

Name: _____

Unit 6 Packet

(Bonding & Molecular Structure)

Each learning objective number is hyperlinked to the page in the packet to make finding the work easier!

Learning objectives:

		Pre-unit	Mid-unit	Post-unit
6.1	I can identify how many valence electrons an atom has [review]	Not sure ▾	Not sure ▾	Not sure ▾
6.2	I can draw Lewis structures for covalent compounds	Not sure ▾	Not sure ▾	Not sure ▾
6.3	I can explain how all of the periodic trends relate to one another (atomic radius, ionization energy, electronegativity, effective nuclear charge). (please note-this is a separate lesson and not a part of the packet!) Click here for the packet information!	Not sure ▾	Not sure ▾	Not sure ▾
6.4	I can determine the type of bond (ionic or covalent) based on bond polarity.	Not sure ▾	Not sure ▾	Not sure ▾
6.5	I can name covalent compounds from the formula, or write the chemical formula based on the name. [review!]using prefixes	Not sure ▾	Not sure ▾	Not sure ▾
6.6	I can determine the number of electron domains, bonding regions, and lone pairs that are around a central atom.	Not sure ▾	Not sure ▾	Not sure ▾
6.7	I can predict, identify, and draw the molecular geometry of a molecule using VESPR	Not sure ▾	Not sure ▾	Not sure ▾

REFRESHER: Ions

(REVIEW)



1.) (REVIEW) Fill in the image below using the following words:

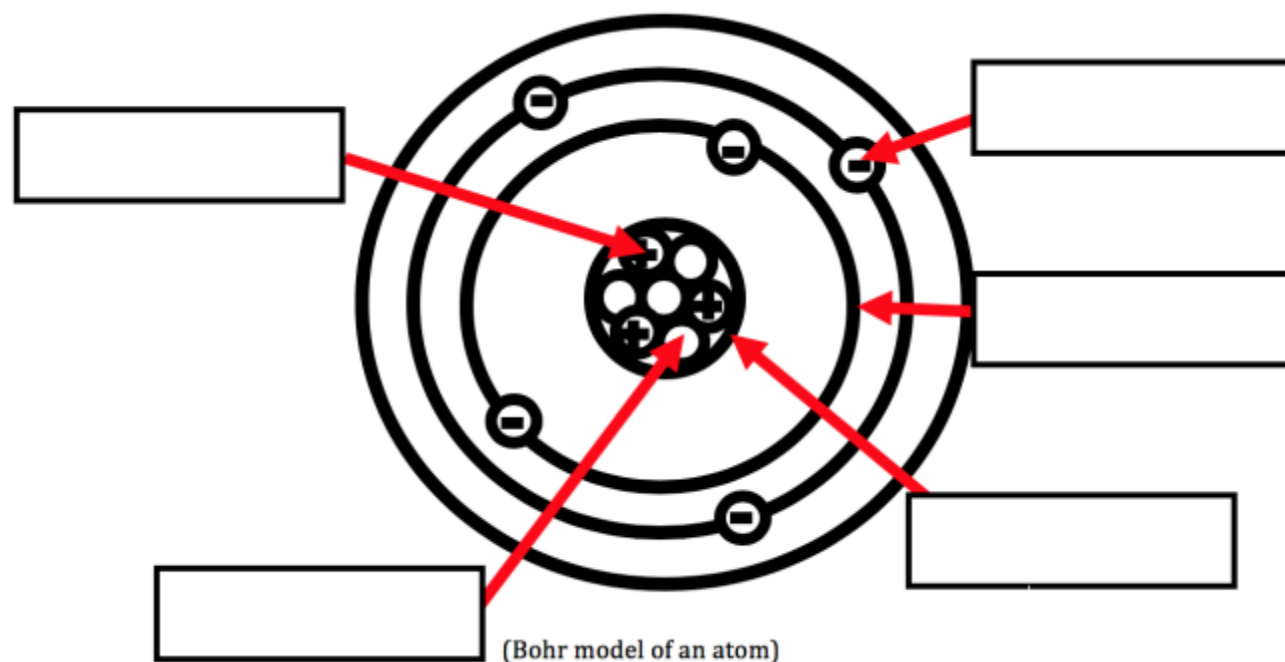
Proton

neutron

electron

nucleus

orbital



[Click here for a virtual drag and drop simulation](#) if you are doing this electronically :) Once you are done you can replace the image above with a screenshot of your virtual atom.

2.) (REVIEW) Name the **3 subatomic particles** found in atoms:

_____, _____, _____

Ions

★ Ion= _____

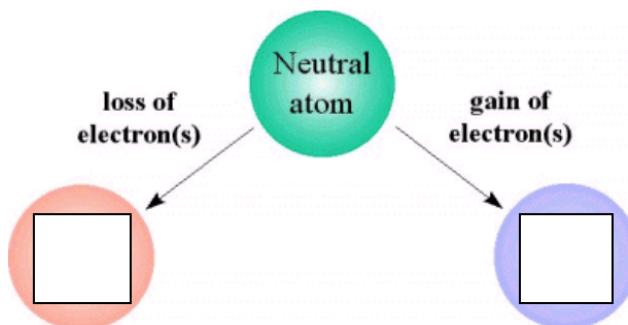
★ Ions form when the number of _____ changes in an atom.

★ When an atom loses or gains electrons and the number of protons and electrons are no longer the same, an atom becomes an _____.

★ There are **two forms of ions:**

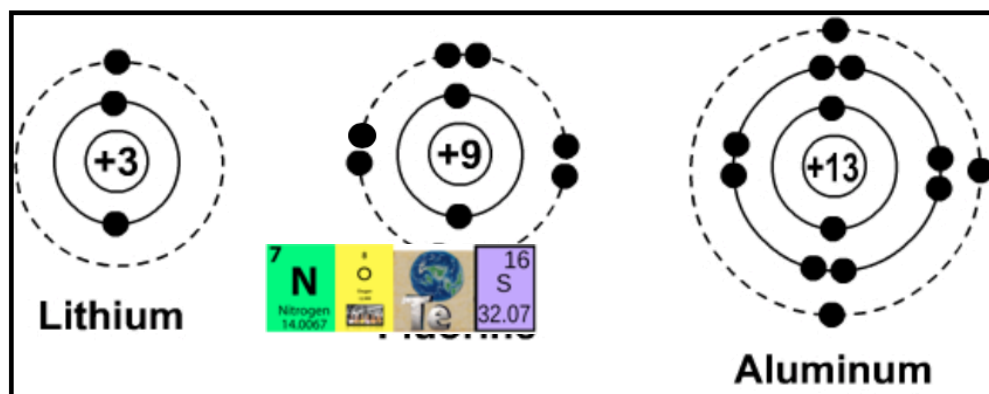
1.)

2.)



3.) Identify the number of total electrons, number of protons (atomic number (Z),) & the net charge.

of protons (atomic number (Z),) &

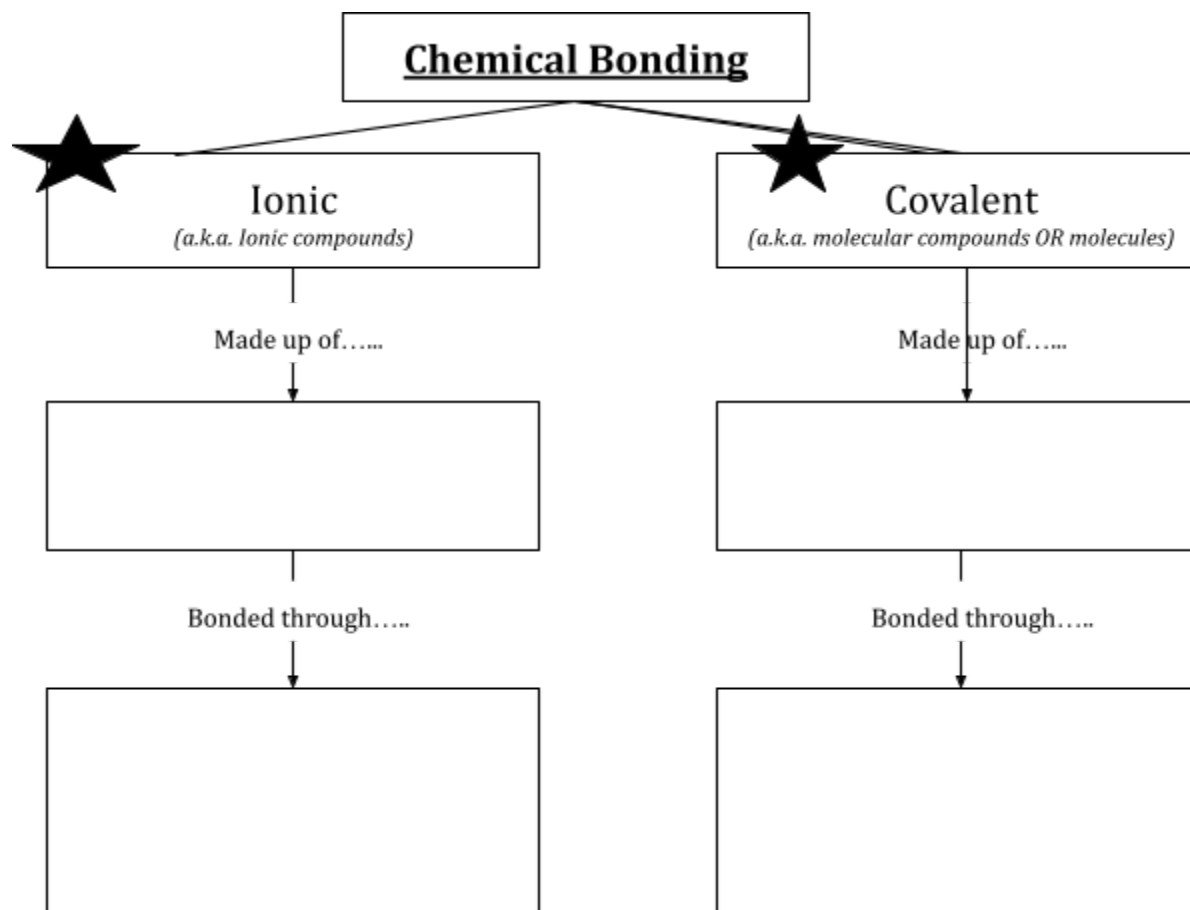


REFRESHER: **Ionic &** **Covalent** **Compounds**

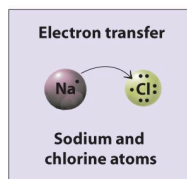
(REVIEW)

(to be filled in throughout the unit)

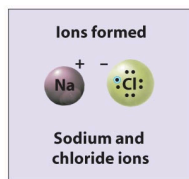
<u>Total electrons</u>			
<u>Z</u>			
<u>Net charge</u>			
<u>Atom or ion?</u>			



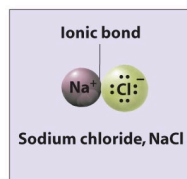
Ionic Compounds:



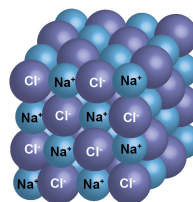
①



②



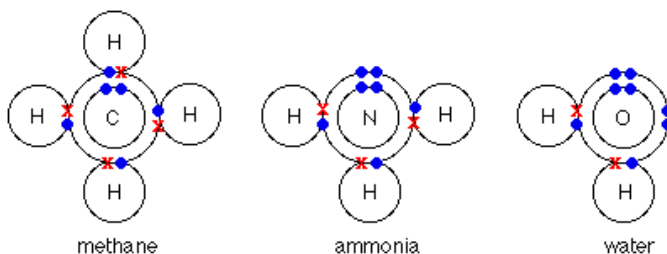
③



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Covalent/Molecular Compounds:

Valence



6.1

Electrons

Purpose: in order to understand how covalent compounds share electrons and draw them, we need to be familiar with identifying the number of valence electrons that an atom has.

1.) What are **valence** electrons? _____

2.) Using your periodic table, determine the element's number of valence electrons (# of electrons in the "outermost" shell) **for at least 15 of the elements below.**

- a) Fluorine _____
- b) Lithium _____
- c) Phosphorous _____
- d) Francium _____
- e) Calcium _____
- f) Carbon _____
- g) Nitrogen _____
- h) Iodine _____
- i) Silicon _____
- j) Oxygen _____
- k) Argon _____
- l) Barium _____
- m) Potassium _____
- n) Aluminum _____
- o) Helium _____
- p) Hydrogen _____

- q) Magnesium _____
- r) Xenon _____
- s) Sulfur _____
- t) Boron _____
- u) Bromine _____

Valence electrons are important because they're involved in bonding. Briefly differentiate between how valence electrons are involved in ionic vs. covalent bonds.

4.) Which groups (columns) on the periodic table tend to lose electrons? What kind(s) of elements are in these groups? Check their electronegativity values in your reference table-- are they relatively high or low?

5.) Which groups (columns) on the periodic table tend to gain electrons? What kind(s) of elements are in these groups? Check their electronegativity values in your reference table-- are they relatively high or low?

6.) Why do the elements from question #4 want to lose electrons? Why do the elements from question #5 want to gain electrons? (HINT: the answer is the same for both)

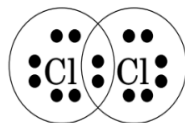
7.) What is the name of an ion that loses electrons and what kind of charge will it have? _____

8.) What is the name of an ion that gains electrons and what kind of charge will it have? _____

LO 6.2: Lewis Dot structure (some review)

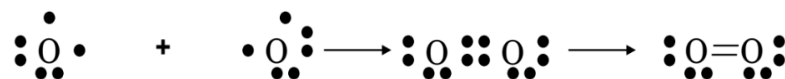
Practice Sheet

**this Cl now has an
octet of 8 electrons**



this Cl atom also has an octet

Sometimes you need to share more than one pair of electrons to achieve an octet:



each O has 6 e-
and wants 2 more

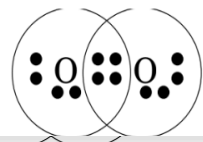
**each O shares 2e-
forming a double
covalent bond**

**the four shared electrons
are represented as two lines between the atoms**

$$O_2$$

an oxygen
molecule

We can check to see that each oxygen has the appropriate number of electrons:



each oxygen atom
now has an octet

**total # valence
electrons = 12
(note the 12 dots)**

For t]
Then

6 steps for drawing Lewis Structures

1.) Find the t

**Add in the*

Electronegativity chart (also in reference table)

2.) If the mole
which elemen

*These
*EXCI

**3.) Create a “
between the**

*bond
electr

4.) Fill in elec

*for n
*Hydr

[illegible]

Most electronegative

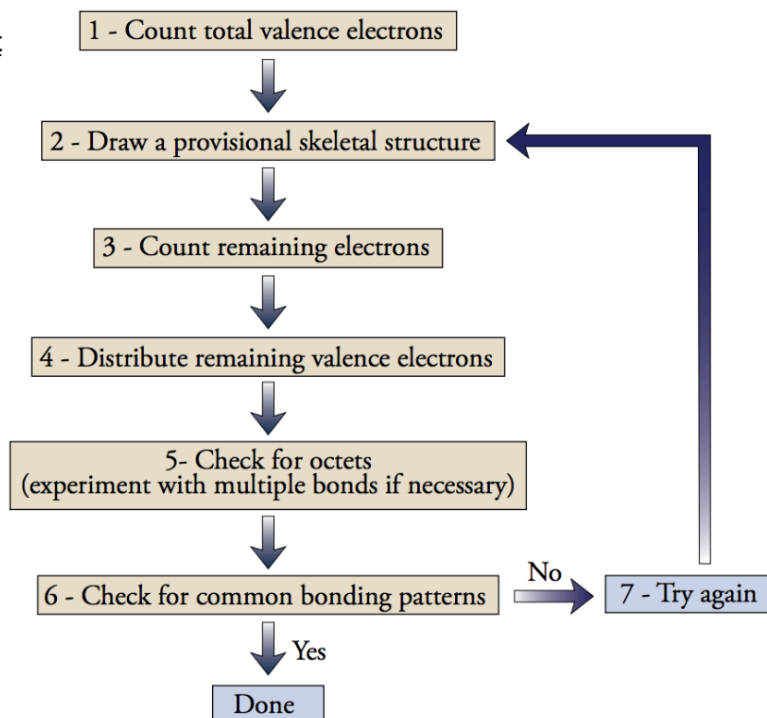
Drawing Covalent Compounds: Lewis Structures

*(LO 6.2) more practice
with covalent molecules!*

Drawing Lewis STRUCTURES

Since covalent molecules SHARE electrons, their bonds are illustrated differently from ionic bonds. Lewis structures are used to depict (2-dimensionally) the structure of covalent molecules and how they bond.

Lewis structure flow chart



Let's do some practice!

1.) CH_4

2.) Br_2

3.) PBr_3

4.) H_2O

Periodic Trends SUMMARY

LO 6.3

Complete this as review for the test!

(LO 5.3)



7 N Nitrogen 14.0067	8 O Oxygen 15.999	52 Te Tellurium 127.6	16 S Sulfur 32.07
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Here's some important Chemistry jargon you should know:

Period= row on the periodic table

Group= column on the periodic table

Property	Definition	(General) Trend <u>across a</u> <u>period</u>	(General) Trend <u>down a</u> <u>group</u>
Atomic Radius			

Ionization Energy			
Electronegativity			
Electron shielding		<i>Remains the same</i>	
Effective Nuclear Charge		↑	↓

to help

H 1									He 2
Li 3	Be 4	B 5	C 6	N 7	O 8	F 9	Ne 10		
Na 11	Mg 12	Al 13	Si 14	P 15	S 16	Cl 17	Ar 18		

H 37								He 31
Li 152	Be 111	B 80	C 77	N 74	O 73	F 72	Ne 71	
Na 186	Mg 160	Al 143	Si 118	P 110	S 103	Cl 100	Ar 98	

EXPLAIN: (use the pics above you)

1) When we discuss **electron shielding**, what's being shielded? And what is it being shielded from?

- 2) Which electrons do you think have the **highest effective nuclear charge**: valence electrons, or inner electrons? Why?
- 3) What happens to the **nuclear charge** of atoms as you move **across a period**? Why?
- 4) What happens to the **amount of electron shielding** as you move **across a period**? Why?
- 5) Based on your answers to 3 & 4, explain **why ionization energy INCREASES as you move across a period**, and **DECREASES as you move down a group** using terms such as atomic radius, electron shielding, and effective nuclear charge.

EXTRA HELP: Electronegativity Video

(LO 5.3)

While watching the edpuzzle video you'll be prompted to record some answers here. Please do so in the space below so that you have it in your notes.

- 1.) What is **electronegativity**?

2.) a.) What is the trend for atomic size and electronegativity when moving across a period?

b.) Explain WHY electronegativity follows that trend as you move across a period. Use words such as nuclear charge, atomic size, and attraction. Feel free to use images to help explain this phenomenon.

3.) a.) What is the trend for atomic size and electronegativity when moving down a group?

b.) Explain WHY electronegativity follows that trend as you down a group. Use words such as nuclear charge, atomic size, and attraction. Feel free to use images to help explain this phenomenon.

4.) (not in the edpuzzle) **Extension:** how do you think electronegativity influences bonding? How will it influence ionic vs. covalent bonds?

Bond Polarity (LO 6.4)


When 2 different elements are involved in a bond, there will be an unequal pull on the electrons involved in that bond. What determines how hard the elements pull on electrons? It's **electronegativity**.

But **so what?** Who cares if the elements pull unevenly on electrons? Well, depending on how uneven the pull is on the electrons, this can influence where the electrons get distributed in a bond. Electron distribution in a compound influences a lot of things! Including what it dissolves in, and how it responds to other substances.... we'll get to that in the next unit.

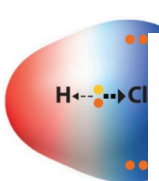
Depending on the distribution of electrons in a bond, we generally categorize bonds into 1 of 3 categories:

To
into, we


hear
you

(a) 

Nonpolar covalent bond
Bonding electrons shared equally between two atoms.
No charges on atoms.

(b) 

Polar covalent bond
Bonding electrons shared unequally between two atoms.
Partial charges on atoms.

(c) 

Bond type	Electronegativity Difference
<i>Nonpolar covalent</i>	≤ 0.4
<i>Polar covalent</i>	0.41-1.79
<i>ionic</i>	≥ 1.8

determine which category a bond falls use the following guidelines using electronegativity values:

*****What do you think of when you the word "polar"? How can this help remember the difference between nonpolar and polar covalent bonds?*****

1.) Using your reference table, find the electronegativity difference between the following elements and determine if a bond between them would be **nonpolar covalent (NC)** , **polar covalent (PC)** , or **ionic (I)**.

Bond	Electronegativity values & difference	Bond type
H - Cl	H: Cl:	

H - H		
C - O		
Ca - O		

Bond Types using Electronegativity Values

(LO 5.4 continued)

1.) Determine the type of bond (ionic, polar covalent, or non-polar covalent) that will form between atoms of the following elements and show the polarity of the bond with a **dipole arrow** if it is **polar covalent** and **charges** if it's **ionic**.

a.) Ca and Cl

b.) C and S

c.) Mg and F

d.) N and O

e.) H and O

2.) The bonds between the following pairs of elements are covalent. Write them according to **DECREASING** polarity.

a.) H—Cl

b.) H—C

c.) H—F

d.) H—O

e.) H—H

3.) How does a polar bond differ from a nonpolar bond? Use images and words to explain.

4.) What are the two ways you can determine what type of bond a compound contains?

Bond Types & Lewis Structures

(LO 5.4 continued)

5.) Using the table of electronegativities from your Periodic table, calculate the EN difference for the atoms that are bonded in the following molecules. Then tell whether the bond is nonpolar covalent, polar covalent, or ionic. Tell which atom has the greater share of the bonding electrons. In your drawing, show which atom is partially positive or partially negative if it is a polar covalent bond.

<i>Molecule & Name</i>	<i>Lewis Structure</i>	<i>EN Difference (between the central atom and the outer ones)</i>	<i>Type of bond</i>	<i>Atom with greater EN</i>

PCl_3				
NH_3				
H_2O				
H_2S				

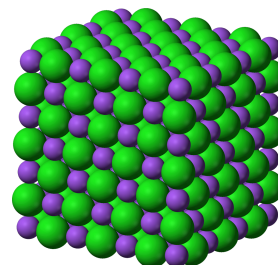
<i>Molecule & Name</i>	<i>Lewis Structure</i>	<i>EN Difference (between the central atom and the outer ones)</i>	<i>Type of bond</i>	<i>Atom with greater EN</i>
Br ₂				
SO ₄ ⁻²				
HCN				
PH ₃				

CS ₂				
CCl ₄				

Ionic Bonds: HOW & WHY they form

(LO 5.4 continued)

Purpose: Now that we know about electronegativity and ionization energy, we bonds form more comprehensively.



can understand how and why ionic

Part A: Periodic Properties for metals and nonmetals

1.) Looking at the information you have written on your periodic table, please fill in the blanks below:

a.) Metals tend to have _____ (*high or low*) ionization energies and _____ (*high or low*) electronegativities. Metals tend to form _____ (*positive or negative*) ions which form because the atoms _____ (*lose or gain*) electrons.

b.) How do the ionization energy and electronegativity values of metals influence the type of ions metals form?

c.) **Nonmetals** tend to have _____ (high or low) ionization energies and _____ (high or low) electronegativities. Nonmetals tend to form _____ (*positive or negative*) ions which form because the atoms _____ (*lose or gain*) electrons.

d.) How do the ionization energy and electronegativity the type of ions nonmetals form?

values of nonmetals influence

Part B: Explaining and displaying how ionic bonds

2.) Please answer the following questions using the table to

a.) What is sodium's electronegativity? _____
What is its first ionization energy? _____

b.) What is fluorine electronegativity? _____
What is its first ionization energy? _____

c.) Based on the values you found, find the determine what kind of bond would form. Does this based on what you know about metals and nonmetals?

Element Symbol	Atomic Number	Electro-negativity (no units)	First Ionization Energy (kJ/mole)
H	1	2.1	1312
He	2	No Value	2371
Li	3	1.0	520
Be	4	1.5	900
B	5	2.0	800
C	6	2.5	1086
N	7	3.0	1402
O	8	3.5	1314
F	9	4.0	1681
Ne	10	No Value	2080
Na	11	0.9	495.8
Mg	12	1.2	737.6
Al	13	1.5	577.4
Si	14	1.8	786.2
P	15	2.1	1012
S	16	2.5	999.6
Cl	17	3.0	1255
Ar	18	No Value	1520
K	19	0.8	418.8
Ca	20	1.0	589.5

form

the right:

electronegativity difference and align with what you'd expect

d.) What is sodium's charge as an ion? Based on its electronegativity value and ionization energy (as compared to the values of fluorine and other atoms in the chart), explain why sodium forms that type of ion (positive or negative).

- e.) What is fluorine's charge as an ion? Based on its electronegativity value and ionization energy (as compared to the values of sodium and other atoms in the chart), explain why fluorine forms that type of ion (positive or negative).
- f.) Using bohr diagrams, draw a sequence of pictures that shows how an ionic bond forms between sodium and fluorine.

Part C: Taking it up a notch

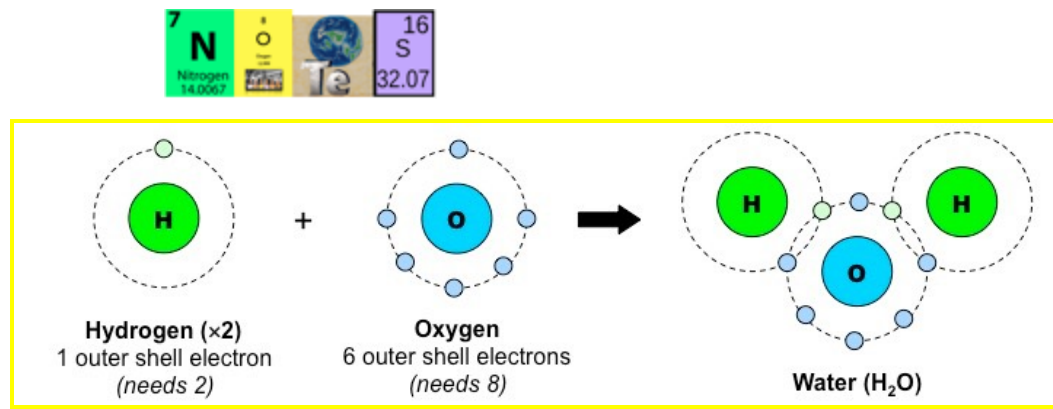
Not all ionic compounds form in a 1:1 ratio. Please determine the ratio that the following elements will combine in and draw a sequence of images that explains WHY these compounds form in those ratios. Label your images with words to clarify what's happening.

3.) $\text{Mg} + \text{F}$

4.) $\text{Na} + \text{O}$

5.) Be + N

Covalent Molecules (Review!)



Covalent/Molecular Compounds Naming & Bonding:

Naming COVALENT Compounds

(LO 6.5)

Write the chemical formulas for at least 10 of the following covalent compounds

- 1.) Antimony tribromide _____
- 2.) Hexaboron silicide _____
- 3.) Chlorine dioxide _____
- 4.) Hydrogen iodide _____
- 5.) Iodine pentafluoride _____
- 6.) Dinitrogen pentafluoride _____
- 7.) Phosphorous triiodide _____
- 8.) Dichlorine monoxide _____
- 9.) Tricarbon heptasulfide _____
- 10.) Diselenium tribromide _____
- 11.) Octaphosphorous monoxide _____
- 12.) Nonasulfur diiodide _____

Write the names for for at least 9 of the following covalent compounds:

- 1) P_4S_5 _____
- 2) SeF_6 _____

3) Si_2Br_6 _____

4) SCl_4 _____

5) CH_4 _____

6) B_2Si _____

7) NF_3 _____

8) FeCl_3 _____

9) SeS_2 _____

10) N_2O_5 _____

11) CO _____

Lewis Structure MORE PRACTICE

(LO 6.6)

In the table below **OR** on your table **OR** on a whiteboard, draw Lewis structures for the following compounds:

Simple structures

CH ₄	NH ₃	H ₂ O	NCl ₃
Polyatomic ions			
PO ₄ ⁻³		SO ₃ ⁻²	
Multiple Bonds			
H ₂ CO	HCN	CO	
Multiple central atoms **challenge**			

C ₂ H ₆	C ₂ H ₅ OH	C ₂ H ₄	C ₂ F ₂
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POGIL: VSEPR Theory/Molecular Geometry

(LO 6.2, 6.7, 6.8, 6.9)

How can molecular shapes be predicted using the VSEPR theory?

Why?

When you draw a Lewis structure for a molecule on paper, you are making a two-dimensional representa-

1. Name the type of structures shown in the left-hand column of Model 1.
9. Explain the difference between a **bonding electron domain** and a **nonbonding electron domain** using the examples in Model 1.

10. Circle the correct word or phrase to complete the sentences:

Pairs of electrons will (attract/repel) each other.

Two bonds on the same atom will try to get as (close to/far from) each other as possible.

14. Often we draw Lewis structures with 90° bond angles. Do any of the molecular shapes in Model 1 have 90° bond angles?

19. Complete the following chart:

Molecule	Lewis Structure	3-D Drawing	Name of 3-D Shape	Bond Angle
----------	-----------------	-------------	----------------------	------------

Extension Question

20. Ozone, O₃, is not a linear molecule. Actually it is bent with an angle that is a little less than 120°.
 - a. Draw the Lewis structure of ozone, O₃.

Only complete the extension questions if you have extra time

VSEPR Theory/Molecular Geometry SUMMARY

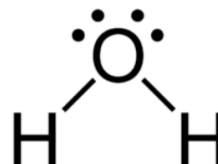


(LO 6.6, 6.7, 6.8)

A.) VSEPR Theory

V _____ -S _____ -E _____ -P _____ -R _____ (VSEPR)

- **VSEPR theory:** the natural tendency for _____ dictates the position that atoms take in a molecule.
- **Areas of high electron density** (a.k.a. _____) orient their respective atoms in such a way that the domains are _____.
- **Examples of electron domains:**
 - _____: single, double, triple, etc.
 - _____ of electrons
 - H_2O has _____ electron domains
 - _____ + _____
- Atoms position themselves in molecules to _____ between electron domains.
 - This arrangement depends on the **number of electrons** present.
 - The arrangement of the atoms is the **molecular geometry**.



B.) Molecular Geometry

Candy molecule activity legend:

Molecular Geometry/Shapes

(fill in together as a class)



Electron Domain s	*Electron Geometry* (geometry of electron domains)	Bonding Regions	Non-bonding electron pairs (lone pairs)	Molecular Shape/Geometry Name (shape atoms make)	How to show 3D shape on paper
2		2	0		
3		3	0		
		2	1		
4		4	0		
		3	1		
		2	2		

Using the table above, draw a Lewis structure for the following molecules that represents its molecular geometry. Then name the molecular shape.

Molecule	Lewis Structure	Molecular Shape	Bond type(s) in molecule (PC, NC, I)
PCl ₃			
Molecule & Name	Lewis Structure	Molecular Shape	Bond type(s) in molecule (PC, NC, I)
BF ₃ (boron's a moron and only needs 6 e ⁻ to be happy)			
CO ₂			

H ₂ O			
CH ₄			
HCN			
Molecule & Name	Lewis Structure	Molecular Shape	Bond type(s) in molecule (PC, NC, I)

CCl ₄			
BH ₃ (note: boron is a moron)			
OF ₂			
Br ₂			

CH ₂ O (C=central atom)			
C ₂ H ₆ (C's are central atoms)		(for each central atom)	

Molecular Shape Animation Activity

(LO 5.6-5.8)

As you work through the PBS animation at bit.ly/2GNpgbd, fill in the chart below.

Molecule	Draw a lewis structure that represents the molecular shape	How many <u>electron domains</u> are around the central atom?	How many <u>bonding regions</u> are around the central atom?	What's the molecular shape name?
CO ₂				

NO₃⁻				
SO₂				
CH₄	<i>How do you draw CH₄ in 3 dimensions?</i>			
NH₃	<i>How do you draw NH₃ in 3 dimensions?</i>			
H₂O				

EXTRA NOTES/TIPS