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Lab Partner ________________________________ Student ID # _________

CHEM 142 Experiment #2: Chemical Models

Goals of this lab:

- Based on Lewis dot structure, identify electron–pair geometry, molecular shape, ideal bond angles, and polarity. Assign formal charges
- Use model kits to translate between two-dimensional and three-dimensional structures
- Using three-dimensional models, analyze isomers of the same molecule and compare properties such as polarity
- Using three-dimensional models, determine the total number of unique isomers
- Use the idea of isomers to support the most likely three-dimensional structures of an unknown molecule

Your lab report will be graded on the following criteria using a poor/good/excellent rating system (see the Self-Assessment on the "Reporting Your Results for Exp #2" page of the lab website for more details):

- Electron counting is accurate
- Electron-pair geometry is accurate
- Molecular shape is accurate
- Polarity (or non-polarity) is accurate
- Three-dimensional structures are drawn well and neatly utilizing the given wedge/dash system
- A valid analysis of possible isomers is conducted
- Arguments for predicted shape are clear and reasonable
- The lab report is completed neatly with legible handwriting and clearly-drawn structures

By signing below, you certify that you have not falsified data, that you have not plagiarized any part of this lab report, and that all calculations and responses other than the reporting of raw data are your own independent work. Failure to sign this declaration will result in 5 points being deducted from your lab score.

Signature: ____

This lab is worth 60 points: 10 points for notebook pages, 50 points for the lab report
(Do NOT include your notebook pages when you scan your report for upload into Gradescope.)

NOTE: on page 7, you will find a template of shapes to use when drawing molecules/ions. Be sure to reference this for help with drawing 3-D structures. Page 7 can be included in your scanned report, but will not be linked to anything in Gradescope.

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Part I. Molecules and Ions

Use the chemical model kits to help you visualize the geometry of each of the following molecules/ions. Models will be especially helpful when determining the polarities of these species.

CH_2Cl_2

Atom	# of valence e^- per atom	Total # of valence e^-
C		
H		
Cl		
Total	---	

3-D Lewis Structure (include ALL lone pairs):

Electron-pair geometry:	
Molecular shape:	
AX_mE_n classification/notation:	
Ideal bond angles:	
Polar or Non-Polar: **(if polar, show dipole moment)**	

IF_4^+

Atom	# of valence e^- per atom	Total # of valence e^-
I		
F		
ion	---	
Total	---	

3-D Lewis Structure (include ALL lone pairs):

Electron-pair geometry:	
Molecular shape:	
AX_mE_n classification/notation:	
Ideal bond angles:	
Polar or Non-Polar: **(if polar, show dipole moment)**	

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$XeOF_4$

Atom	# of valence e^- per atom	Total # of valence e^-
Xe		
O		
F		
Total	---	

3-D Lewis Structure (include ALL lone pairs):

Electron-pair geometry:	
Molecular shape:	
AX_mE_n classification/notation:	
Ideal bond angles:	
Polar or Non-Polar: **(if polar, show dipole moment)**	

BH_3

Atom	# of valence e^- per atom	Total # of valence e^-
B		
H		
Total	---	

3-D Lewis Structure (include ALL lone pairs):

Electron-pair geometry:	
Molecular shape:	
AX_mE_n classification/notation:	
Ideal bond angles:	
Polar or Non-Polar: **(if polar, show dipole moment)**	

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SF_6

Atom	# of valence e^- per atom	Total # of valence e^-
S		
F		
Total	---	

3-D Lewis Structure (include ALL lone pairs):

Electron-pair geometry:	
Molecular shape:	
AX_mE_n classification/notation:	
Ideal bond angles:	
Polar or Non-Polar: (if polar, show dipole moment)	

$BrCl_3$

Atom	# of valence e^- per atom	Total # of valence e^-
Br		
Cl		
Total	---	

3-D Lewis Structure (include ALL lone pairs):

Electron-pair geometry:	
Molecular shape:	
AX_mE_n classification/notation:	
Ideal bond angles:	
Polar or Non-Polar: (if polar, show dipole moment)	

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Formal Charge

Draw Lewis dot structures for HCO_3^-, CN^-, NO_3^-, and OH^-, indicating all non-zero formal charges. 3-D structures are not necessary, but do include ALL lone pairs.

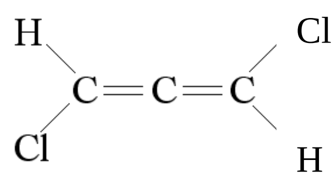
HCO_3^-

CN^-

NO_3^-

OH^-

Build the following structure:



Is this molecule polar or non-polar? Why or why not? (*2 pts*)

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Part II. Isomers

$C_2H_2F_2$

There are 3 possible structures (isomers) for this chemical formula.

Build the 3 possible isomers with your model kit and use the models to help you determine if the molecules you built are polar or non-polar.

Atom	# of valence e^- per atom	Total # of valence e^-
C		
H		
F		
Total	---	

3-D Lewis Structure 1 (include ALL lone pairs):

Polar or Non-Polar: **(if polar, show dipole moment)**	

3-D Lewis Structure 2 (include ALL lone pairs):

Polar or Non-Polar: **(if polar, show dipole moment)**	

3-D Lewis Structure 3 (include ALL lone pairs):

Polar or Non-Polar: **(if polar, show dipole moment)**	

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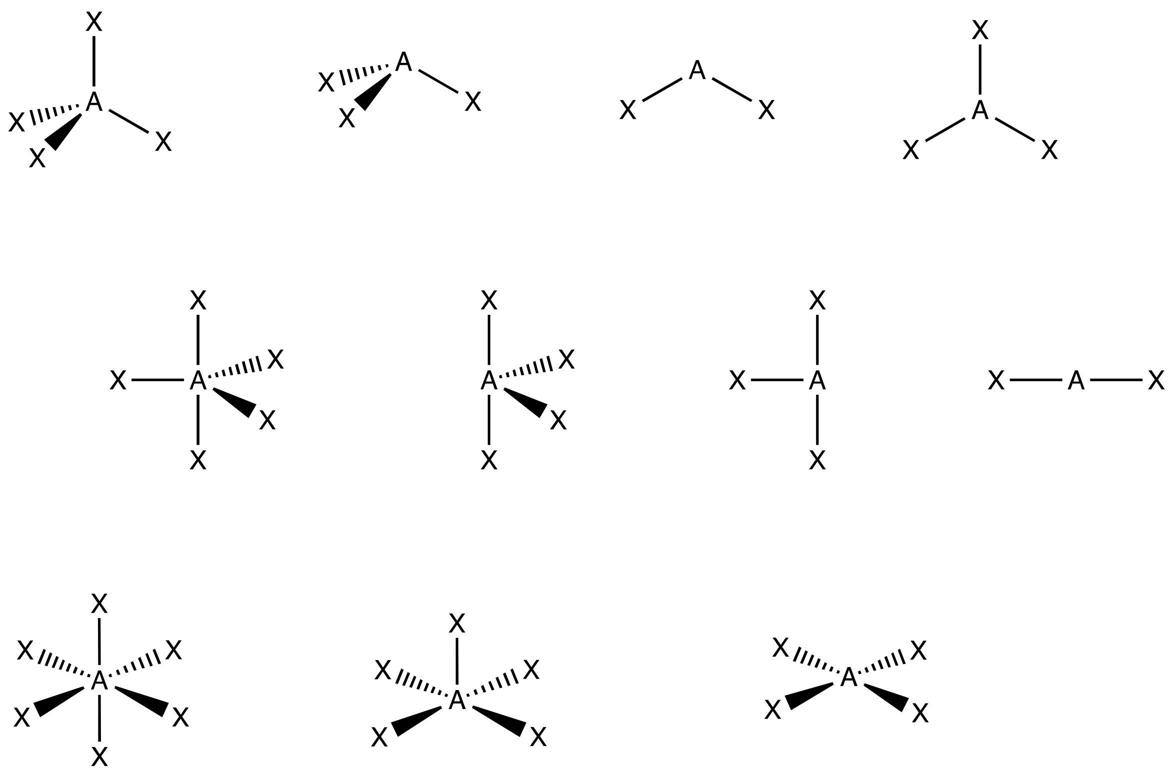
THIS PAGE SHOULD NOT BE LINKED TO ANY OF THE GRADING ITEMS IN GRADESCOPE
Template of shapes to use when drawing molecules/ions



Counting Isomers

In the last part of this activity you will be using the molecular models to explore the "shapes" of molecules and the implications of such shapes for determining the number of "distinct" *isomers* consistent with the actual molecular formula and with the shape under consideration.

Isomers are chemical species with the same molecular formula, but different properties due to either different bonds (structural isomers) or different spatial arrangements (stereoisomers). If there is only one unique arrangement of the atoms, there is only "one" isomer. However, many molecular shapes and formulae allow for multiple isomers. We will focus on stereoisomers for each of these scenarios. One type of stereoisomer is a geometric isomer, which you have already worked with (results in cis and trans isomers). Another type is an optical isomer, which we encounter when the two configurations are mirror images of each other and cannot be superimposed on one another.

Note that this activity provides an introduction to these concepts *before* we have fully introduced or discussed them in lecture…so don't hesitate to work with your lab partner and with students in other groups in solving these problems and discussing the related questions!

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Square Planar Molecules

AX_4E_2

Consider a square planar molecule (AX_4E_2), where A is the central atom with four identical atoms attached to it. Construct a model of such a molecule using the yellow "ball" in the center with 4 sticks coming out of it. At the end of each stick, place one of the small white balls with only one hole to form a square planar structure. How many distinct/unique square planar molecules can you create by only rearranging the white balls? Also sketch all of the possible arrangements consistent with the molecular formula and the square planar structure.

# of distinct isomers that can be drawn: _______

AX_3YE_2

Keeping the square planar structure from the AX_4E_2 molecule, replace one of the X (white) atoms with a Y atom (small green ball with one hole)? How many distinct/unique square planar molecules can you create by only rearranging the white and green balls? Sketch all the possible arrangements.

# of distinct isomers that can be drawn: _______

$AX_2Y_2E_2$

Now consider the same square planar configuration, but the molecular formula $AX_2Y_2E_2$ (two small white balls and two small green balls). How many distinct/unique square planar molecules can you create by only rearranging the white and green balls? Sketch all the possible arrangements.

# of distinct isomers that can be drawn: _______

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Tetrahedral Molecules

AX_4

Another common arrangement of 4 atoms is that of a tetrahedron, rather than a planar square. Construct a tetrahedral model of an AX_4 molecule using the black ball with four holes in it as the center atom (A), and small white balls (X) at the other ends of the sticks. How many distinct/unique tetrahedral molecules can you create by only rearranging the white balls? Also sketch all of the possible arrangements consistent with the molecular formula and the tetrahedral structure.

# of distinct isomers that can be drawn: _______

AX_3Y

If we replace one of the X atoms (white balls) in the tetrahedral shape with a Y atom (a small green ball). How many distinct/unique tetrahedral molecules can you create by only rearranging the white and green balls? Sketch all of the possible arrangements consistent with the molecular formula and the tetrahedral structure.

# of distinct isomers that can be drawn: _______

AX_2Y_2

Now make a tetrahedral model (AX_2Y_2) by switching a second white ball out for another green one. How many distinct/unique tetrahedral molecules can you create by only rearranging the white and green balls? Sketch all the possible arrangements.

# of distinct isomers that can be drawn: _______

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Comparing tetrahedral and square planar isomers

Suppose a molecule with five atoms (AB_2C_2) is synthesized in the lab and found to have *two* isomers. Does the molecule have a square planar or tetrahedral structure? Provide an explanation to support your answer.

Circle one: square planar tetrahedral
Explain:

Optical Isomers - AXYZW

Construct a tetrahedron for a AXYZW molecule, with A as the central atom (black ball) and four different colored balls (white, green, orange, and purple) at the end of the sticks. How many distinct/unique tetrahedral molecules can you create while keeping A as the central atom and rearranging the other atoms/balls? Sketch the possible arrangements consistent with this molecular formula and the tetrahedral structure. Compare and contrast the distinct isomers.

Hints:

- two isomers are the "same molecule" if they can be exactly superimposed, but if they can't be then they are optical isomers
- try building additional tetrahedra, each with formula AXYZW and A as the central atom, so you can more easily compare and contrast the structures

# of distinct isomers that can be drawn: _______