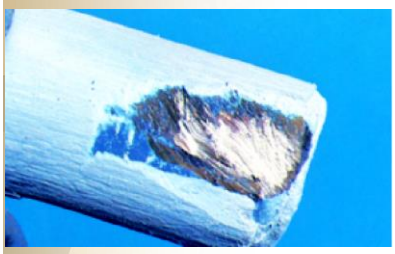

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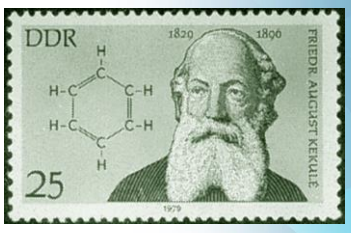

Periodic table - properties of elements types of Chemical Bonds

Chapters 8-9

Instructors of Chem3111 2022-2023

The Modern Periodic Table

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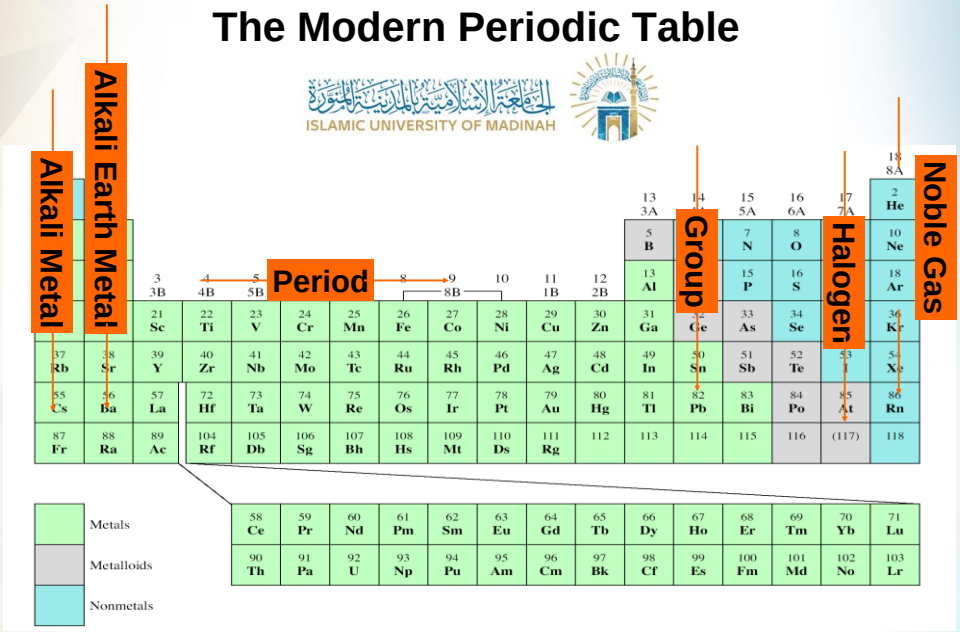

Electron Configurations of Cations and Anions Of Representative Elements

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Na [Ne]$3s^1$ Na^+ [Ne]

Ca [Ar]$4s^2$ Ca^{2+} [Ar]

Al [Ne]$3s^23p^1$ Al^{3+} [Ne]

Atoms lose electrons so that cation has a noble-gas outer electron configuration.

Atoms gain electrons so that anion has a noble-gas outer electron configuration.

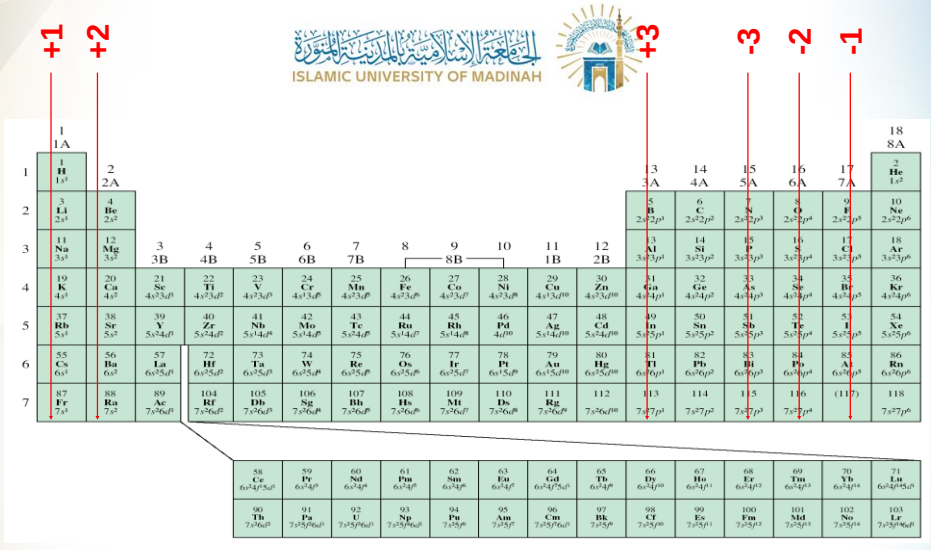
H $1s^1$ H^- $1s^2$ or [He]

F $1s^22s^22p^5$ F^- $1s^22s^22p^6$ or [Ne]

O $1s^22s^22p^4$ O^{2-} $1s^22s^22p^6$ or [Ne]

N $1s^22s^22p^3$ N^{3-} $1s^22s^22p^6$ or [Ne]

Cations and Anions Of Representative Elements



Representative Elements: elements with electron configuration of incompletely filled s or p subshell. Elements in Groups 1A-to-7A

Isoelectronic: have the same number of electrons, and hence the same ground-state electron configuration

Na^+: [Ne] Al^{3+}: [Ne] F^-: $1s^2 2s^2 2p^6$ or [Ne]

O^{2-}: $1s^2 2s^2 2p^6$ or [Ne] N^{3-}: $1s^2 2s^2 2p^6$ or [Ne]

Na^+, Al^{3+}, F^-, O^{2-}, and N^{3-} are all *isoelectronic* with Ne

What neutral atom is isoelectronic with H^- ?

H^-: $1s^2$ same electron configuration as He

The electron arrangement of an atom at its lowest possible energy state is known as the ground state electron configuration

Electron Configurations of Cations of Transition Metals

Transition Elements: elements with electron configuration of incompletely filled d subshells or readily give rise to cations that have incompletely filled d subshells. Elements in Groups 1B-to-7B

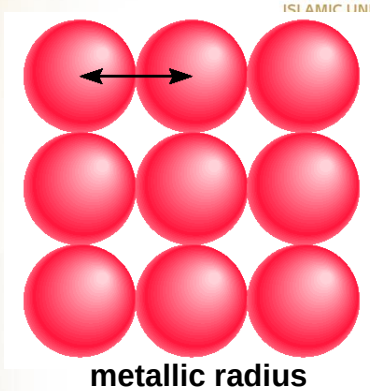
When a cation is formed from an atom of a transition metal, electrons are always removed first from the *ns* orbital and then from the (*n* – 1)*d* orbitals.

Fe: $[Ar]4s^2 3d^6$ Mn: $[Ar]4s^2 3d^5$

Fe^{2+}: $[Ar]4s^0 3d^6$ or $[Ar]3d^6$ Mn^{2+}: $[Ar]4s^0 3d^5$ or $[Ar]3d^5$

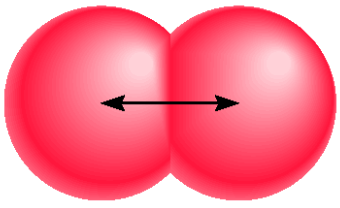
Fe^{3+}: $[Ar]4s^0 3d^5$ or $[Ar]3d^5$

Atomic Radii



metallic radius

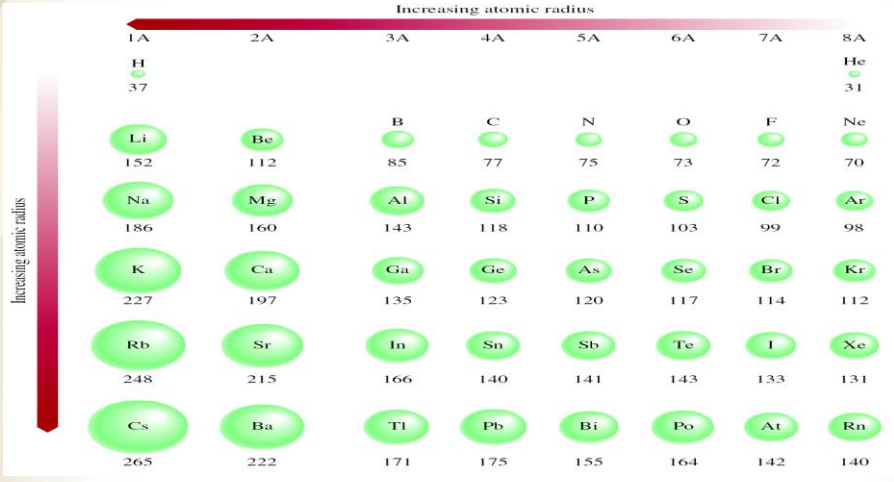
The metallic radius: is the radius of an atom joined by the metallic bond. The metallic radius is half of the total distance between the nuclei of two adjacent atoms in a metallic cluster



covalent radius

Covalent Radius: "When two atoms are bound together by a single bond in a covalent molecule distance between two atoms from center is known as covalent radius

General trends of the Atomic Radii



Ionization energy is the minimum energy (kJ/mol) required to remove an electron from a gaseous atom in its ground state.

$I_1 + X_{(g)} \longrightarrow X^+_{(g)} + e^-$ I_1 first ionization energy

$I_2 + X^+_{(g)} \longrightarrow X^{2+}_{(g)} + e^-$ I_2 second ionization energy

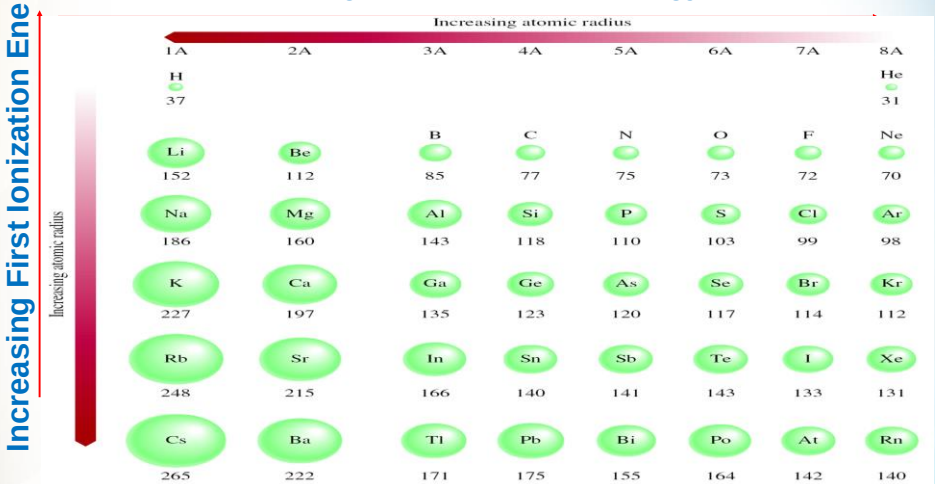
$I_3 + X^{2+}_{(g)} \longrightarrow X^{3+}_{(g)} + e^-$ I_3 third ionization energy

$$I_1 < I_2 < I_3$$

The electron arrangement of an atom at its lowest possible energy state is known as the ground state electron configuration

General Trends in First Ionization Energies

Increasing First Ionization Energy



- **Electron affinity (EA) is the energy related to adding an electron to a gaseous atom**
- **Represented as $X(g) + e^- \rightarrow X^-(g)$**
- Whereas **IE (Ionization Energy)** is: **$X(g) \rightarrow X^+(g) + e^-$**
- **The trend for EA is the same as that for IE**
- **Imagine an atom with a high IE. It is difficult to remove an electron; so, it will also be easy to add a new one**
- **Noble gases do not follow the trend in EA (a filled valence shell makes it energetically unfavorable to add an electron)**

Bonding definition , types and properties

Valence electrons are the outer shell electrons of an atom. The valence electrons are the electrons that participate in chemical bonding.

Group	e⁻ configuration	# of valence e⁻
1A	ns^1	1
2A	ns^2	2
3A	ns^2np^1	3
4A	ns^2np^2	4
5A	ns^2np^3	5
6A	ns^2np^4	6
7A	ns^2np^5	7

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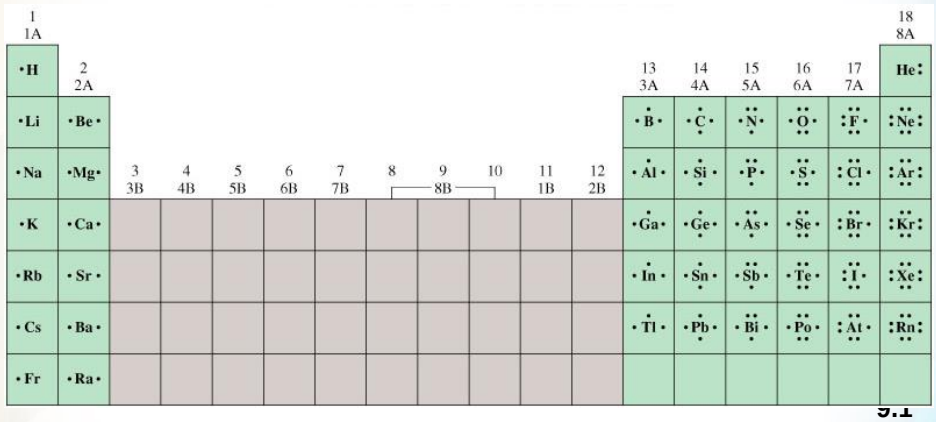
Lewis Dot Symbols for the Representative Elements & Noble Gases



The Ionic Bond

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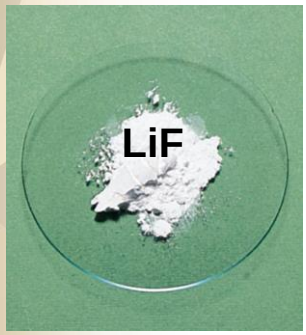
Ionic bond: the electrostatic force that holds ions together in an ionic compound.



$$Li^{\bullet} + :\ddot{F}:^{\bullet} \longrightarrow Li^{+}[:\ddot{F}:]^{-}$$

$1s^2 2s^1 \quad 1s^2 2s^2 2p^5 \quad 1s^2 \quad 1s^2 2s^2 2p^6$

[He] [Ne]

$$Li^{\bullet} \longrightarrow Li^{+} + e^{-}$$

$$e^{-} + :\ddot{F}:^{\bullet} \longrightarrow :\ddot{F}:^{-}$$

$$Li^{+} + [:\ddot{F}:]^{-} \longrightarrow Li^{+}[:\ddot{F}:]^{-}$$

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A covalent bond is a chemical bond in which two or more electrons are shared by two atoms.

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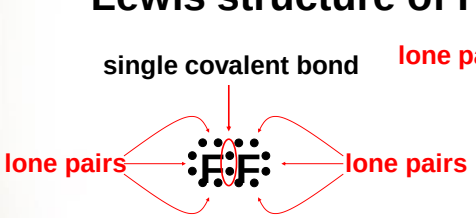
Why should two atoms share electrons?

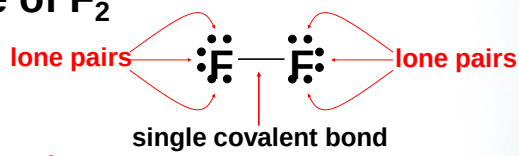
$$H^{\bullet} + {}^{\bullet}H \longrightarrow H:H$$

$$:\ddot{F}:^{\bullet} + {}^{\bullet}\ddot{F}: \longrightarrow :\ddot{F}:\ddot{F}:$$

$7e^-$ $7e^-$ $8e^-$ $8e^-$

Lewis structure of F_2





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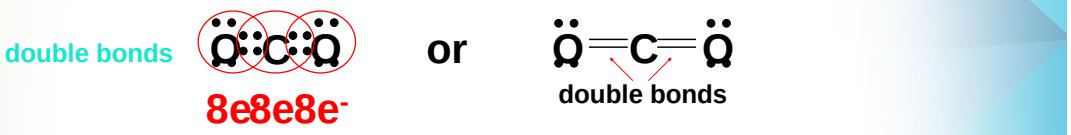
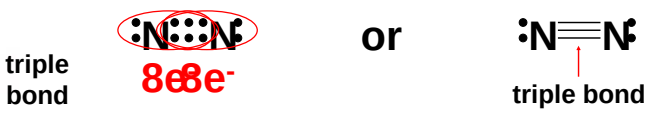
Lewis structure of water

single covalent bonds

Double bond – two atoms share two pairs of electrons



***Triple bond* – two atoms share three pairs of electrons**



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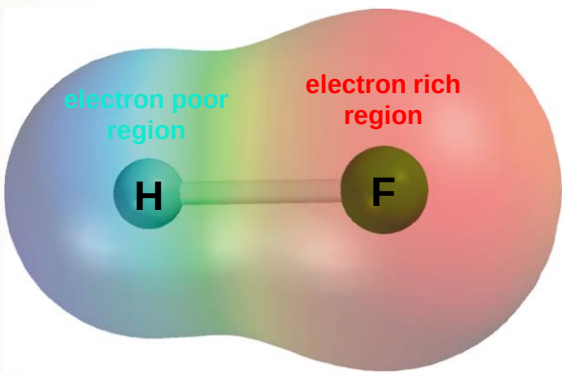
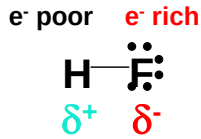
Polar covalent bond or polar bond is a covalent bond with greater electron density around one of the two atoms





Hydrofluoric acid

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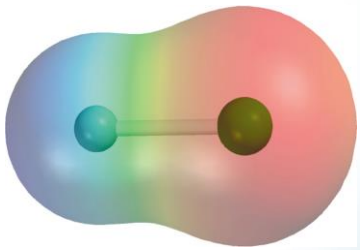
Electronegativity is the ability of an atom to attract toward itself the electrons in a chemical bond.

Electron Affinity - measurable, Cl is highest

$$X_{(g)} + e^- \longrightarrow X^-_{(g)}$$

Electronegativity - relative, F is highest



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The Electronegativities of Common Elements

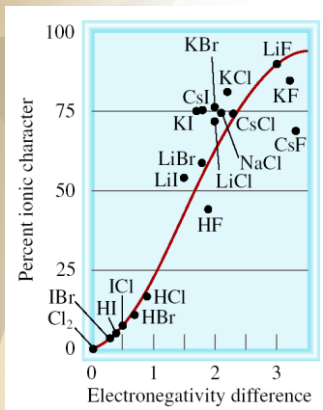
Increasing electronegativity

Increasing electronegativity

1A												3A	4A	5A	6A	7A	8A
H 2.1	2A																
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	
Na 0.9	Mg 1.2	3B	4B	5B	6B	7B		8B			1B	2B	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.9	Ni 1.9	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La-Lu 1.0-1.2	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Tl 1.8	Pb 1.9	Bi 1.9	Po 2.0	At 2.2	
Fr 0.7	Ra 0.9																

9.5

Classification of bonds by difference in electronegativity



Difference	Bond Type
0.4	Covalent
0.4 < and <2	Polar Covalent
≥ 2	Ionic

Increasing difference in electronegativity

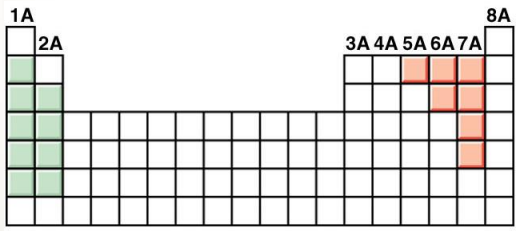
Covalent → **Polar Covalent** → **Ionic**

share e⁻ — **partial transfer of e⁻** — **transfer e⁻**

Classify the following bonds as ionic, polar covalent, or covalent: The bond in CsCl; the bond in H_2S; and the NN bond in H_2NNH_2.

(The Electronegativities of Common Elements) sea previous table

Cs – 0.7	Cl – 3.0	3.0 – 0.7 = 2.3	Ionic
H – 2.1	S – 2.5	2.5 – 2.1 = 0.4	Polar Covalent
N – 3.0	N – 3.0	3.0 – 3.0 = 0	Covalent



9.5

Metallic Bonds

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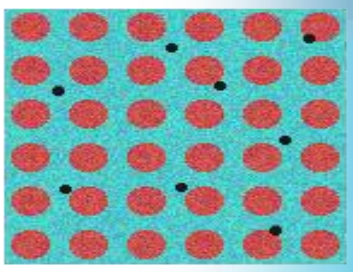
- The valence electrons of metal atoms can drift freely from one part of the metal to another- this is sometimes called a "sea of electrons"
- Metallic bonds consist of the attraction between these free floating electrons and the positively charged metal ions (cations).

This attraction is the "bond" that holds metals together.



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