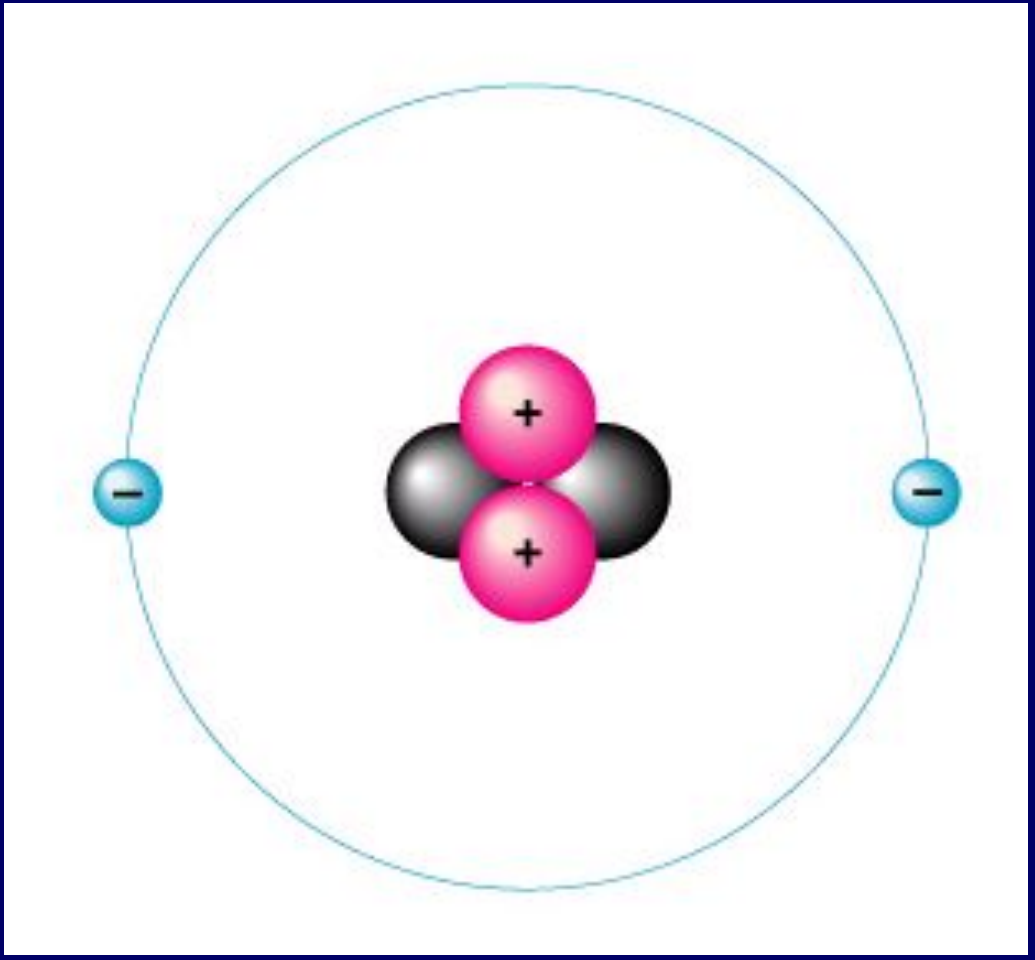
Chemical Bonds

Atom – the smallest unit of matter "indivisible"

Helium atom



electron shells

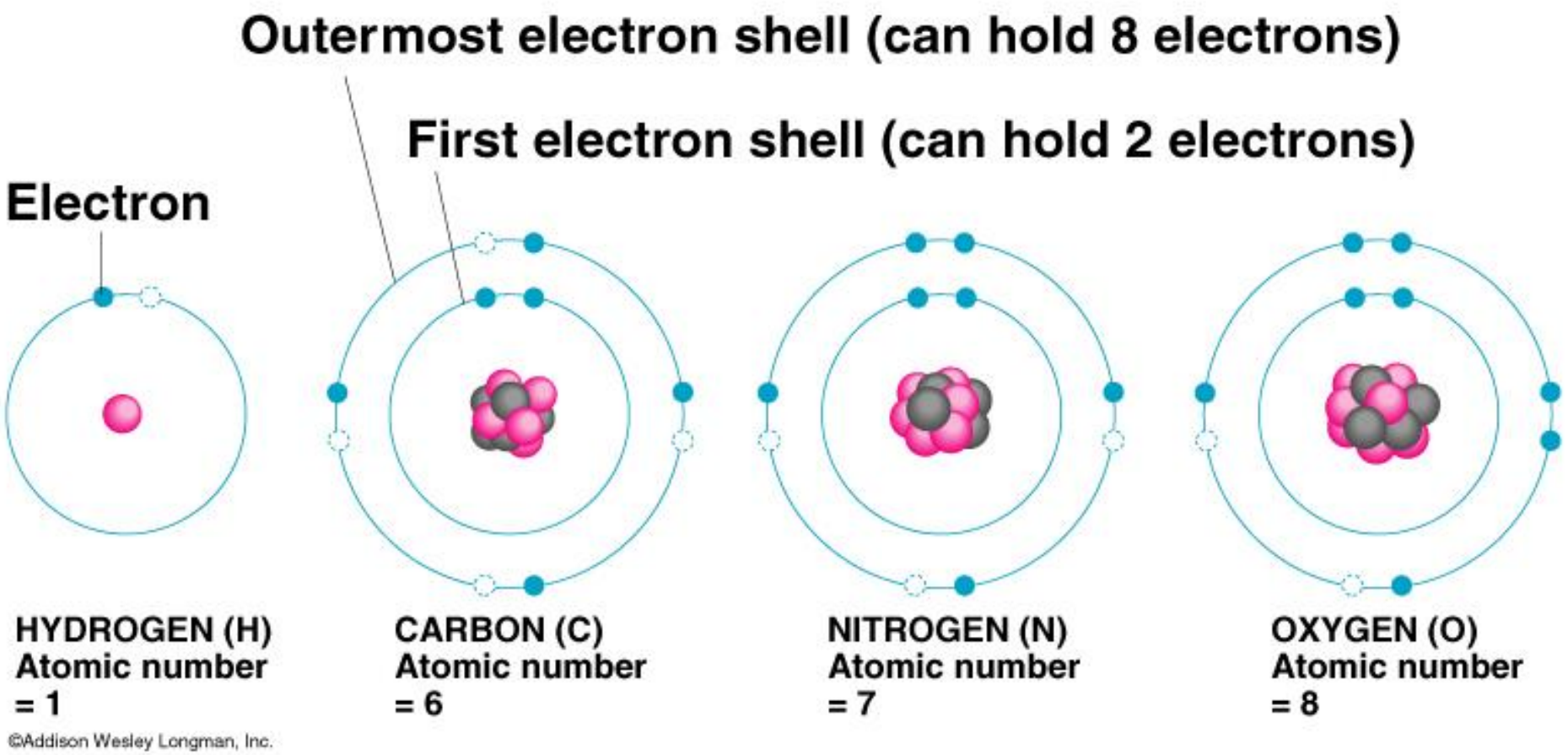
a) Atomic number = number of Electrons

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

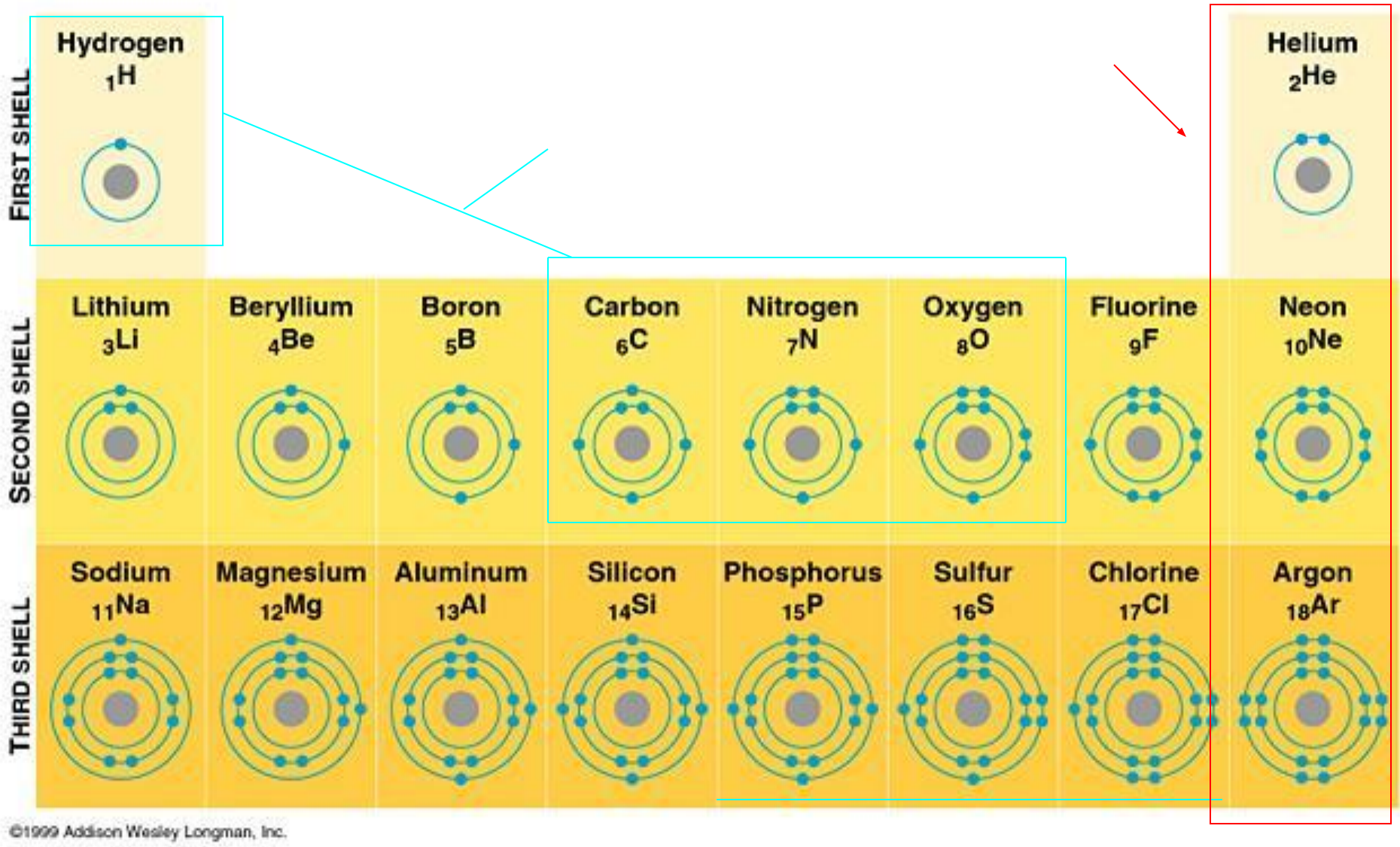
Why are electrons important?

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

Periodic Chart of the Elements

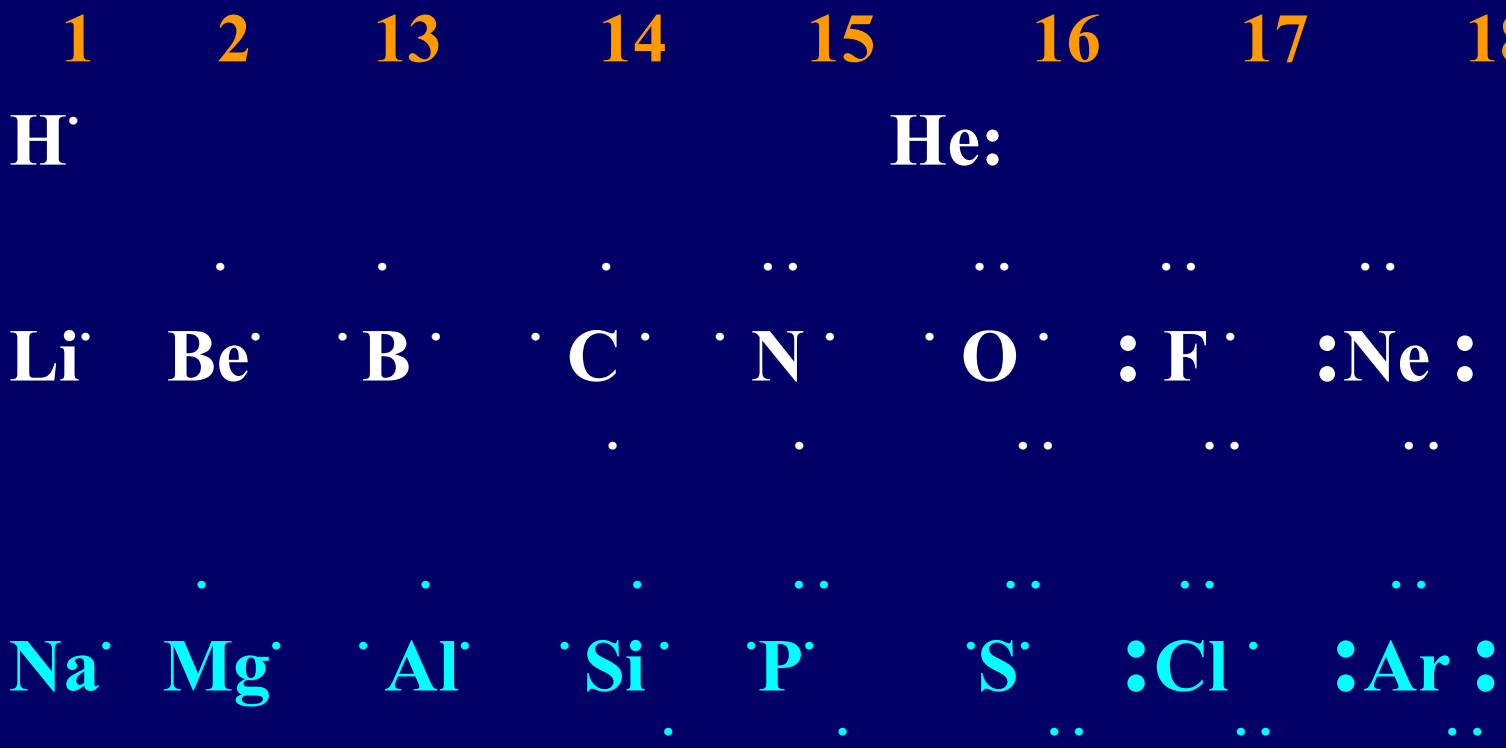
1 H																2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	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



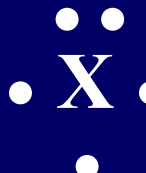
Chemical bonds: an attempt to fill electron shells

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 ⟶ ion $^{1+}$

Group 2 metals ⟶ ion $^{2+}$

- **Group 13 metals ⟶ 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 3e^- 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 3e^-

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. 50p^+ and 46 e-

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

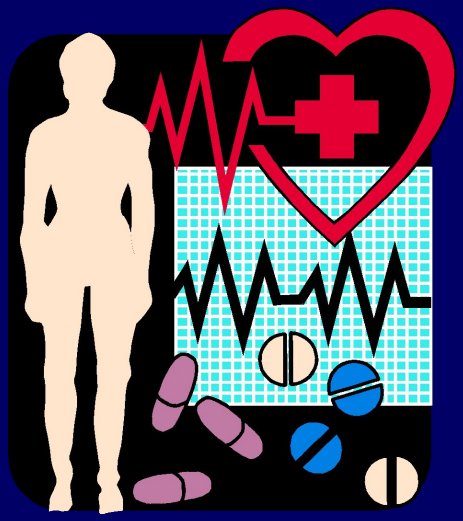
C. 15 p^+ and 18e-

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

Ions from Nonmetal Ions

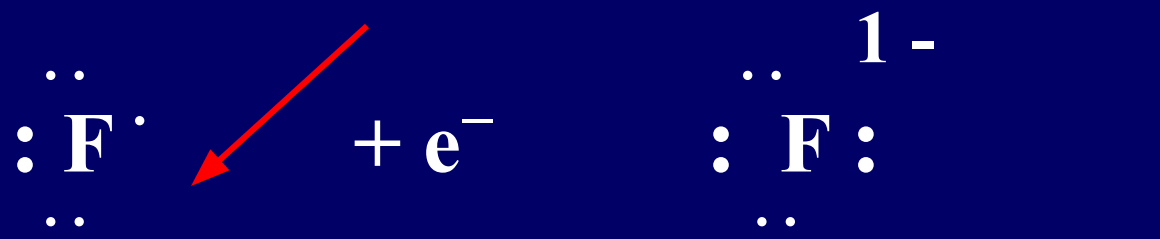
- In ionic compounds, nonmetals in 15, 16, and 17 gain electrons from metals
- Nonmetal add electrons to achieve the octet arrangement
- Nonmetal ionic charge:

  3-, 2-, or 1-



Fluoride Ion

unpaired electron **octet**



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

9 p+ **9 p^+**

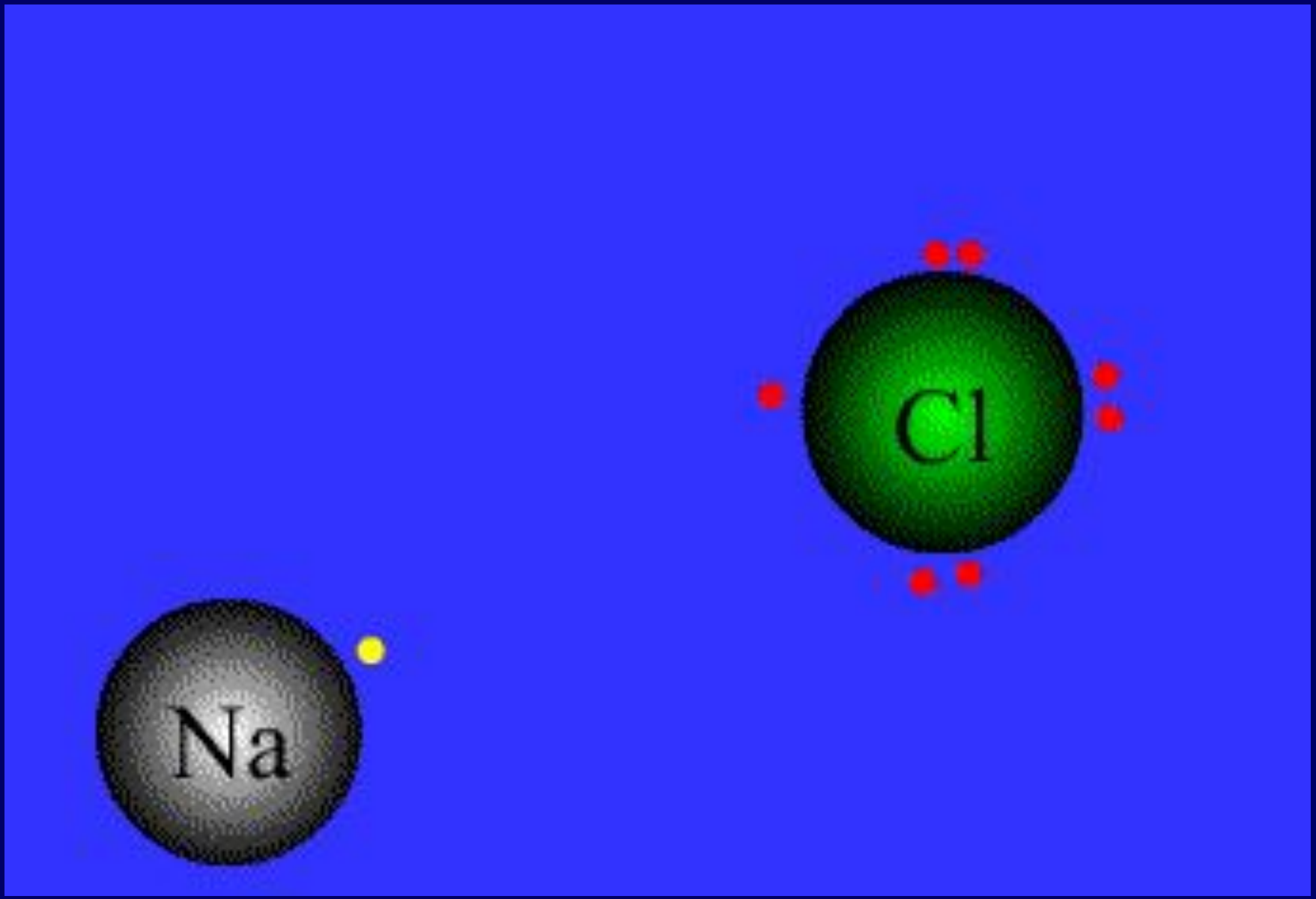
9 e- **10 e-**

0 **1 -**

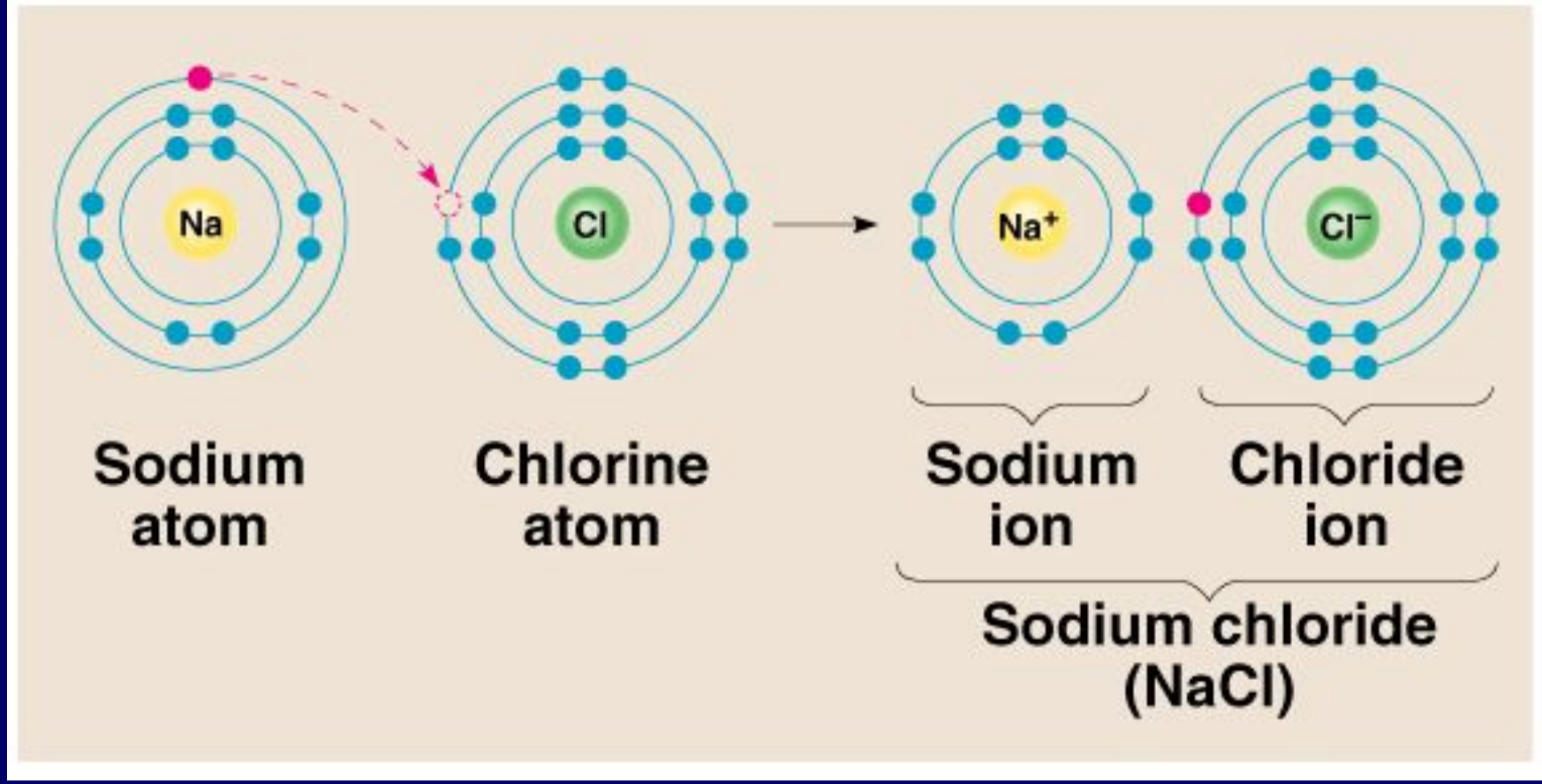
ionic charge

Ionic Bond

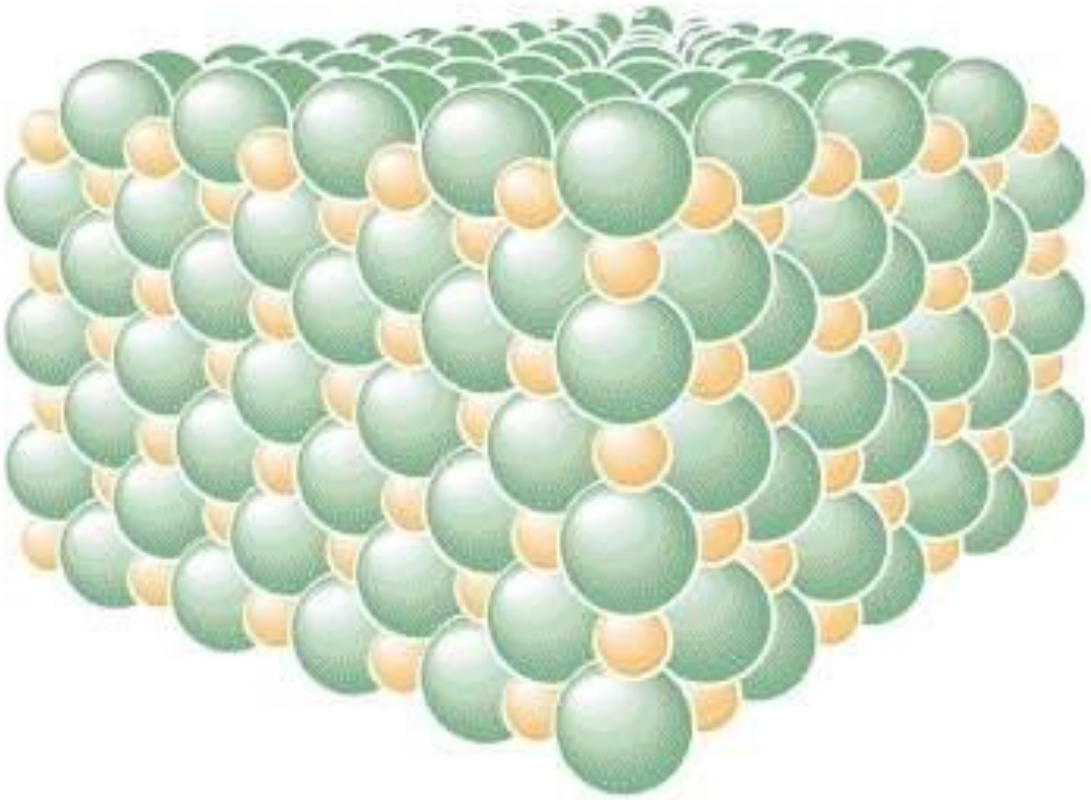
- Between atoms of metals and nonmetals with very different electronegativity
- Bond formed by transfer of electrons
- Produce charged ions all states. Conductors and have high melting point.
- Examples; $NaCl$, $CaCl_2$, K_2O


Cl
Na

Ionic Bonds: One Big Greedy Thief Dog!

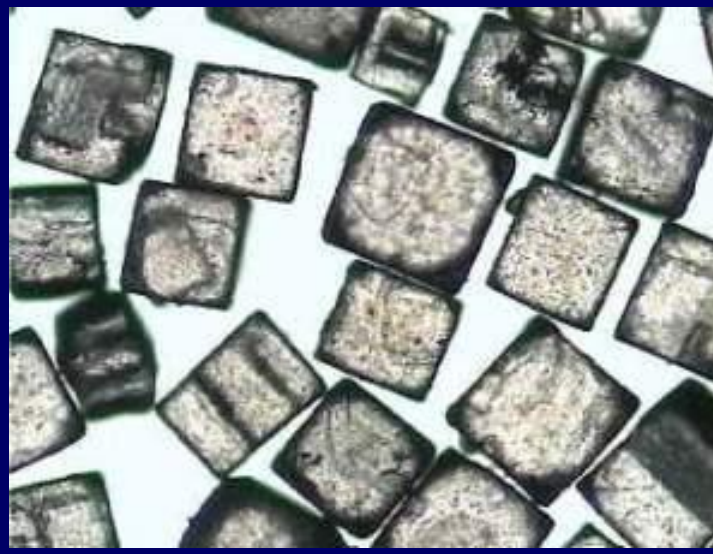


1). Ionic bond – electron from Na is transferred to Cl, this causes a charge imbalance in each atom. The Na becomes (Na+) and the Cl becomes (Cl-), charged particles or ions.



Sodium ion (Na^+)

Chloride ion (Cl^-)

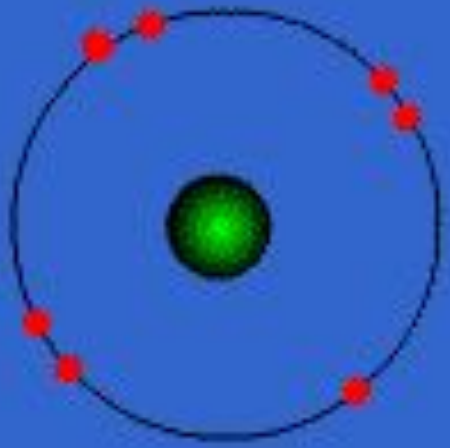


COVALENT BOND

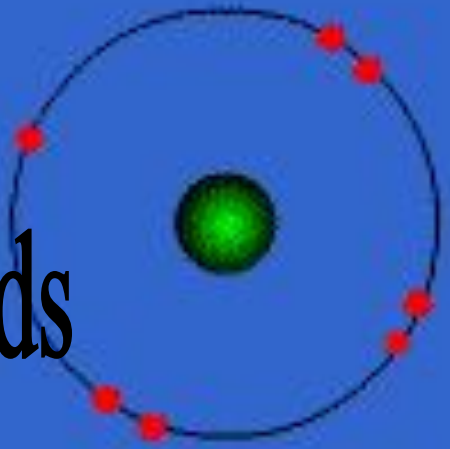
bond formed by the *sharing* of electrons

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



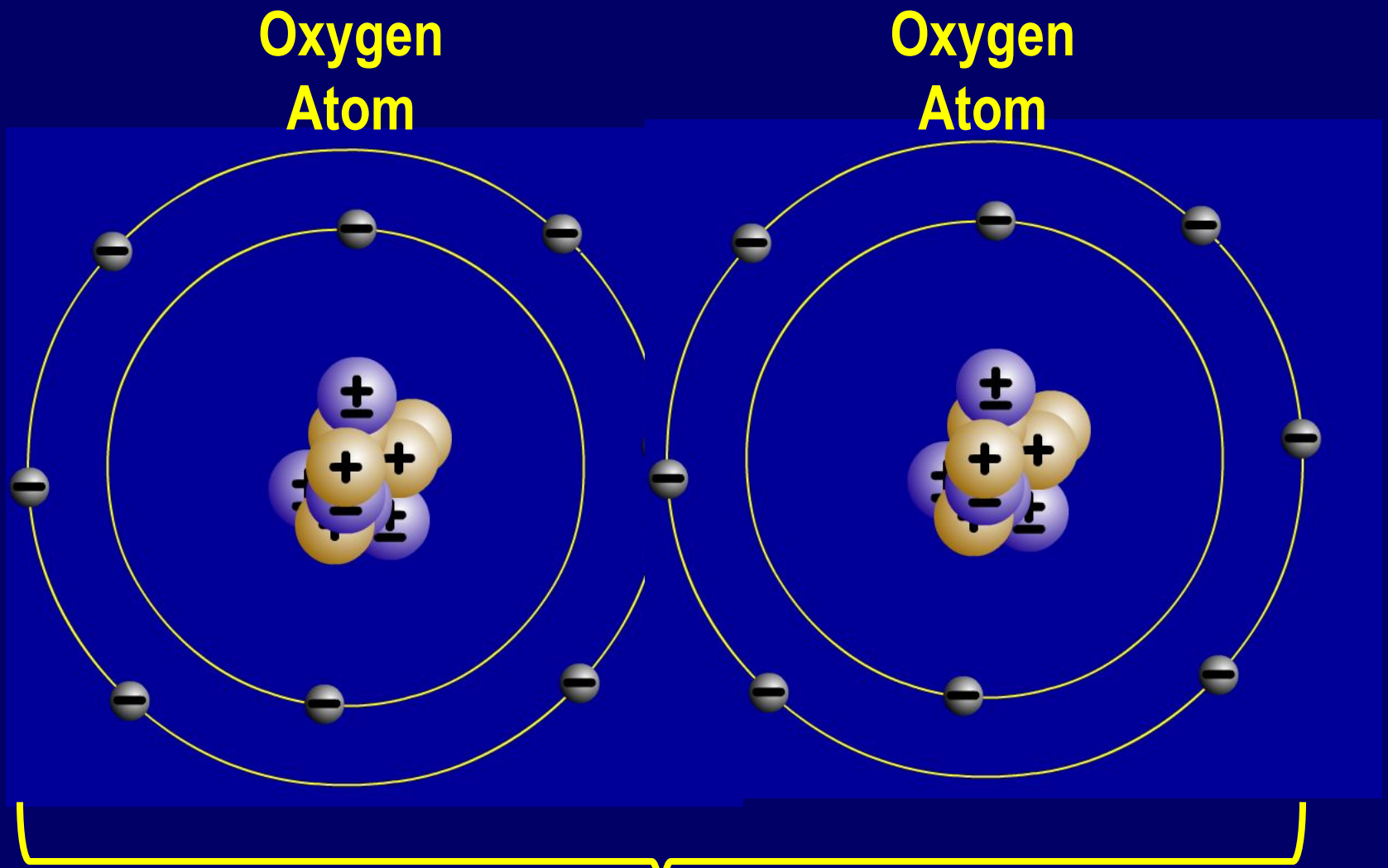
Bonds in all the polyatomic ions and diatomics are all covalent bonds

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.

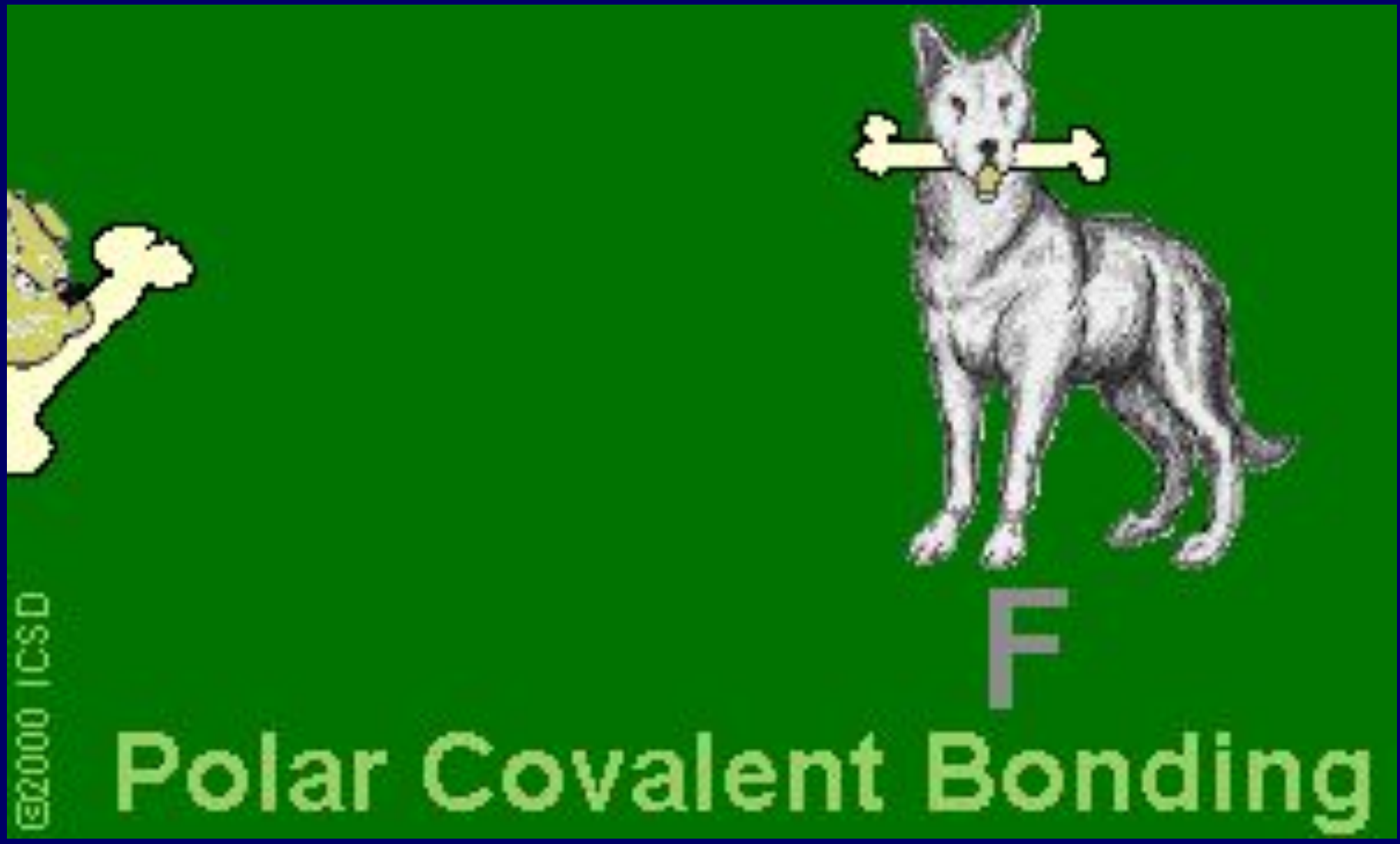


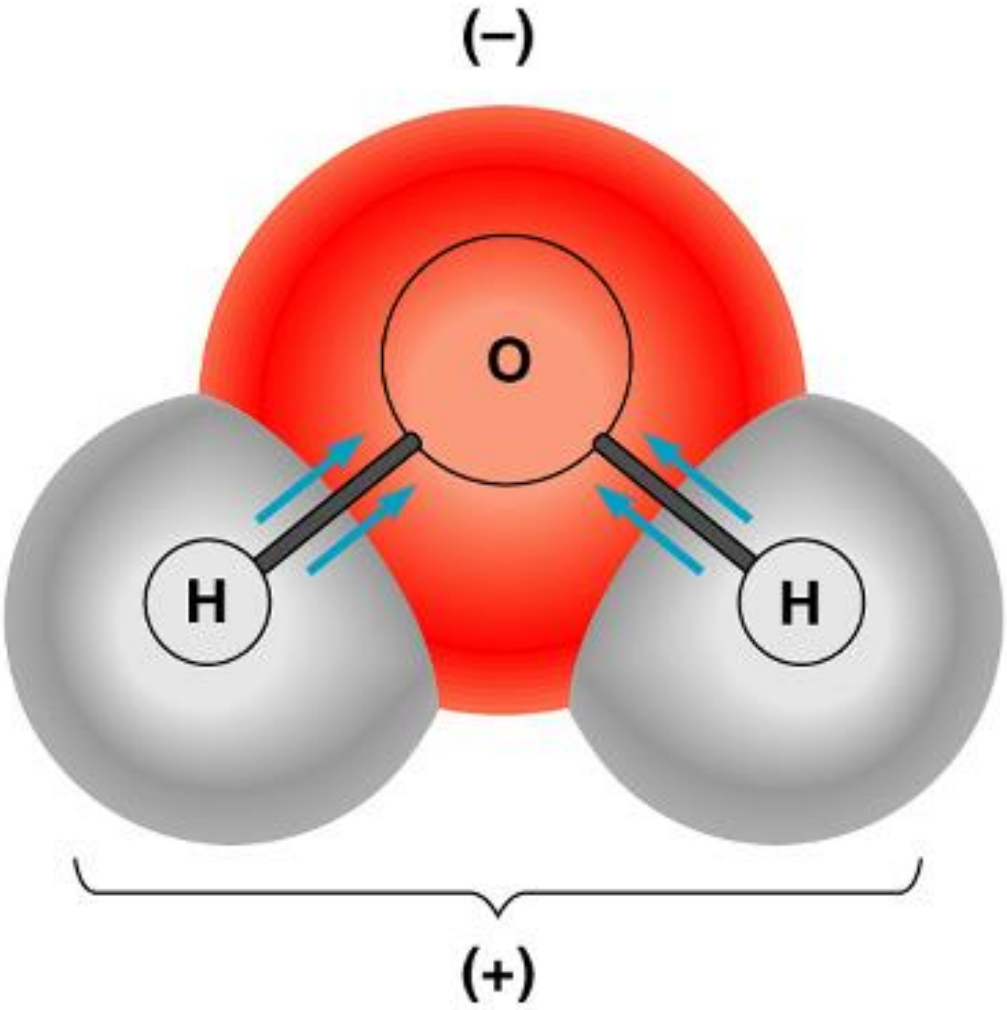
POLAR COVALENT BONDS

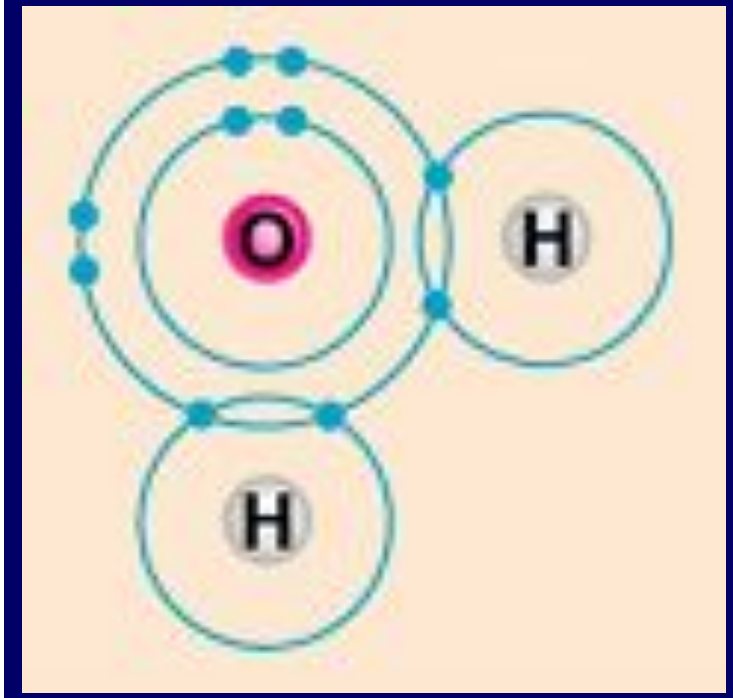
when electrons are shared but shared *unequally*

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

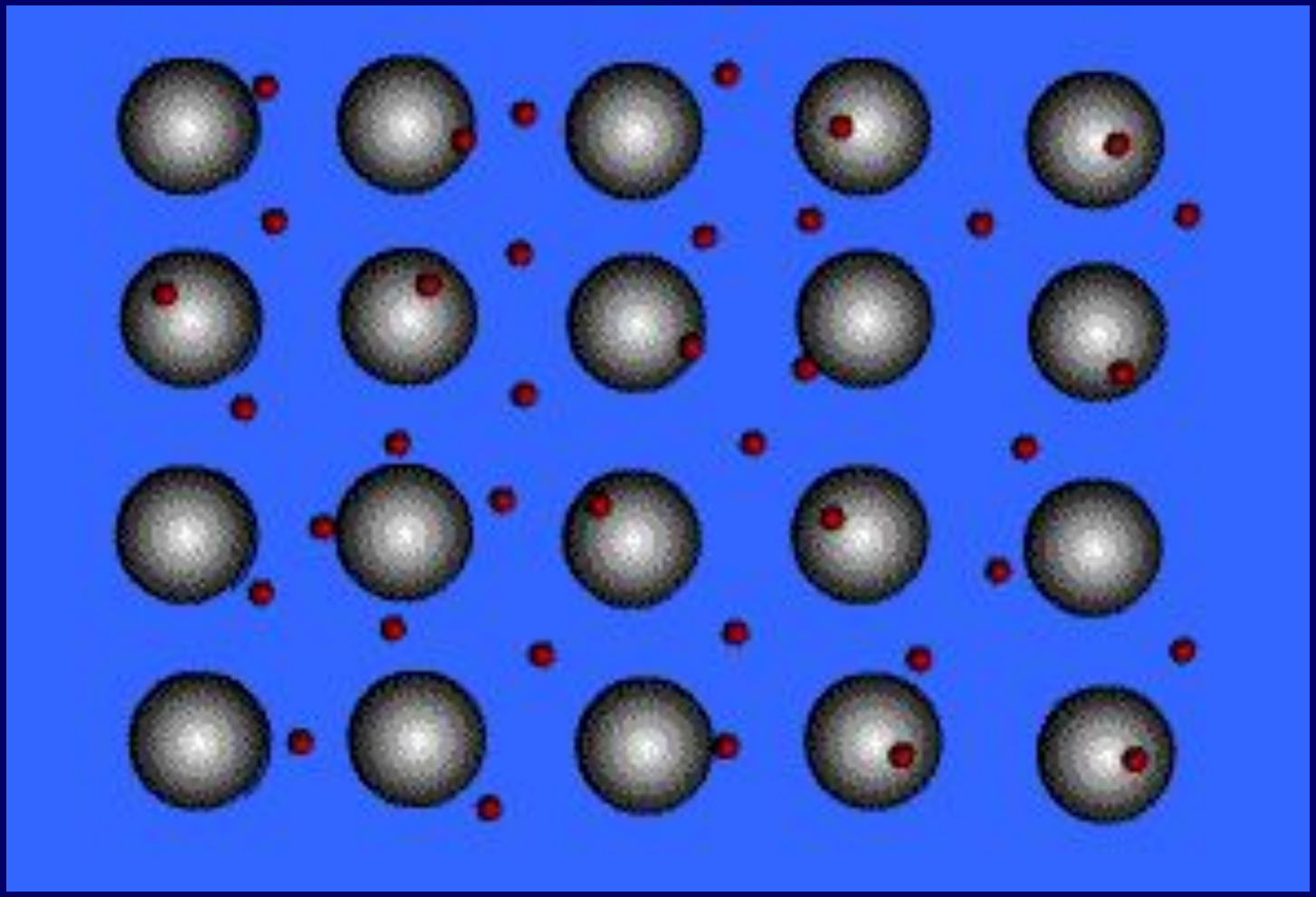
bond found in metals; holds metal atoms together very strongly

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

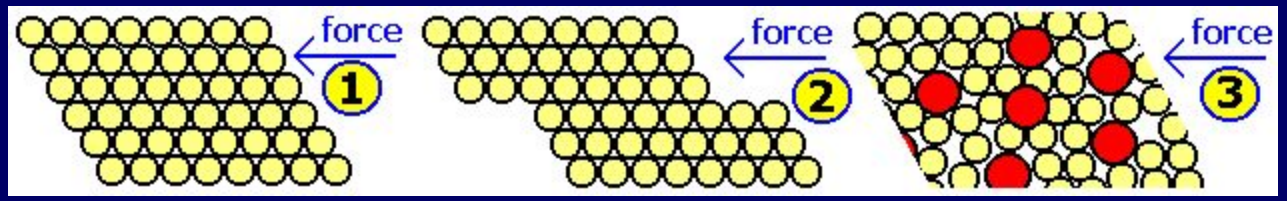
Metallic Bonds: Mellow dogs with plenty of bones to go around.

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