Mr. Balmer Name: _____ Period: ____

Molecular Models

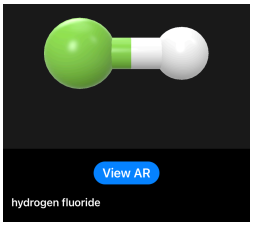
Introduction: The following activity is aimed at reviewing the concept of Lewis dot structures. The second part of the activity will be used to introduce the concepts of three-dimensional structure and the valence shell electron pair repulsion (VSEPR) theory. The questions that follow should help you to make some important connections between valence electrons and molecular shape.

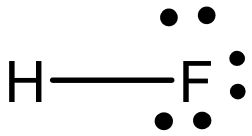
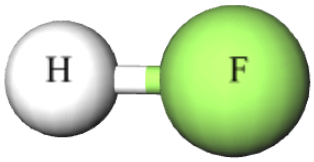
1) Draw a Lewis dot structure (using lines for bonds) for the following compounds or polyatomic ions. Show all of your work (total valence electrons and formal charges). After we have checked and fixed all of your Lewis dot structures, you will use the MolAR augmented reality app on the iPad to view the molecules in three-dimensional space. Open the app and search for the molecules below using the **bolded** name or chemical formula. Point your device at your desk and then click the view AR button. Take a walk around the molecule and view it from all angles before the ball and stick model.

MolAR Augmented Reality

AR for chemistry

Designed for iPad. Not verified for macOS.



	Chemical Name (Molecular Formula)	Lewis Dot Structure (Using Lines for Bonds)	Ball and Stick Model (Use colors and symbols to identify elements)
example	**hydrogen fluoride** (HF)	8 total valence electrons H: 1-1=0 F: 7-7=0 	

	Chemical Name (Molecular Formula)	Lewis Dot Structure (Using Lines for Bonds)	Ball and Stick Model (Use colors and symbols to identify elements)
s i n g l e b o n d s	1) **ammonia** (NH_3)		
	2) phosphorus trihydride, aka **phosphine** (PH_3)		
	3) **methane** (CH_4)		
	4) **water** (H_2O)		
	5) boron trihydride (BH_3)		
	6) boron trichloride (BCl_3)		
	7) **sulfur hexafluoride** (SF_6) cool video		

	Chemical Name (Molecular Formula)	Lewis Dot Structure (Using Lines for Bonds)	Ball and Stick Model (Use colors and symbols to identify elements)
Multiple Bonds	8) **carbon monoxide** (CO)		
	9) **carbon dioxide** (CO_2)		
	10) **sulfur dioxide** (SO_2)		3d structure is "fishy" because S breaks the octet.
	11) **ozone** (O_3)		
	12) nitrogen dioxide (NO_2)		3d structure is "fishy"

Don't forget to add extra electrons or subtract electrons based on the ion's charge.			
	Polyatomic Ion Name (Formula)	**Lewis Dot Structure (Put your ion in [brackets] with its charge.)**	**Ball and Stick Model (Use colors and symbols to identify elements)**
Polyatomic Ions	13) **hydronium** ion (H_3O^+)		
	14) **hydroxide** ion (OH^-)		
	15) **carbonate** ion (CO_3^{2-})		
	16) **sulfate** ion (SO_4^{2-})		probably will show sulfur exceeding the octet rule
	17) **phosphate** ion (PO_4^{3-})		
	18) **cyanide** ion (CN^-)		

Discussion Questions

1) What is the valence shell electron pair repulsion (VSEPR) theory?

2) When you look at the H-B-H bond angle(s) in your **Lewis dot structure** for BH_3, what bond angle(s) did you draw? When you look at the H-B-H bond angle(s) in your 3-dimensional ball and stick model for BH_3, what bond angle(s) would you predict? The MolAR app won't calculate bond angles, so you'll need to go to www.molview.org to do this. In Molview, use the Jmol→Measurement→Angle menu to verify the H-B-H bond angle in the ball and stick model. To do this in the right-side 3-dimensional model, click on an H, then the B, and then another H. ***Why do you think there is a difference between the angle in your Lewis dot structure and the ball and stick model?***

3) Why are BCl_3 and BH_3 planar (flat), while NH_3 and PH_3 are trigonal pyramidal? Hint: Look at their Lewis dot structures and the definition of VSEPR theory.

4) What is the bond angle for methane (CH_4)? In Molview, use the Jmol→Measurement→Angle menu. In the right-side 3-dimensional model, click on an H, click on the C, and then click on another H. the H-C-H bond angle should appear. ***Is this angle different than what you would have predicted based on your Lewis structure? If there is a difference explain what causes the difference. Think about VSEPR theory.***

5) Even though CO_2, H_2O, SO_2, O_3, and NO_2 are all made of three atoms, they have different shapes. ***Why is there a difference? Hint: Look at their Lewis structures and VSEPR theory.***

6) Draw a space-filling model (van der Waals spheres model) of HF. Search for hydrogen fluoride.
   In MolAR: Click the settings button (. . .) and choose **Space-Filling**.
   In Moleview: Use the Model→van der Waals Spheres menu.

   What does this model help to show? Hint: Think of modern atomic theory.

7) Draw a wireframe model of **caffeine** ($C_8H_{10}N_4O_2$). Searching for caffeine.
In MolAR: Click the settings button (. . .) and choose **Skeletal**.
In Molview: Use the Model→**Wireframe** menu.

When might this model form be useful? Hint: It might be helpful to view this molecule as a space-filling model for comparison.

8) Compare the bond length of single bonds (C-O), double bonds (C=O), and triple bonds ($C \equiv O$). In Molview, use the Jmol→Measurement→Distance menu. In the 3-dimensional picture click on the C atom and click on the O or N atom. The bond length should appear.

methanol	acetone	carbon dioxide	carbon monoxide
(CH_3OH)	(CH_2O)	(CO_2)	(CO)
C—O	C=O	C=O	$C \equiv O$

Conclusion: Tell me something "NU"

New: What new modifications would you make to the experiment to study new independent variables or some other real-life application of this experiment? **Be specific**. Adding more repeated trials doesn't count as a modification. You cannot say you wouldn't make any changes. Don't use the words **change, different, etc.** If you want to use different materials, give me some **specific examples.**

Uncertain: What concepts from the lab are you still uncertain about? In other words, what questions do you still have after completing the lab? You cannot say that you are uncertain about nothing. If you have no uncertainties, then ask me a H.O.T. question related to the lab.