

CHEM 108

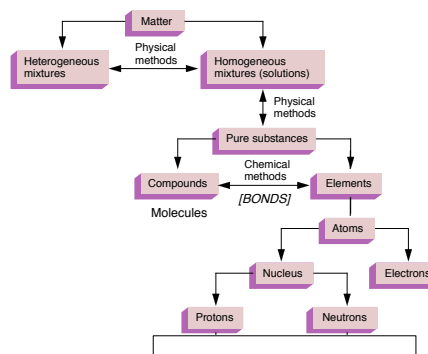
Organization of Matter III

Discussion Questions 1.7

Molecules/ Compounds/ Bonds and The Periodic Table

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Atoms & Molecules



Compounds & Chemical Bonds

Atoms in a compound (molecule) are in ratios of whole numbers with specific 3-dimensional arrangements due to attractive inter-atomic forces (Bonds). These provide favorable energy states & spatial positions (lower energy & farther apart are better), which result in molecules having new chemical, physical, and biological properties.

Electrons, Configurations, & Bonds

Noble Gases and The Rule of Eight

- When a nonmetal and a metal combine, they form an **ionic bond**: Valence electrons of the metal are lost and the nonmetal gains these electrons to achieve a Noble gas electron configuration.
- When two nonmetals combine, they form a **covalent bond**: They share electrons to achieve a Noble gas electron configuration.

Periodic Properties

Periodic Properties

<http://chemconnections.org/general/movies/periodic-prop.MOV>

Number of Valence Electrons for Elements in the "A" lettered Vertical Columns Equal the Column Number

Period	1A (1)	2A (2)	3A (13)	4A (14)	5A (15)	6A (16)	7A (17)	8A (18)
1	H ⁺							
2	Li ⁺							
3	Na ⁺	Mg ²⁺						
4	K ⁺	Ca ²⁺						
5	Rb ⁺	Sr ²⁺						
6	Cs ⁺	Ba ²⁺						
7								

Ionic Bonds

- Result from electrostatic attractions of closely packed, oppositely charged ions.
- Form when an atom which can easily lose electrons reacts with one which has a high electronegativity (electron affinity), that is, it can easily gain electrons.
- Eg. Mg and Cl; K and O

The Relationship Between Ions Formed and the Nearest Noble Gas

Electron Configurations

Ionic Compounds

- Neutrally Charged
- Eg. Salt: $\text{NaCl} \rightarrow 1 \text{Na}^+ \text{ and } 1 \text{Cl}^-$
- What is the proportion of ions for a compound formed from Mg ion and chlorine?
- Mg^{2+} and Cl^-
- 1 Mg^{2+} combines with 2 Cl^-



Ionic Compounds

Neutrally Charged

Eg. Salt: $\text{NaCl} \rightarrow 1 \text{Na}^+ \text{ and } 1 \text{Cl}^-$

Provide Formulas for the Compounds formed from the Ions of the Atoms

	Na	Mg	In
Cl			
N			
O			

Nomenclature Tutorial (print)

Ionic Compounds

Provide Formulas for the Compounds formed from the Ions of the Atoms

	Na	Mg	In
Cl		MgCl_2	
N			
O			In_2O_3

Mg
magnesium

Name the compound.
magnesium chloride

Mg^{2+} and Cl^-

Cl
chlorine

indium oxide

Li_xCoO_2
Cathode

Li_xFePO_4

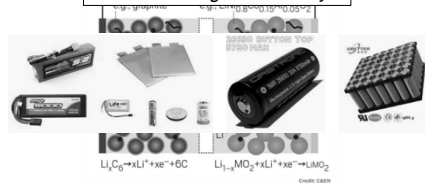
Polyacetylene
Anode



Credit: Mitsu Jacoby/CORBIS; Birmingham University; The Japan Prize Foundation

John B. Goodenough (left), M. Stanley Whittingham, and Akira Yoshino were awarded the 2019 Nobel Prize in Chemistry.

2019 Nobel Prize in Chemistry
Li-ion rechargeable battery



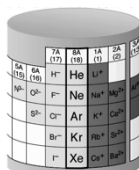
Credit: CORBIS

Lithium-ion batteries work through the reversible flow of lithium ions between an anode and a cathode.

QUESTION

Predict the formula for the binary ionic compound formed by aluminum and oxygen.

- A) Al_2O_3 B) Al_3O_2 C) Al_2O D) AlO_2

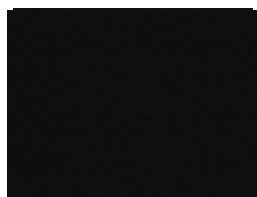


ANSWER

Predict the formula for the binary ionic compound formed by aluminum and oxygen.

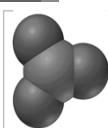
- A) Al_2O_3 B) Al_3O_2 C) Al_2O D) AlO_2

Ionic vs. Covalent Bonding



<http://chemconnections.org/general/movies/ionic-covalent.mov>

Polyatomic Ions



Carbonate ion
 CO_3^{2-}

Common Polyatomic Ions			
Ion	Name	Ion	Name
Hg_2^{2+}	Mercury(I)	NCS^-	Thiocyanate
NH_4^+	Ammonium	CO_3^{2-}	Carbonate
NO_2^-	Nitrite	HCO_3^-	Hydrogen carbonate (bicarbonate is a widely used common name)
NO_3^-	Nitrate	ClO_2^-	Hypochlorite
SO_3^{2-}	Sulfite	ClO_3^-	Chlorite
SO_4^{2-}	Sulfate	ClO_4^-	Chlorate
HSO_4^-	Hydrogen sulfate (bisulfate is a widely used common name)	$C_2H_3O_2^-$	Perchlorate
OH^-	Hydroxide	$C_2H_3O_2^-$	Acetate
CN^-	Cyanide	MnO_4^-	Permanganate
PO_4^{3-}	Phosphate	$Cr_2O_7^{2-}$	Dichromate
HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate

<http://chemconnections.org/general/chem120/polyatomics.html>

QUESTION

Which formula is correct?

- A) $MgNO_3$ B) NH_4CO_3 C) $Na(PO_4)_3$ D) $Al_2(SO_4)_3$

Common Polyatomic Ions			
Ion	Name	Ion	Name
Hg_2^{2+}	Mercury(I)	NCS^-	Thiocyanate
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HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate

ANSWER

Which formula containing polyatomic ions is correct?

- A) $MgNO_3$ B) NH_4CO_3 C) $Na(PO_4)_3$ D) $Al_2(SO_4)_3$

Common Polyatomic Ions			
Ion	Name	Ion	Name
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		$C_2O_4^{2-}$	Oxalate

CHEM 108

Organization of Matter III


Discussion Questions 1.7

Molecules/ Compounds/ Bonds

Electronegativity


and

The Periodic Table



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Electronegativity



<http://chemconnections.org/general/movies/electronegativity.mov>

Covalent Bonding

	I A											IIIA	IVA	V A	VIA	VIIA	VIII ^A	
1	H 2.1												B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	He 2
2	Li 1.0	Be 1.5																Ne
3	Na 0.9	Mg 1.2										Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar	
4	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 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr
5	Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.7	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.6	In 1.8	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe
6	Cs 0.7	Ba 0.9	La 1.1	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 2.1	Tl 1.8	Pb 1.8	Bi 1.9	Po 2.0	At	Rn
7	K [*] 0.7	Ra 0.9	Ac [*] 1.0	Th [*] 1.3	Pa [*] 1.5	U [*] 1.6	Np [*] 1.6	Pl [*] 1.8	Am [*] 1.8	Cm [*] 1.9	Bk [*] 1.1	Lf [*] 1.1						

Lanthanides

58	59	60	61	62	63	64	65	66	67	68	69	70	71	Lu
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	

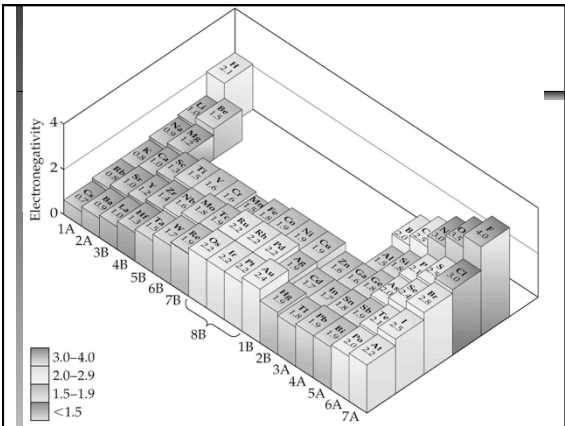
Actinides

90	91	92	93	94	95	96	97	98	99	100	101	102	103	
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Electronegativity

Periodic Trends:
Electronegativity

<http://chemconnections.org/general/movies/Periodic-e.n.MOV>



QUESTION

For the elements Rb, F, and O, the order of increasing electronegativity is:

- A) $\text{Rb} < \text{F} < \text{O}$.
- B) $\text{Rb} < \text{O} < \text{F}$.
- C) $\text{O} < \text{F} < \text{Rb}$.
- D) $\text{F} < \text{Rb} < \text{O}$.
- E) none of these.

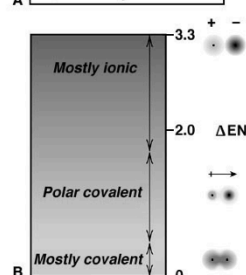
ANSWER

B) $\text{Rb} < \text{O} < \text{F}$.

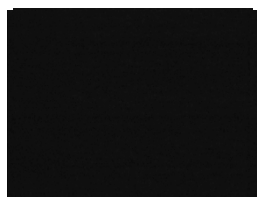
Electronegativities increase moving up a column and to the right in the periodic table.

Boundary Ranges for Classifying Ionic Character of Chemical Bonds

ΔEN	IONIC CHARACTER
>1.7	Mostly ionic
$0.4-1.7$	Polar covalent
<0.4	Mostly covalent
0	Nonpolar covalent



Ionic vs. Covalent Bonding



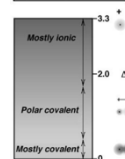
<http://chemconnections.org/general/movies/ionic-covalent.mov>

QUESTION

Atoms having greatly differing electronegativities are expected to form:

- 1) no bonds.
- 2) polar covalent bonds.
- 3) nonpolar covalent bonds.
- 4) ionic bonds.
- 5) covalent bonds.

ΔEN	IONIC CHARACTER
>1.7	Mostly ionic
$0.4-1.7$	Polar covalent
<0.4	Mostly covalent
0	Nonpolar covalent



ANSWER

D) ionic bonds.

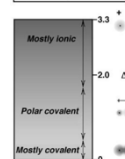
If two atoms have greatly differing electronegativities the more electronegative atom will pull on the bonding electrons so strongly the electrons will transfer from one atom to the other.

QUESTION

Atoms having the same electronegativity are expected to form:

- A) no bonds.
- B) polar covalent bonds.
- C) nonpolar covalent bonds.
- D) ionic bonds.
- E) covalent bonds.

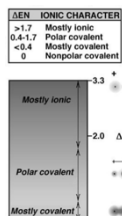
ΔEN	IONIC CHARACTER
>1.7	Mostly ionic
$0.4-1.7$	Polar covalent
<0.4	Mostly covalent
0	Nonpolar covalent



Answer

Atoms having the same electronegativity are expected to form:

- A) no bonds.
- B) polar covalent bonds.
- C) **nonpolar covalent bonds.**
- D) ionic bonds.
- E) covalent bonds.



Question

Which of the following bonds is the most polar?

- A) H—F
- B) H—Cl
- C) H—Br
- D) H—CH₃

Answer

Which of the following bonds is the most polar?

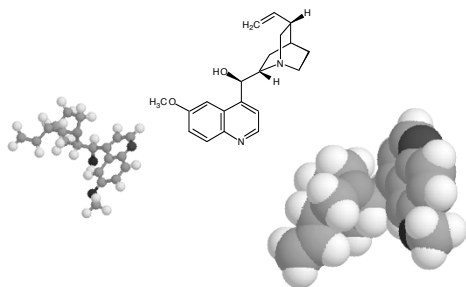
- A) **H—F**
- B) H—Cl
- C) H—Br
- D) H—CH₃

Chemical Formulas & Molecular Representations

Representing Substances

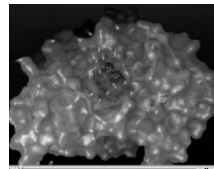
<http://chemconnections.org/general/movies/Representations.MOV>

Structural Representations of Quinine



Proteins & Small Molecules

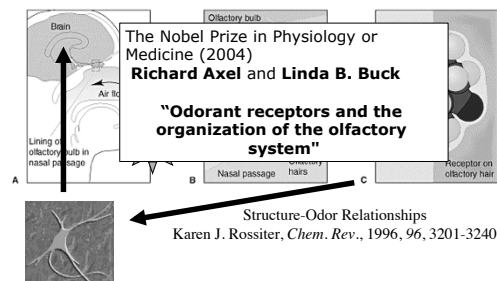
The interaction of a large protein bio-polymer, acetylcholinesterase, with a relatively small molecule of acetylcholine. A general process similar to the way that scientists that think we smell and many physiological processes.



<http://chemconnections.org/general/movies/richard.mpg>

*Detecting stuff we cannot see: the Sense of Smell
Models, Theories & Interactions*

<http://chemconnections.org/organic/chem226/Labs/Smell/smell-links.html>



Vanillin (Smell)
Sensitivity
 $\sim 1 \times 10^{-5} \text{ mol / m}^3_{\text{air}}$

