SC111 - Valence Shell Electron Pair Repulsion (VSEPR) Theory and Molecular Shapes Activity

EAY 09.20.2021 FV

COLLABORATION IS ALLOWED!

You may work on this with others and /or consult with chemistry faculty (including me) for help.

Directions: Read and initial next to each statement, print your name above and write your signature below as indicated. Your initial located next to each item below signifies your understanding and compliance with the instructions for this assignment which will be counted as a homework assignment.

_____ I understand that I must return the assignment to my instructor, by the stated deadline of _____ (instructor determined deadline).

_____ I understand that I may discuss this assignment with other midshipmen. Although I may discuss with other midshipmen, I understand this is an ***individual assignment*** and I cannot plagiarize my answers from other midshipmen. Furthermore, I can seek assistance from a USNA chemistry instructor. **Please provide the names of any midshipmen/instructors you worked with below and all resources used.**

Midshipman names (dated) and resources used:

_____ I understand that violation of this agreement will result in an F on this assignment and it cannot be replaced, it will be averaged in (as a 0%) with my other homework scores. Violations of this agreement as it relates to the USNA Honor Concept will be turned in.

I, _____, (signature) certify that this work was done on my own and is in accordance with the directions above.

POINTS MISSED:	***SCORE:***	***GRADE:***

Learning Objectives:

By the end of these exercises, the student should be able to demonstrate the following proficiencies:

1. Draw Lewis electron-dot structures of polyatomic ions and molecules.
2. Given a Lewis electron-dot structure, distinguish between bonded pairs and non-bonded pairs of electrons.
3. Use the Valence Shell Electron Pair Repulsion (VSEPR) theory to predict the arrangement name and the molecular geometries of molecules and polyatomic ions.
4. Given a Lewis electron-dot structure, assign hybridization to the atoms.
5. Determine polarity of the molecule
6. Designate sigma (σ) and pi (π) bonds present in the molecule.

Instructions: *Work through the exercises below. Use the molecular model simulations to build three dimensional models of the molecules (or polyatomic ions) in the exercises and to help you answer the questions.*

1) Draw the Lewis dot structure of the following molecules below before building them on the computer.

2) Open the PhET simulation titled : "Molecular Shapes"
   a. https://phet.colorado.edu/sims/html/molecule-shapes/latest/molecule-shapes_en.html
   b. At the bottom of the page, select "Model"
   c. You can now build the molecular models of the molecules (or ions) listed below in 3D using the simulation to help visualize their characteristics.
      i. Make sure to include lone pairs of electrons on the central atom.
      ii. Check the boxes for "Molecule Geometry" and "Show bond angles" and fill in the following chart.
      iii. Some of the molecules below are listed under the "Real Molecules" tab at the bottom of the page. Be sure to check your simulations here. Please note, not all of the examples below are listed under this tab. You may use this tab to assist you in understanding and picturing the 3D structure of the additional molecules (or ions).
   d. From your model for each molecule on the next 5 pages, provide entries in the columns with the following information.
      i. Number of electrons bonded to the central atom
      ii. Number of valence electrons
      iii. Number of electron domains or total number of electron pairs (steric number)
      iv. Name of the arrangement of electron pairs
         1. For example : linear, trigonal planar, tetrahedral, trigonal bipyramidal, octahedral)
      v. A brief sketch of each molecule in 3D from the model.
      vi. The name of the molecular geometry
         1. For example: linear, trigonal planar, tetrahedral, trigonal bipyramidal, octahedral, bent, trigonal pyramidal, see-saw, T-shaped, square pyramidal, square planar) of the atoms in the molecule.
      vii. Values of the bond angle(s) around the central atom.
         1. For example: 180 º, 109.5 º, less than 109.5 º, 120 º, less than 120 º, etc.
      viii. Formal charge on the central atom.
      ix. List the hybridization of the central atom.
      x. State how many sigma (σ) and pi (π) bonds are present in the molecule (or polyatomic ion).

3) To further illustrate dipole moments and polarity, open the simulation titled "Molecule Polarity."
   a. https://phet.colorado.edu/sims/cheerpj/molecule-polarity/latest/molecule-polarity.html?simulation=molecule-polarity
   b. Click on the tab "Real Molecules."
      i. Please note, not all of the examples below are listed under this tab. You may use this tab to assist you in understanding and visualizing bond dipoles to answer the additional molecules (or ions).
   c. Click the boxes under "Bond Dipoles" to see if the compounds you built had polar bonds (a gray arrow will show up if yes).
   d. Click on the box under "Molecular Dipole" to see if the compound you built is a polarity molecule (a red arrow will show up if yes).
   e. Draw each bond moment and the overall dipole moment if present.
      i. For neutral species, list whether it is polar or nonpolar overall

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
CO_2							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
H_2O							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
BF_3							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
CF_4							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
CH_3F							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
NH_3							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
PCl_5							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
SF_6							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
BF_2^-							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
AsH_3							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
$TeCl_4$							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
ClF_3							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
I_3^-							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
BrF_5							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds

Formula	Lewis Structure	# Bonded to central atom	# of Electron Domains	Molecular Geometry (Sketch in 3D and Name)	Bond Angles	Hybridization of central atom	Polar or Nonpolar?
XeF_4							
		# Lone Pairs on central atom	Arrangement Name		Formal Charge of central atom	Total # of σ bonds	Total # of π bonds