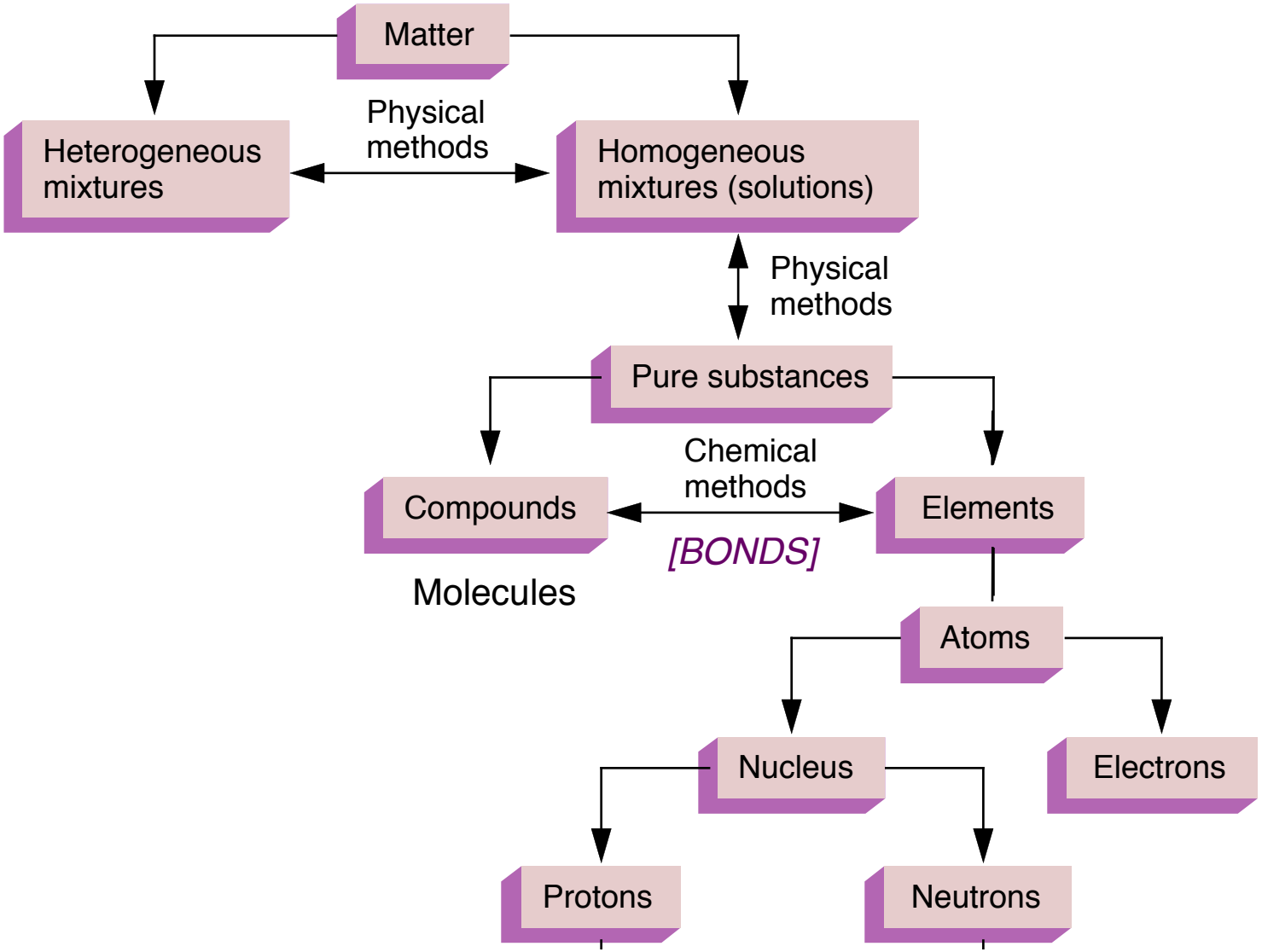
CHEM 108

Discussion Guide 1.7

Molecules/ Compounds/ Bonds and The Periodic Table

Atoms & Molecules



Compounds & Chemical Bonds

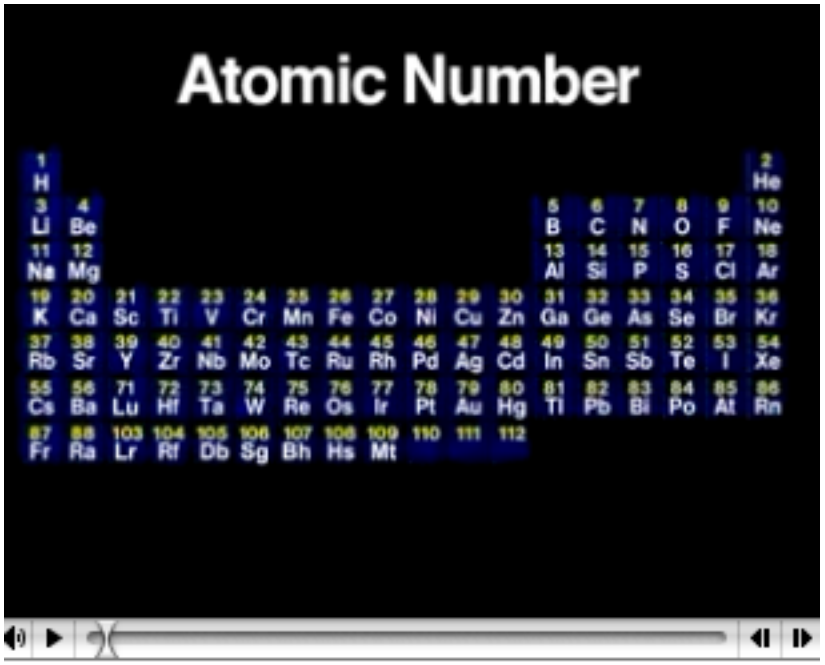
Atoms in a compound (molecule) are in ratios of whole numbers with specific 3-dimensional arrangements due to attractive inter-atomic forces (Bonds). These provide favorable energy states & spatial positions (lower energy & farther apart are better), which result in molecules having new chemical, physical,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

Electrons, Configurations, & Bonds

Noble Gases and The Rule of Eight

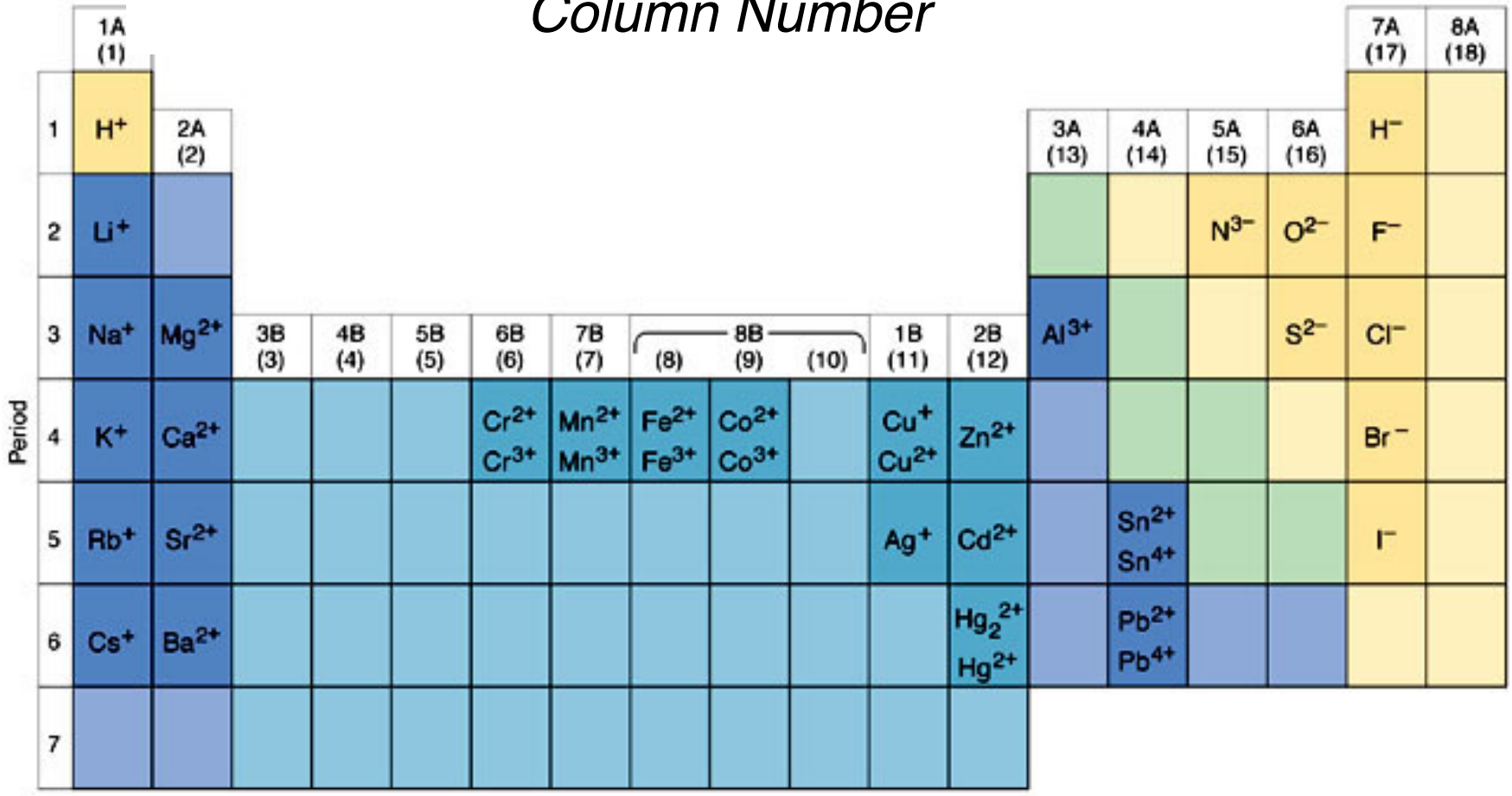
- *When a nonmetal and a metal combine, they form an **ionic bond**: Valence electrons of the metal are lost and the nonmetal gains these electrons to achieve a Noble gas electron configuration.*
- *When two nonmetals combine, they form a **covalent bond**: They share electrons to achieve a Noble gas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

Periodic Properties



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

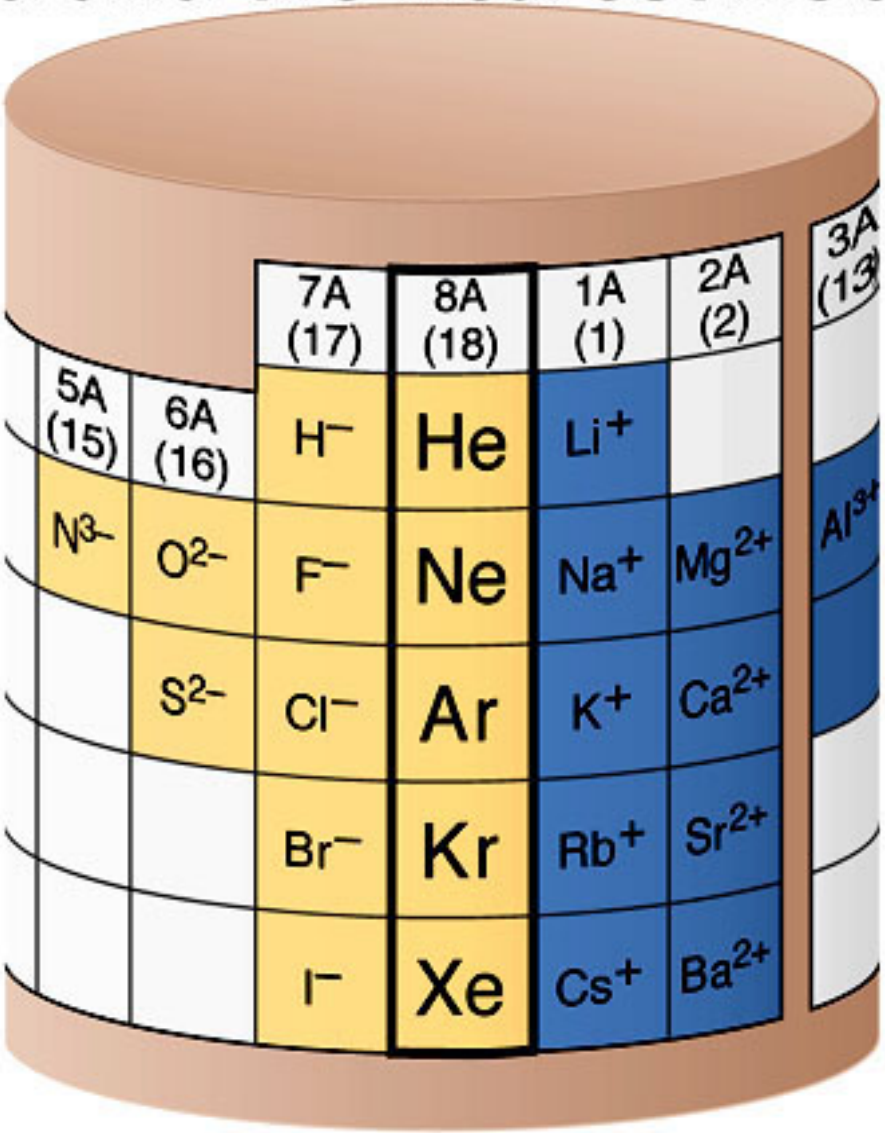
Number of Valence Electrons for Elements in the "A" lettered Vertical Columns Equal the Column Number



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: NaCl → 1 Na^+ and 1 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^-*

$MgCl_2$

Ionic Compounds

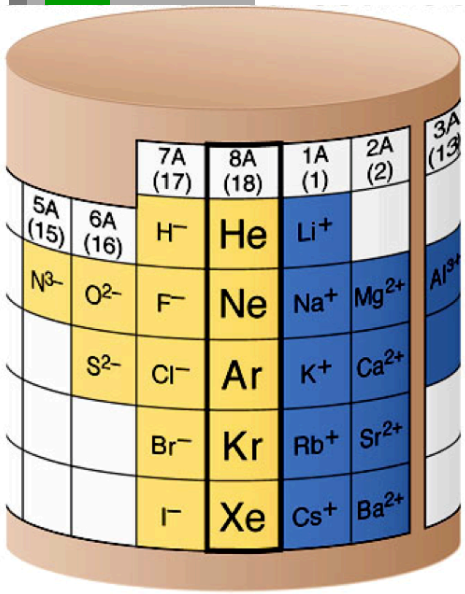
- *Neutrally Charged*
- *Eg. Salt: NaCl → 1 Na^+ and 1 Cl^-*

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

	Na	Mg	In
Cl			
N			
O			

Ionic Compounds

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



	Na	Mg	In
Cl		$MgCl_2$	
N			
O			

Mg

Name the compound.

Mg^{2+} and Cl^-

Cl

Quantum Chemistry

Electron Configurations

&

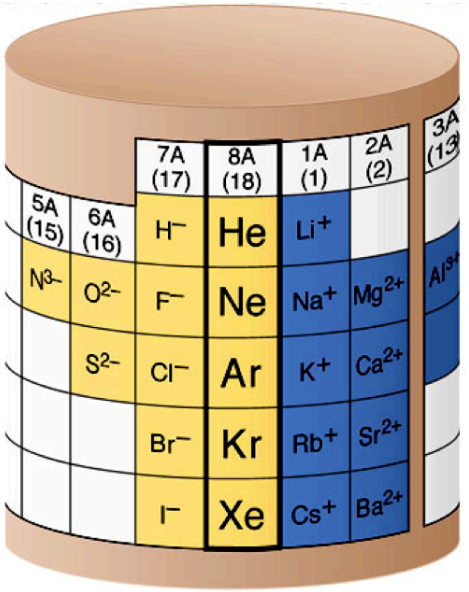
The Periodic Table

Discussion Guide 1.7

QUESTION

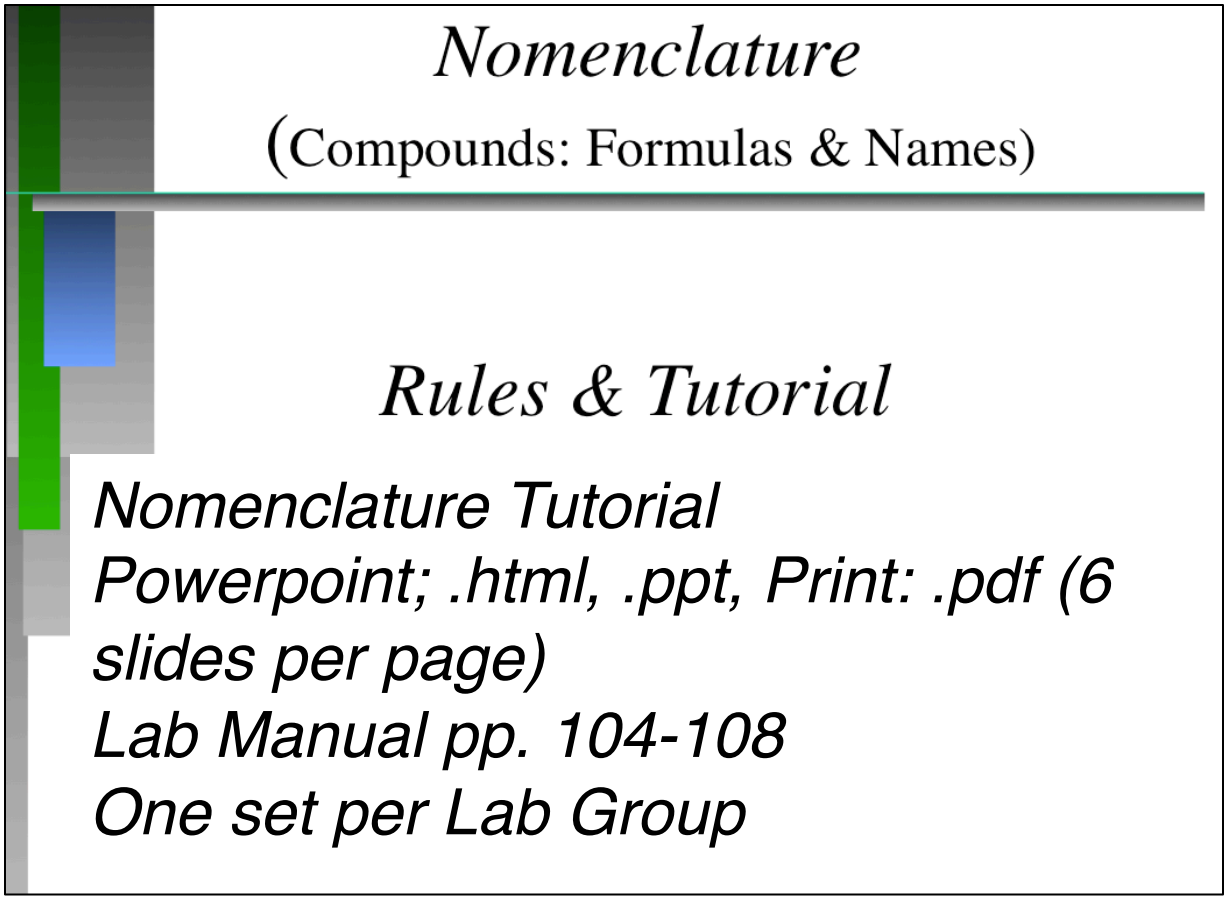
Predict the formula for the binary ionic compound formed by aluminum and oxygen.

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

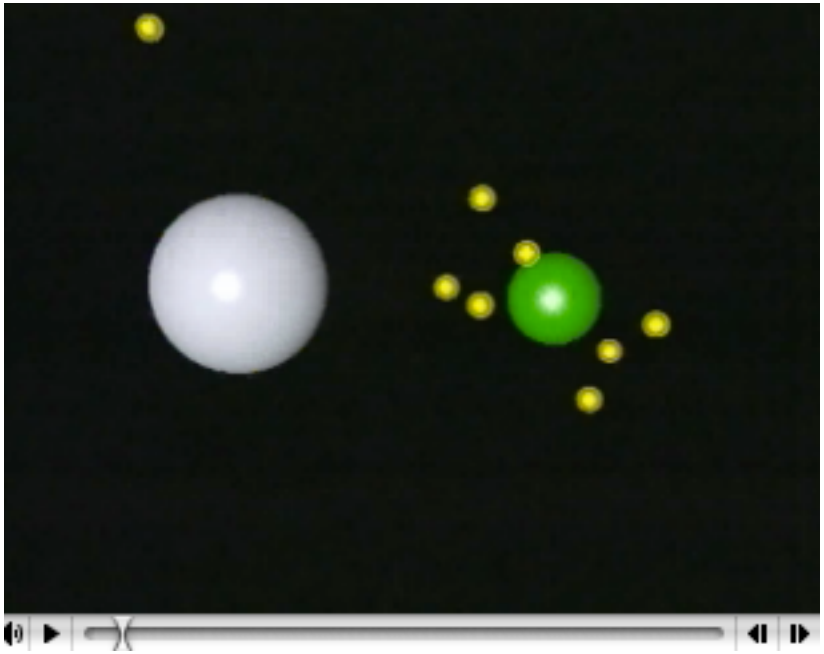


Complete Self-Paced Tutorial

http://chemconnections.org/general/chem108/Nomenclature.htm

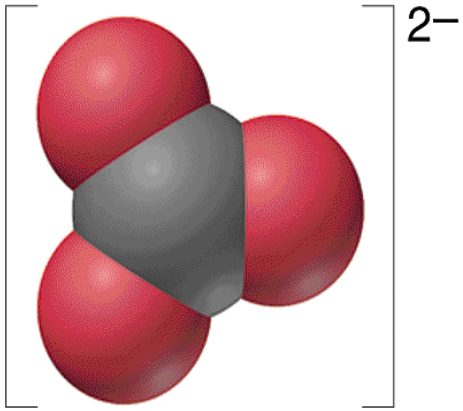


Ionic vs. Covalent Bonding



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		
SO_3^{2-}	Sulfite		
SO_4^{2-}	Sulfate	ClO^-	Hypochlorite
HSO_4^-	Hydrogen sulfate (bisulfate is a widely used common name)	ClO_2^-	Chlorite
		ClO_3^-	Chlorate
		ClO_4^-	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) $Al_2(SO_4)_3$

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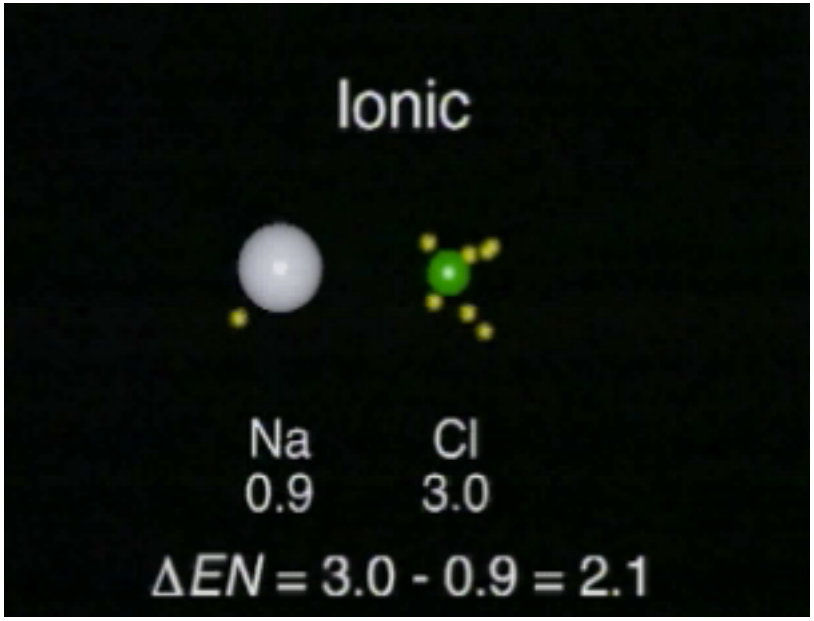
		ClO_4^-	Perchlorate
OH^-	Hydroxide	$C_2H_3O_2^-$	Acetate
CN^-	Cyanide	MnO_4^-	Permanganate
PO_4^{3-}	Phosphate	$Cr_2O_7^{2-}$	Dichromate
HPO_4^{2-}	Hydrogen phosphate	CrO_4^{2-}	Chromate
$H_2PO_4^-$	Dihydrogen phosphate	O_2^{2-}	Peroxide
		$C_2O_4^{2-}$	Oxalate

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*

Electronegativity

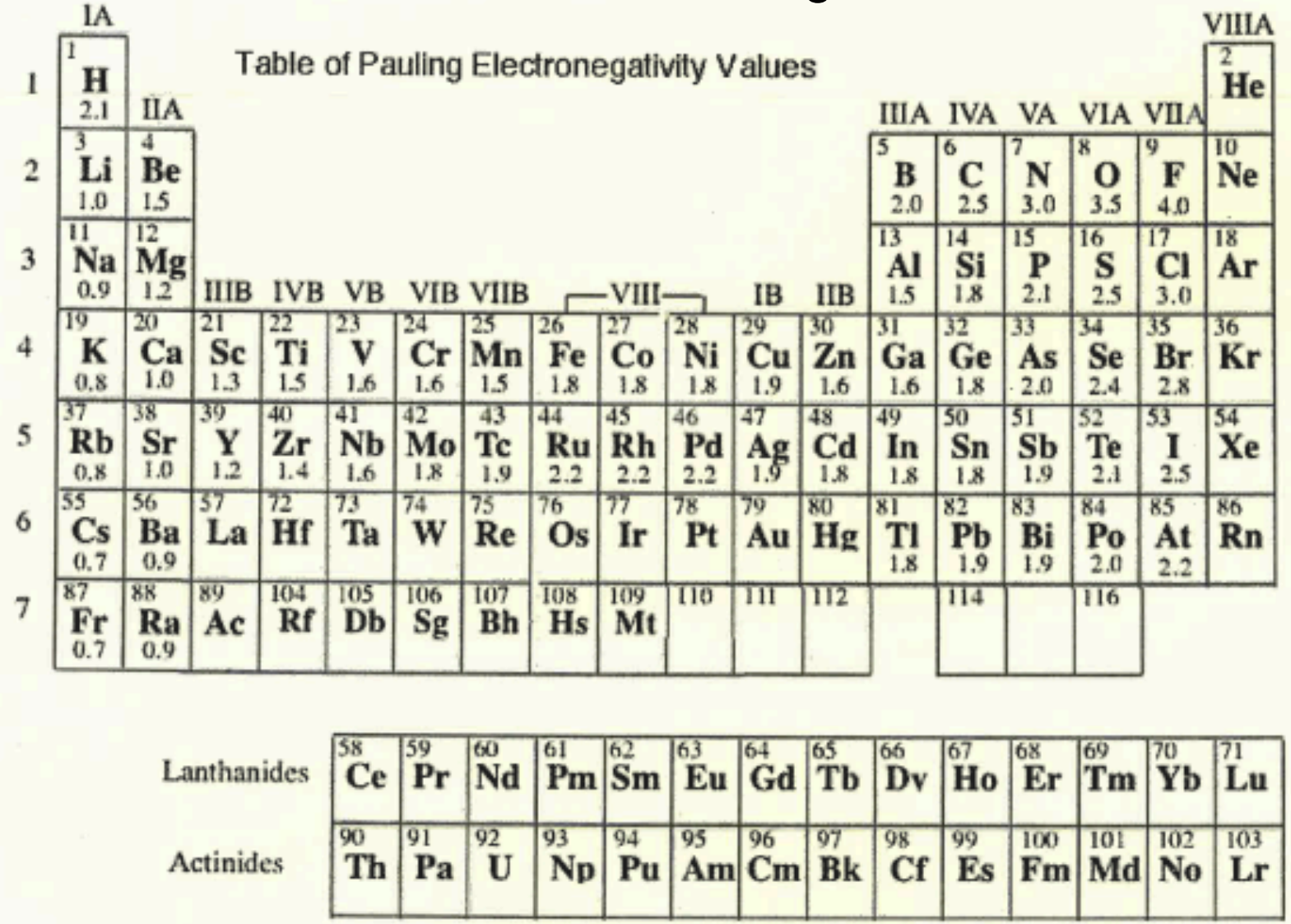


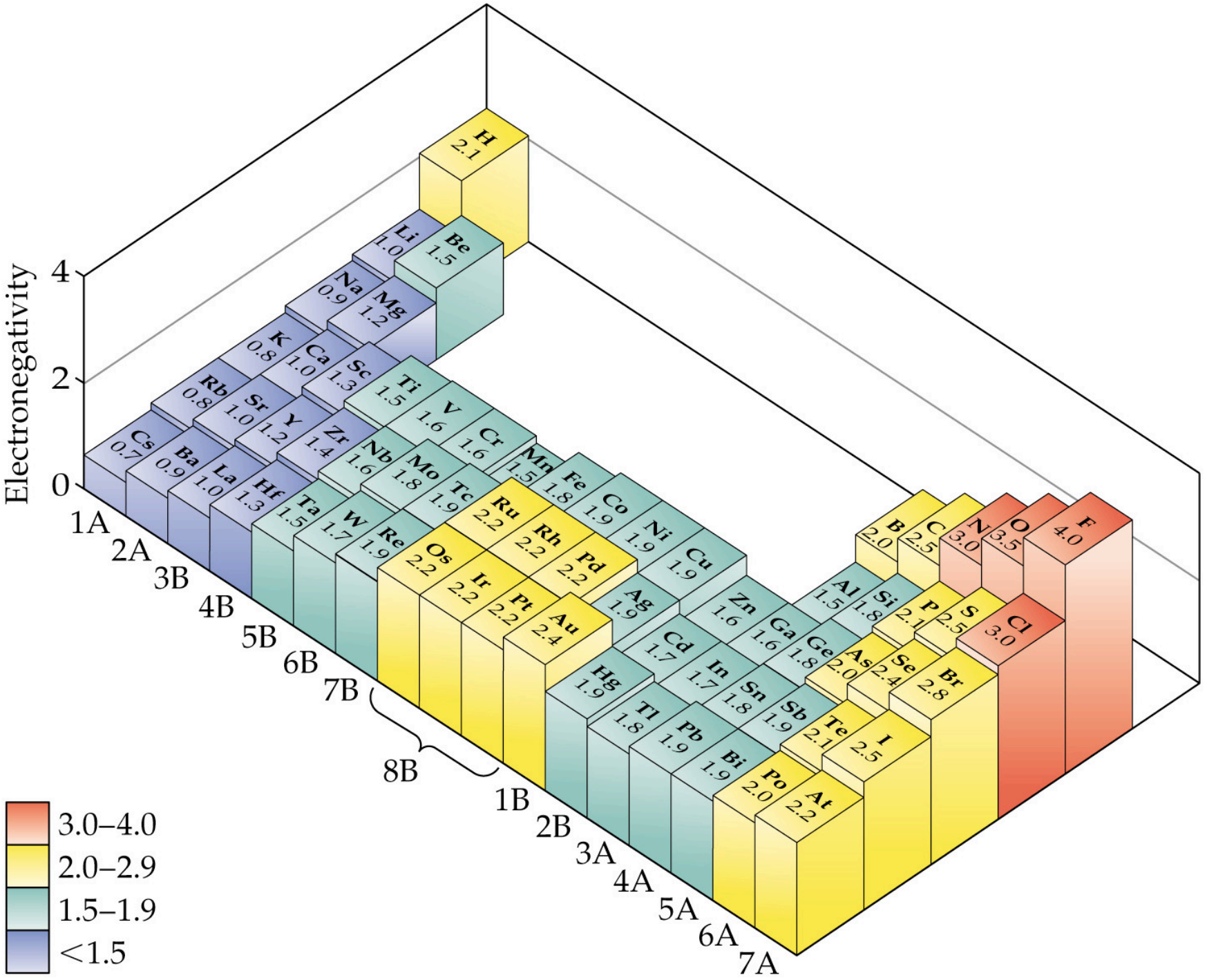
http://chemconnections.org/general/movies/electronegativity.mov

Electronegativity

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

Covalent Bonding




Electronegativity
4
2
0
1A
2A
3B
4B
5B
6B
7B
8B
1B
2B
3A
4A
5A
6A
7A
H 2.1
Li 1.0
Be 1.5
Na 0.9
Mg 1.2
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
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
Cs 0.7
Ba 0.9
La 1.0
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
B 2.0
C 2.5
N 3.0
O 3.5
F 4.0
Al 1.5
Si 1.8
P 2.1
S 2.5
Cl 3.0
3.0–4.0
2.0–2.9
1.5–1.9
<1.5

QUESTION

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

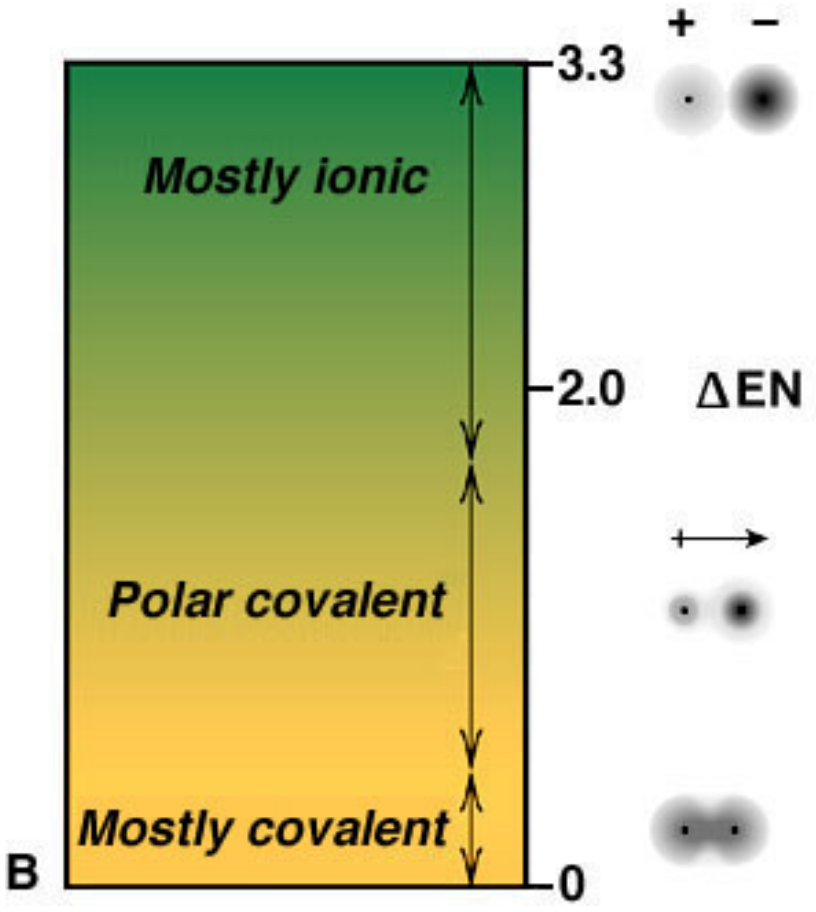
A) Rb < F < O.
B) Rb < O < F.
C) O < F < Rb.
D) F < Rb < O.
E) none of these.

Boundary Ranges for Classifying Ionic Character of Chemical Bonds

A

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

B

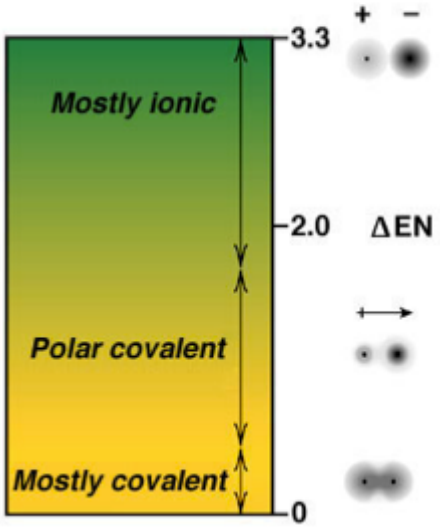


QUESTION

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

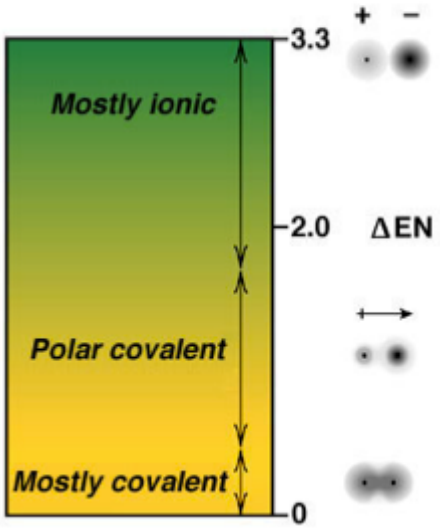


QUESTION

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



Question

Which of the following bonds is the most polar?

A) H—F

B) H—Cl

C) H—Br

D) $H—CH_3$

(Collaborative)

Names: _____

Molecular Modeling Report Form

These pages replace the Molecular Model Lab, pp. 97-103, of the Chemistry 108 Experiments Lab Manual. Complete the following modeling related exercises and include the names of all group members, who contributed to the work, on the form.

The first column lists formulas for a number of compounds. The bonding type is to be determined for these compounds using differences in their respective electronegativity values (refer to the in class information). The second column is for the electronegativity difference, the absolute value of the difference in electronegativity between the 2 different atoms in the compound, $|EN_2 - EN_1|$. The third column is for the average electronegativity of the two atoms, $(EN_1 + EN_2)/2$.

Compound	$\lvert EN_1 - EN_2 \rvert$	$\frac{EN_1 + EN_2}{2}$	Bonding Type
HF	*4.0 – 2.1 = 1.9*	*3.0*	*polar covalent*
HCl			
HBr			
HI			
CsF			
NaF			
CaO			
BaO			
NH_3			
CH_4			
CCl_4			
H_2O			
N_2O			
SO_2			
H_2			
O_2			

(Collaborative)

Names: _____

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Compound	$\lvert EN_1 - EN_2 \rvert$	$\frac{EN_1 + EN_2}{2}$	Bonding Type
HF	*4.0 – 2.1 = 1.9*	*3.0*	*polar covalent*
HCl			
HBr			
HI			
CsF			
NaF			
CaO			
BaO			
NH_3			
CH_4			
CCl_4			
H_2O			
N_2O			
SO_2			
H_2			
O_2			

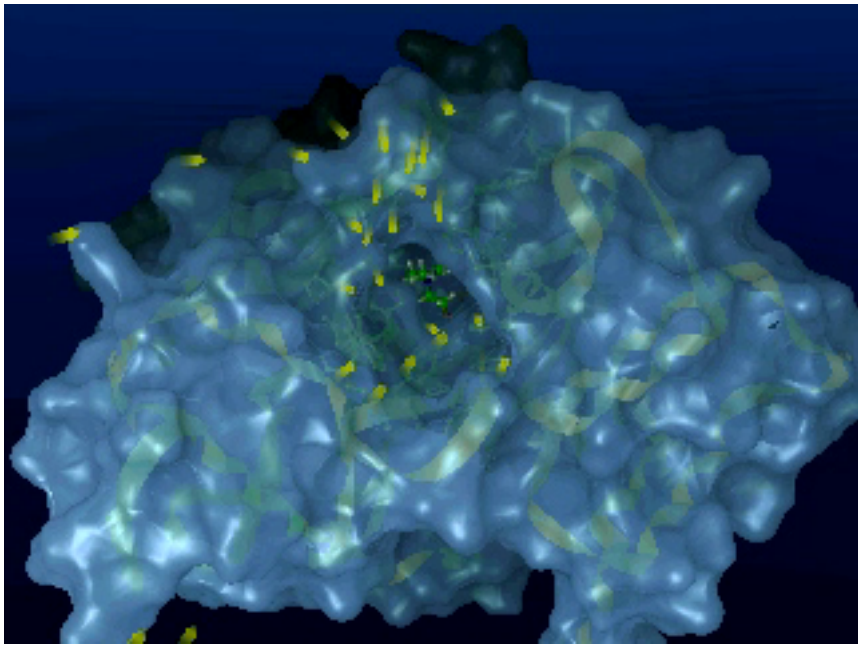
Complete first & second pages.
To be checked in lab.

Chemical Formulas & Molecular Representations

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

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

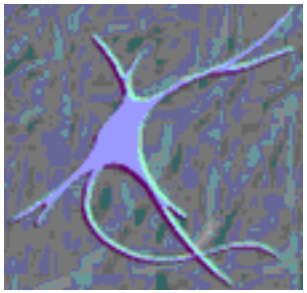
Detecting stuff we cannot see: the Sense of Smell Models, Theories & Interactions

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

The Nobel Prize in Physiology or Medicine (2004)

Richard Axel and **Linda B. Buck**

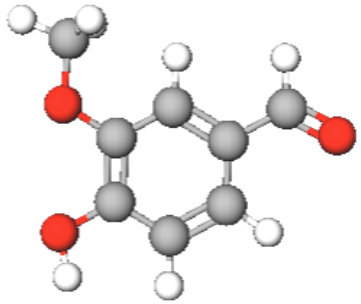
"Odorant receptors and the organization of the olfactory system"



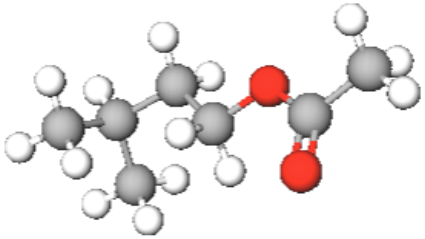
Structure-Odor Relationships

Karen J. Rossiter, *Chem. Rev.*, 1996, *96*, 3201-3240

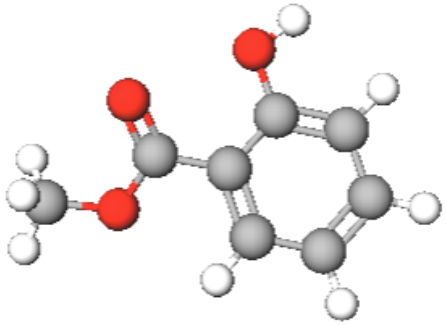
Vanillin (Smell)
Sensitivity
~ 1 x 10^{-5} mol / m^3_{air}



Vanillin
($C_8H_8O_3$)



isoamyl acetate
(banana)



methyl salicylate
(wintergreen)