



Week 2  
INTERATOMIC  
BONDING

Materials Science

---

# Atomic Structure

- Valence electrons (electrons at outermost shell) determine all of the following properties
  - 1) Chemical
  - 2) Electrical
  - 3) Thermal
  - 4) Optical

# Electronic Structure

- Electrons have wavelike and particulate properties.
- This means that electrons are in **orbitals** defined by a probability.
- Each orbital at discrete energy level determined by **quantum numbers**.

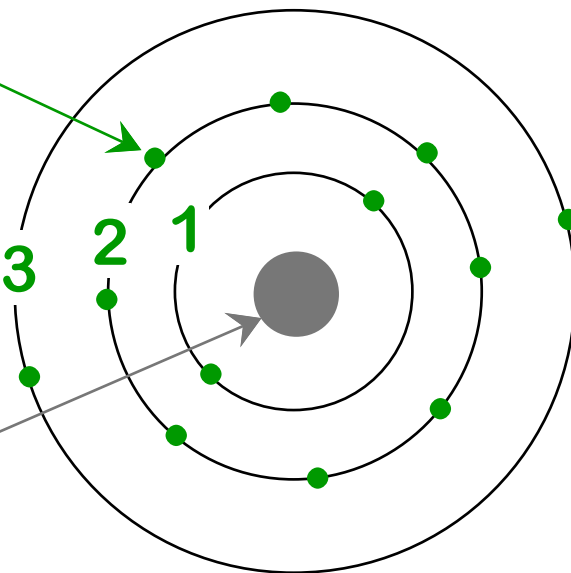
# Electron Configurations

- Valence electrons – those in unfilled shells.
- Filled shells are more stable.
- Valence electrons are most available for bonding and tend to control the chemical properties .

# Electron Configurations

orbital electrons:  
 $n =$  principal  
quantum number

$n=3$



**Nucleus:  $Z =$  # protons (1 for H to 94 for Pu)**

**$N =$  # neutrons**

**Atomic Number =  $Z$**

**Atomic mass  $A \approx Z + N$**

# The Periodic Table

Columns: Similar Valence Structure

give up 1e  
give up 2e  
give up 3e

accept 2e  
accept 1e  
inert gases

IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII			IB	IIB	IIIA	IVA	VA	VIA	VIIA	0											
1 H	2 He										3 B	4 C	5 N	6 O	7 F	8 Ne												
3 Li	4 Be										13 Al	14 Si	15 P	16 S	17 Cl	18 Ar												
11 Na	12 Mg										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	Rare earth series	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	Acti-nide series	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds																			

Metal  
Nonmetal  
Intermediate

Adapted from  
Fig. 2.6,  
Callister 7e.

Electropositive elements:  
Readily give up electrons  
to become + ions.

Electronegative elements:  
Readily acquire electrons  
to become - ions.

# Electronegativity

- Ranges from **0.7** to **4.0**,
- Large values: tendency to acquire electrons.

IA																	0
H																	He
2.1	IIA											IIIA	IVA	VA	VIA	VIIA	-
Li	Be											B	C	N	O	F	Ne
1.0	1.5											2.0	2.5	3.0	3.5	4.0	-
Na	Mg											Al	Si	P	S	Cl	Ar
0.9	1.2	IIIB	IVB	VB	VIB	VIIIB	VIII			IB	IIB	1.5	1.8	2.1	2.5	3.0	-
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
0.8	1.0	1.3	1.5	1.6	1.6	1.5	1.8	1.8	1.8	1.9	1.6	1.6	1.8	2.0	2.4	2.8	-
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.2	2.2	2.2	1.9	1.7	1.7	1.8	1.9	2.1	2.5	-
Cs	Ba	La-Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
0.7	0.9	1.1-1.2	1.3	1.5	1.7	1.9	2.2	2.2	2.2	2.4	1.9	1.8	1.8	1.9	2.0	2.2	-
Fr	Ra	Ac-No															
0.7	0.9	1.1-1.7															



Smaller electronegativity

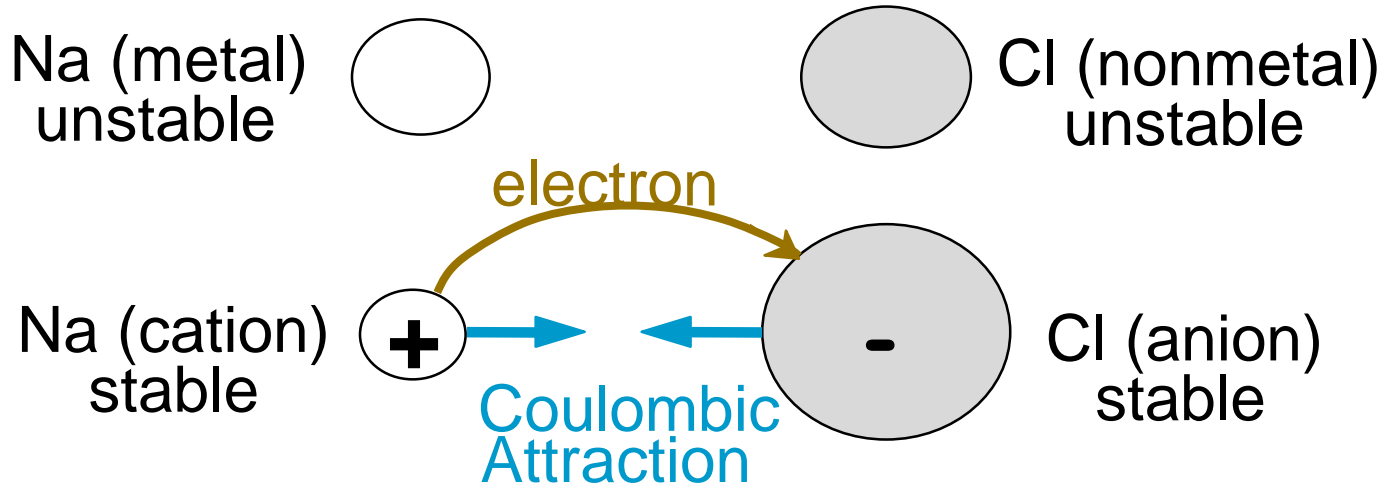


Larger electronegativity

Adapted from Fig. 2.7, *Callister 7e*. (Fig. 2.7 is adapted from Linus Pauling, *The Nature of the Chemical Bond*, 3rd edition, Copyright 1939 and 1940, 3rd edition. Copyright 1960 by Cornell University.)

# Ionic Bonding

- Occurs between + and - ions.
- Requires **electron transfer**.
- Large difference in electronegativity required.
- Example: NaCl









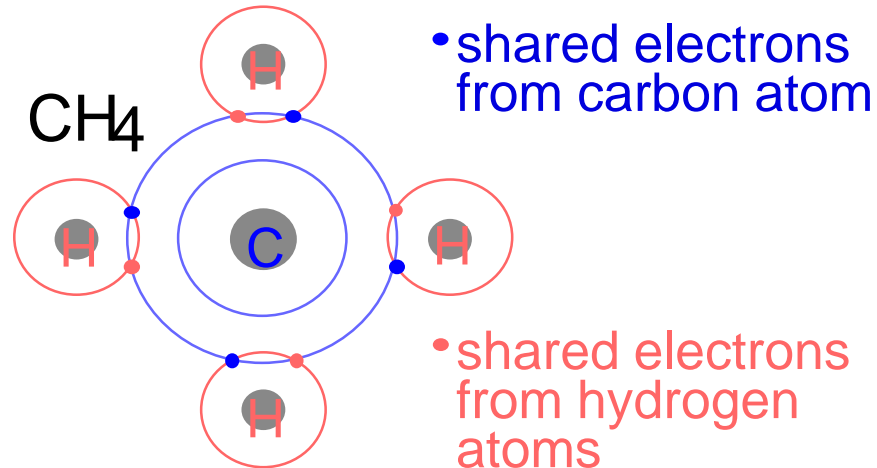
# Covalent Bonding

- similar **electronegativity**  $\therefore$  share electrons
- bonds determined by valence –  $s$  &  $p$  orbitals dominate bonding
- Example:  $\text{CH}_4$

C: has 4 valence  $e^-$ ,  
needs 4 more

H: has 1 valence  $e^-$ ,  
needs 1 more

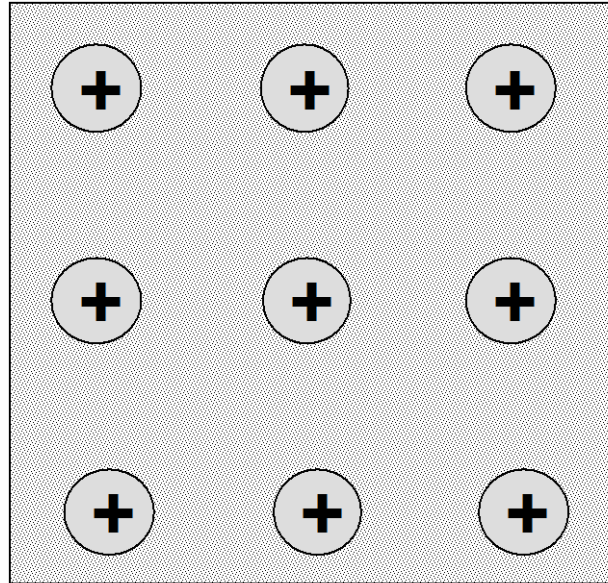
Electronegativities are  
comparable.



- It is a bond with a localized direction.



# Metallic Bonding



- Primary bond for **metals** and their **alloys**
- It is a strong and nondirectional bonding.

# Summary: Bonding

<u>Type</u>	<u>Bond Energy</u>	<u>Comments</u>
Ionic	Large!	Nondirectional ( <b>ceramics</b> )
Covalent	Variable large-Diamond small-Bismuth	Directional <b>semiconductors, ceramics</b> <b>polymer</b> chains)
Metallic	Variable large-Tungsten small-Mercury	Nondirectional ( <b>metals</b> )

# Summary: Primary Bonds

## Ceramics

(Ionic & covalent bonding):

Large bond energy

large  $T_m$

large  $E$

small  $\alpha$

## Metals

(Metallic bonding):

Variable bond energy

moderate  $T_m$

moderate  $E$

moderate  $\alpha$

## Polymers

(Covalent & Secondary):

Directional Properties  
Secondary bonding dominates

small  $T_m$

small  $E$

large  $\alpha$

