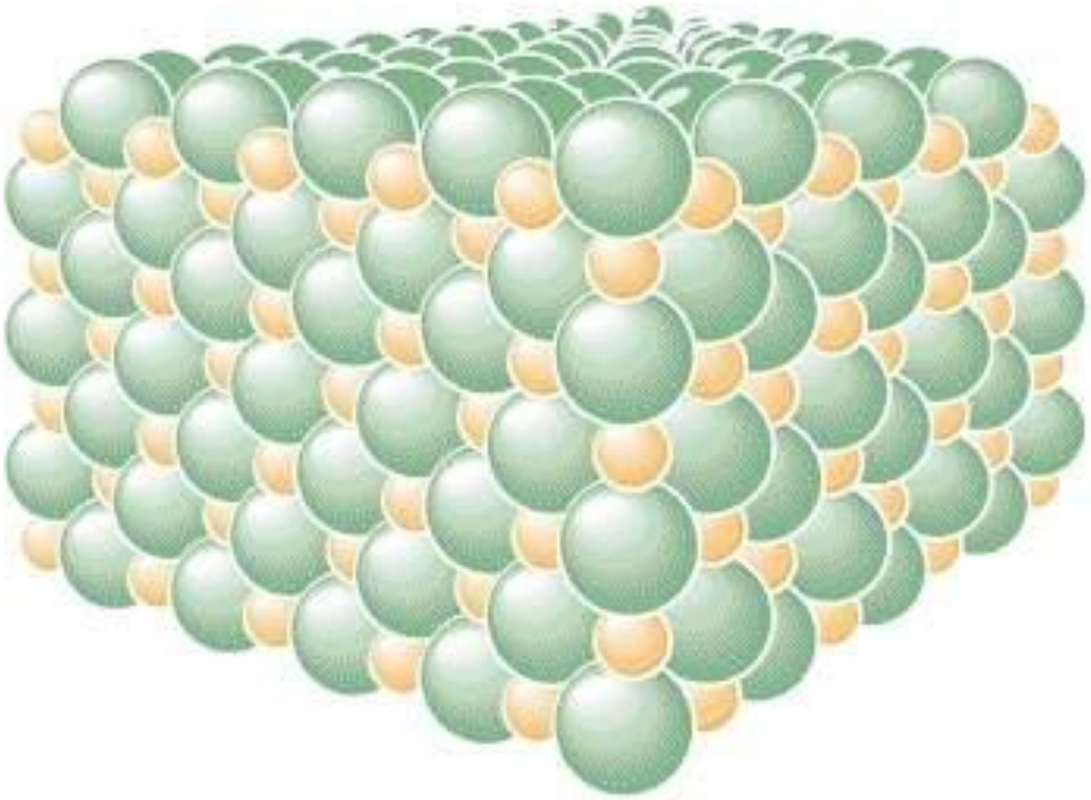
- Between atoms of metals and nonmetals with very different electronegativity
- Bond formed by transfer of electrons
- Produce charged ions all states. Conductors and have high melting point.
- Examples; $NaCl$, $CaCl_2$, $K_2O$


Cl
Na

# Ionic Bonds: One Big Greedy Thief Dog!



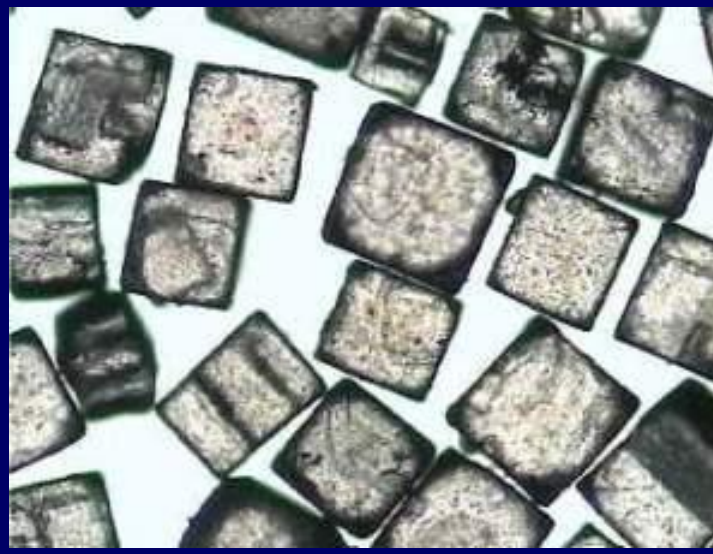

1). Ionic bond – electron from Na is transferred to Cl, this causes a charge imbalance in each atom. The Na becomes (Na+) and the Cl becomes (Cl-), charged particles or ions.



Sodium ion ($Na^+$)

Chloride ion ($Cl^-$)



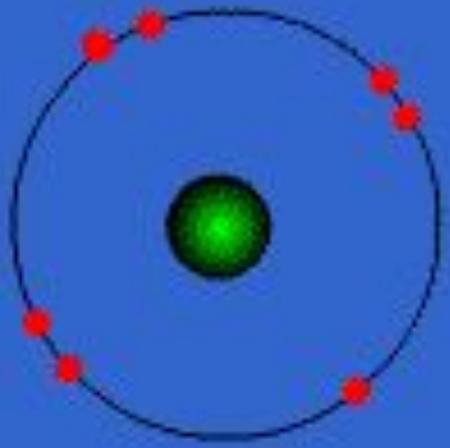


# COVALENT BOND

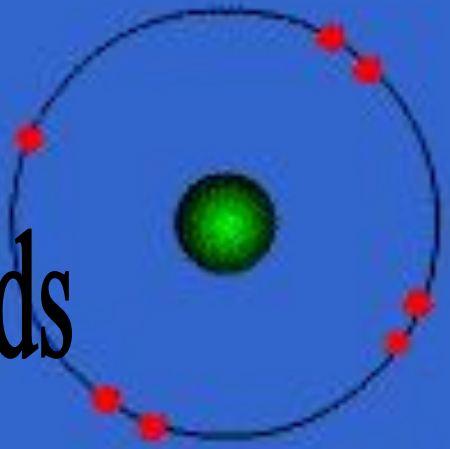
**bond formed by the *sharing* of electrons**

# Covalent Bond

- Between nonmetallic elements of similar electronegativity.
- Formed by sharing electron pairs
- Stable non-ionizing particles, they are not conductors at any state
- Examples; $O_2$, $CO_2$, $C_2H_6$, $H_2O$, SiC



# Covalent Bonds



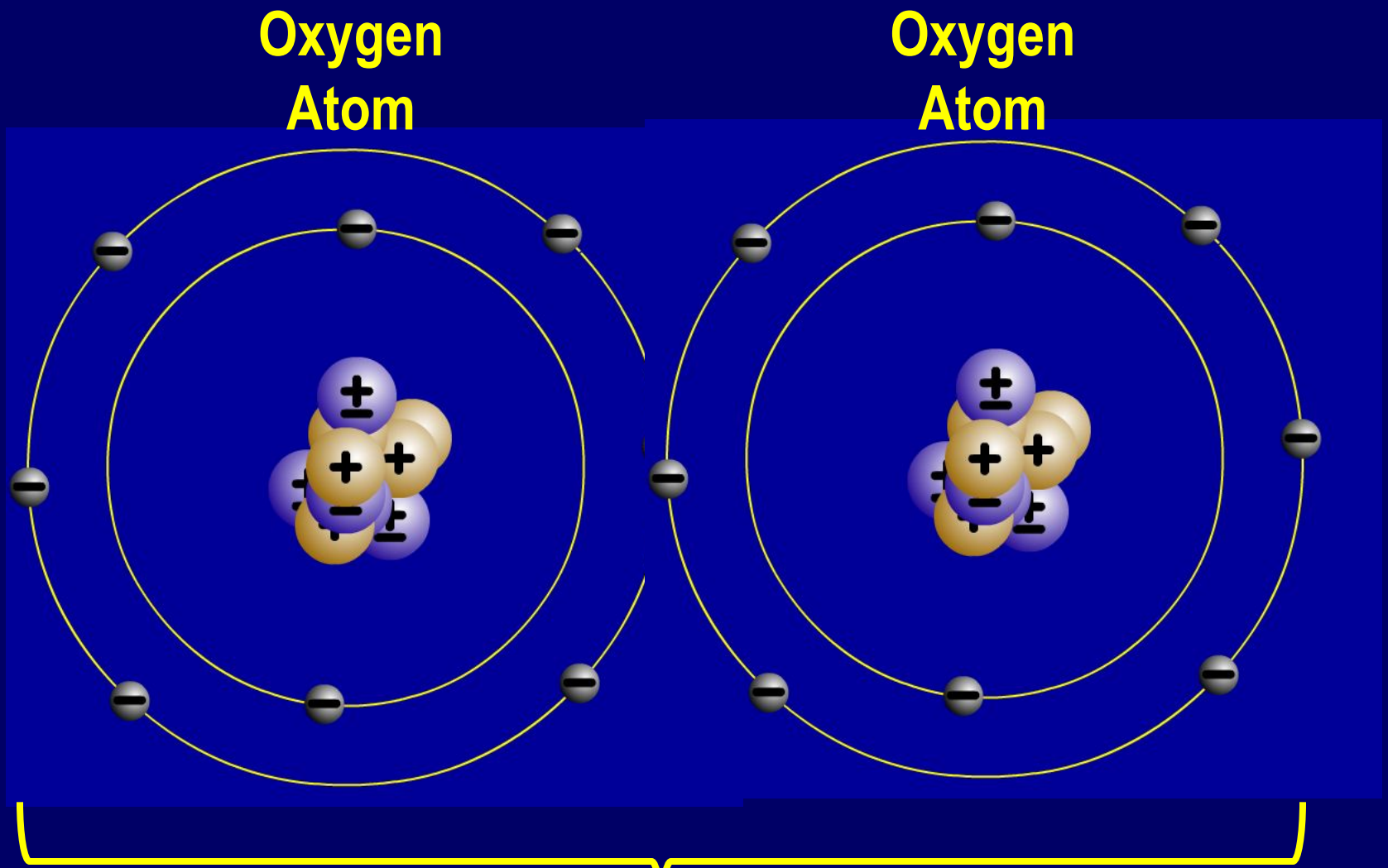
**Bonds in all the polyatomic ions and diatomics are all covalent bonds**

# NONPOLAR COVALENT BONDS

## when electrons are shared *equally*

$H_2$ or $Cl_2$

## 2. Covalent bonds- Two atoms share one or more pairs of outer-shell electrons.

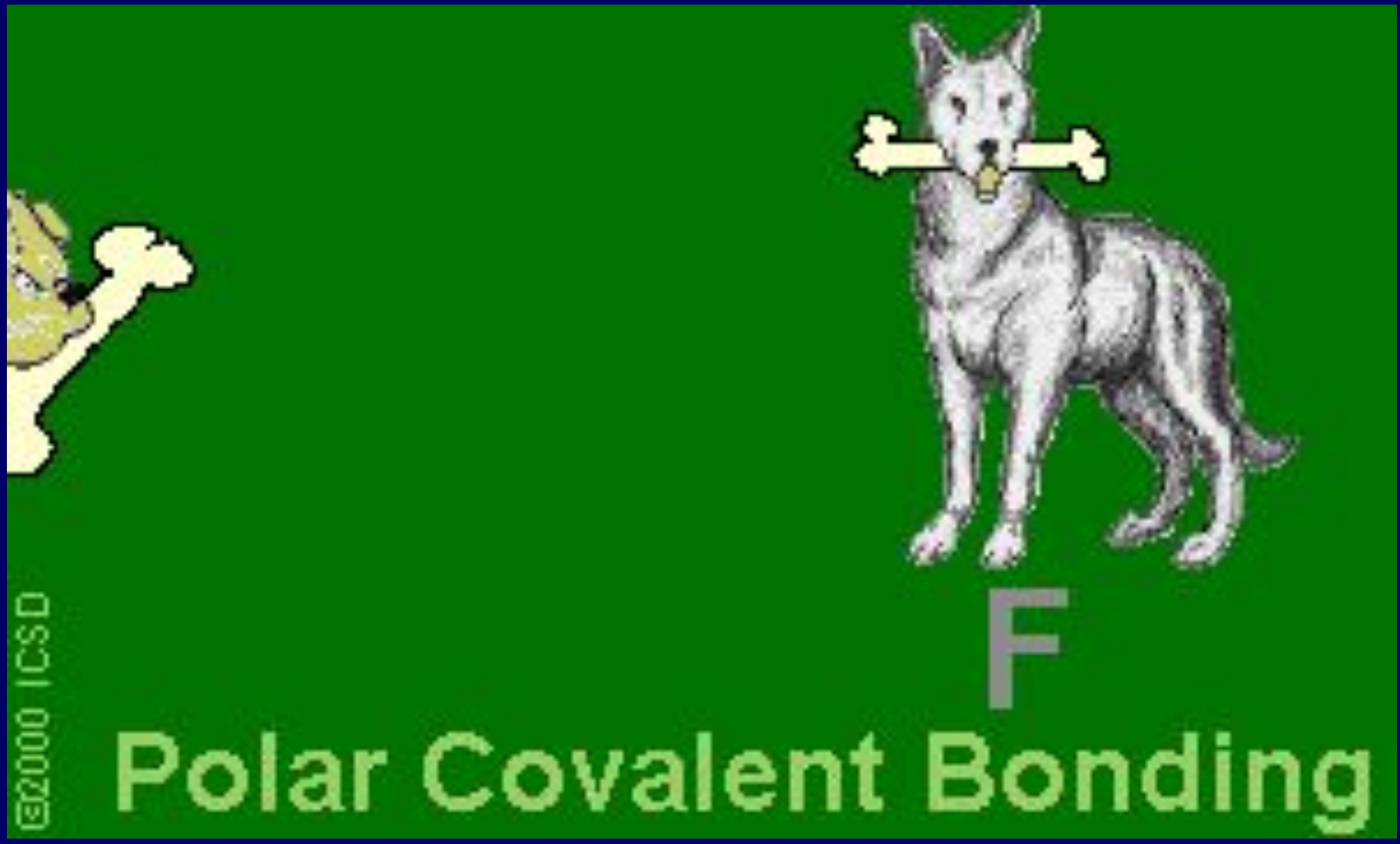


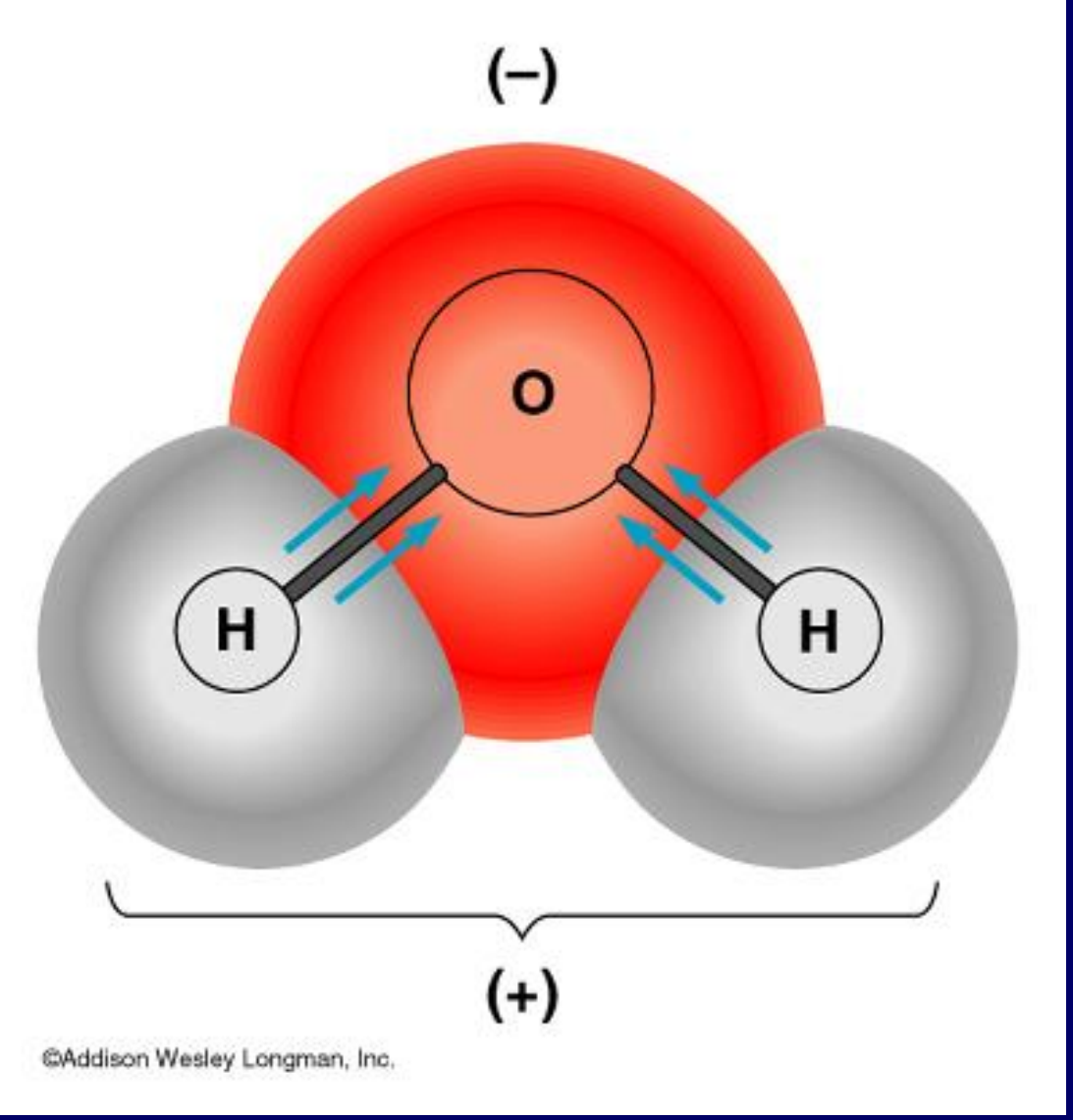
# POLAR COVALENT BONDS

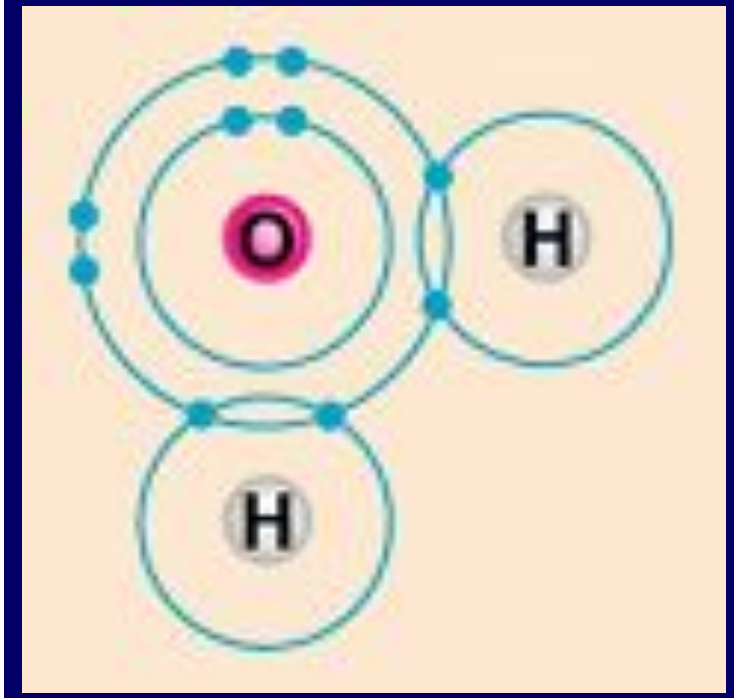
**when electrons are shared but shared *unequally***

**$H_2O$**

# Polar Covalent Bonds: Unevenly matched, but willing to share.






- water is a *polar molecule* because oxygen is more electronegative than hydrogen, and therefore electrons are pulled closer to oxygen.

# METALLIC BOND

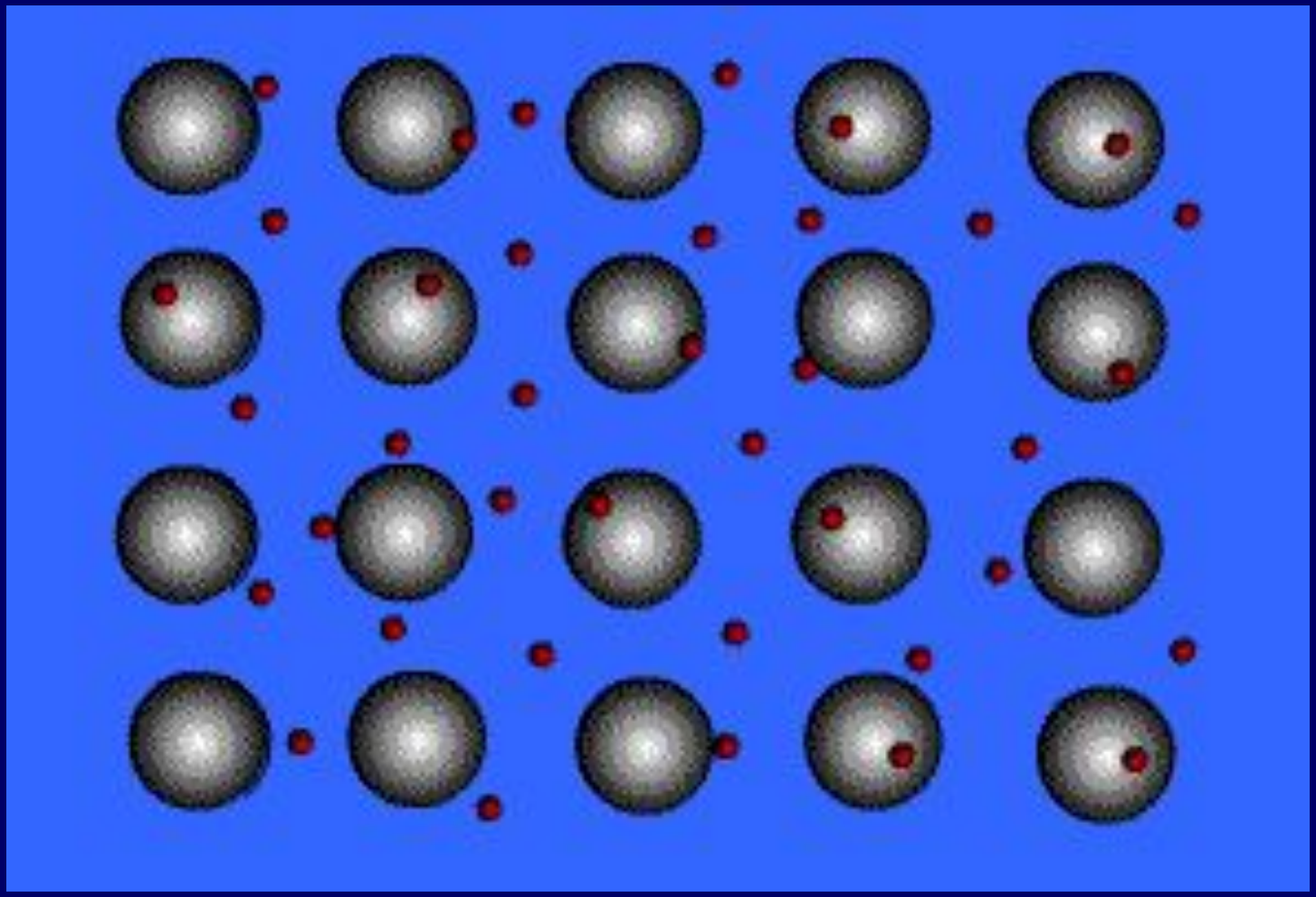
**bond found in metals; holds metal atoms together very strongly**

# Metallic Bond

- Formed between atoms of metallic elements
- Electron cloud around atoms
- Good conductors at all states, lustrous, very high melting points
- Examples; Na, Fe, Al, Au, Co

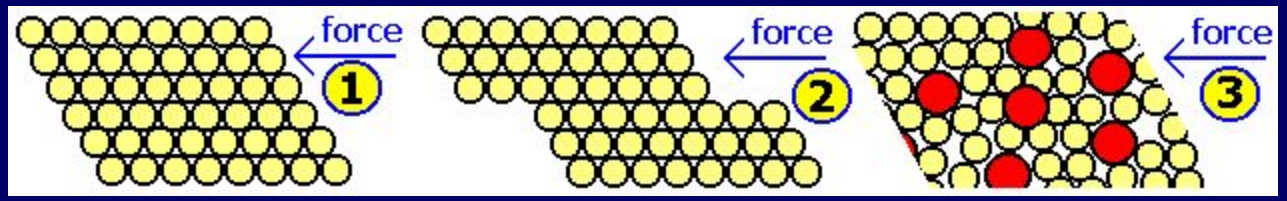
# Metallic Bonds: Mellow dogs with plenty of bones to go around.

# Ionic Bond, A Sea of Electrons



# Metals Form Alloys

Metals do not combine with metals. They form Alloys which is a solution of a metal in a metal. Examples are steel, brass, bronze and pewter.



# Formula Weights

- Formula weight is the sum of the atomic masses.
- Example- $CO_2$
- Mass, C + O + O

  12.011 + 15.994 + 15.994

  43.999

# Practice

- Compute the mass of the following compounds round to nearest tenth & state type of bond:
- NaCl;
- 23 + 35 = 58; Ionic Bond
- $C_2H_6$;
- 24 + 6 = 30;  Covalent Bond
- $Na(CO_3)_2$;
- 23 + 2(12 +  3x16) = 123; Ionic & Covalent