SI Chemistry - Full Discipline Demo

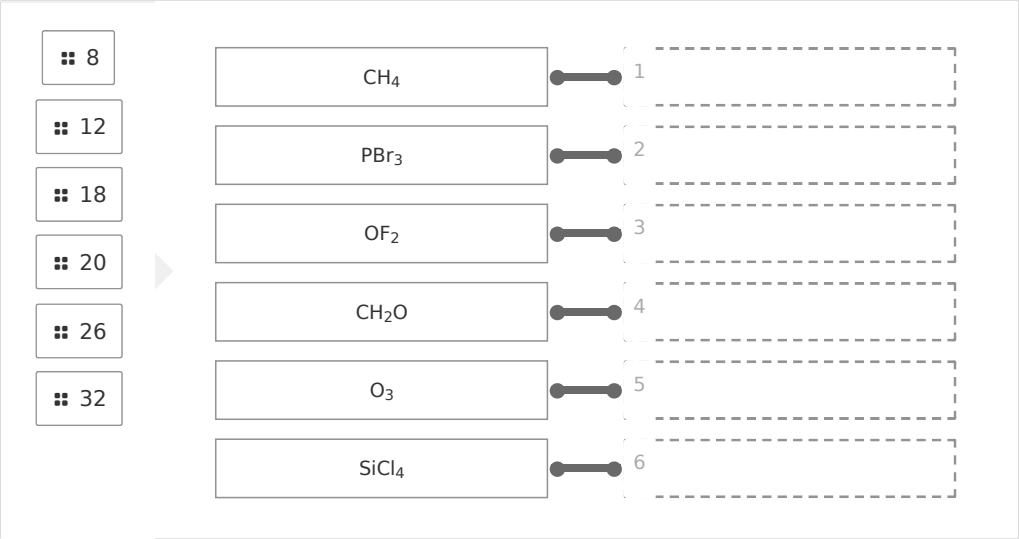
Molecular Modeling and Lewis Structures

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match the number of valence electrons with the correct compound.



Correct answers:

1 8 2 26 3 20 4 12 5 18 6 32

Move the terms to complete each statement.

allotropes | duet | electron deficient | structures | valence electrons | VSEPR

A model that describes the three dimensional arrangement of electrons based on electron repulsion is called the 1 model.

Two hydrogen atoms form a 2 when they have covalent bonds.

Diamond and graphite are two 3 of carbon.

Resonance 4 show the same connection of atoms but different arrangement of the bonds.

An atom that has less than eight electrons surrounding it in a compound is said to be 5 .

The number of outermost electrons is the number of 6 .

Correct answers:

1 VSEPR 2 duet 3 allotropes 4 structures 5 electron deficient 6 valence electrons

Determine the correct molecular geometry based on the number of bonds and lone pairs around the central atom.

Bent | Tetrahedral | Trigonal Planar | Trigonal Pyramidal

Bonds	Lone Pairs	Geometry
2	2	1
3	0	2
3	1	3
4	0	4

Correct answers:

1 Bent 2 Trigonal Planar 3 Trigonal Pyramidal 4 Tetrahedral

Exploration

The localized electron model assumes that a molecule is bonded through the _____.

- sharing of valence electron pairs ✔
- transfer of valence electron pairs

Allotropes are _____.

- different structural modifications of an element ✔
- versions of an element having the same number of neutrons but differing numbers of protons
- molecules bonded through the sharing of valence electron pairs
- typically crystalline in structure

The number of valence electrons of an atom can be found in the row number on the periodic table.

- True
- False ✔

Magnesium has _____ valence electrons.

- 1
- 2 ✔
- 3
- 4
- 8

An example of an atom with 3 valence electrons is _____.

- sodium
- magnesium
- aluminum ✔
- All of the above

The octet rule is based upon the observation that atoms are most stable when surrounded by how many valence electrons?

- 6
- 4
- 12
- 8 ✔

Resonance occurs when there is only one option for the Lewis structure model.

- True
- False ✔

What atoms always obey the octet rule?

- Hydrogen, carbon, nitrogen, oxygen
- Nitrogen, oxygen, fluorine, copper
- Oxygen, fluorine, nitrogen, carbon ✔
- Oxygen, carbon, chlorine, helium

The goal of the VSEPR model is to arrange the position of the atoms and lone pairs surrounding the central atom in a manner that minimizes _____.

- lone pairs
- the number of electrons
- repulsion ✔
- space and size

Molecular modeling kits are useful in determining the Lewis structure of a molecule.

- True
- False ✔

When a molecule has more than one interior atom, _____.

- multiple Lewis structures may be drawn
- the atoms are always represented by different colored balls in the modeling kit
- more than one geometry may be used to describe the molecule ✔
- the atoms are always connected by a double bond

Exercise 1

Data Table 1: CHO_2^-
(SAMPLE ANSWER BELOW)

# of Valence Electrons	# of Atoms and Sets of Lone Pairs Surrounding Central Atom	Structure Geometry (Name)
18	3	Trigonal planar

Photo 1: Lewis Structure of CHO_2^-
(SAMPLE ANSWER BELOW)

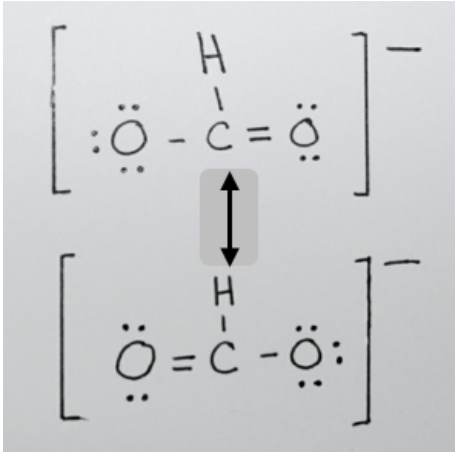
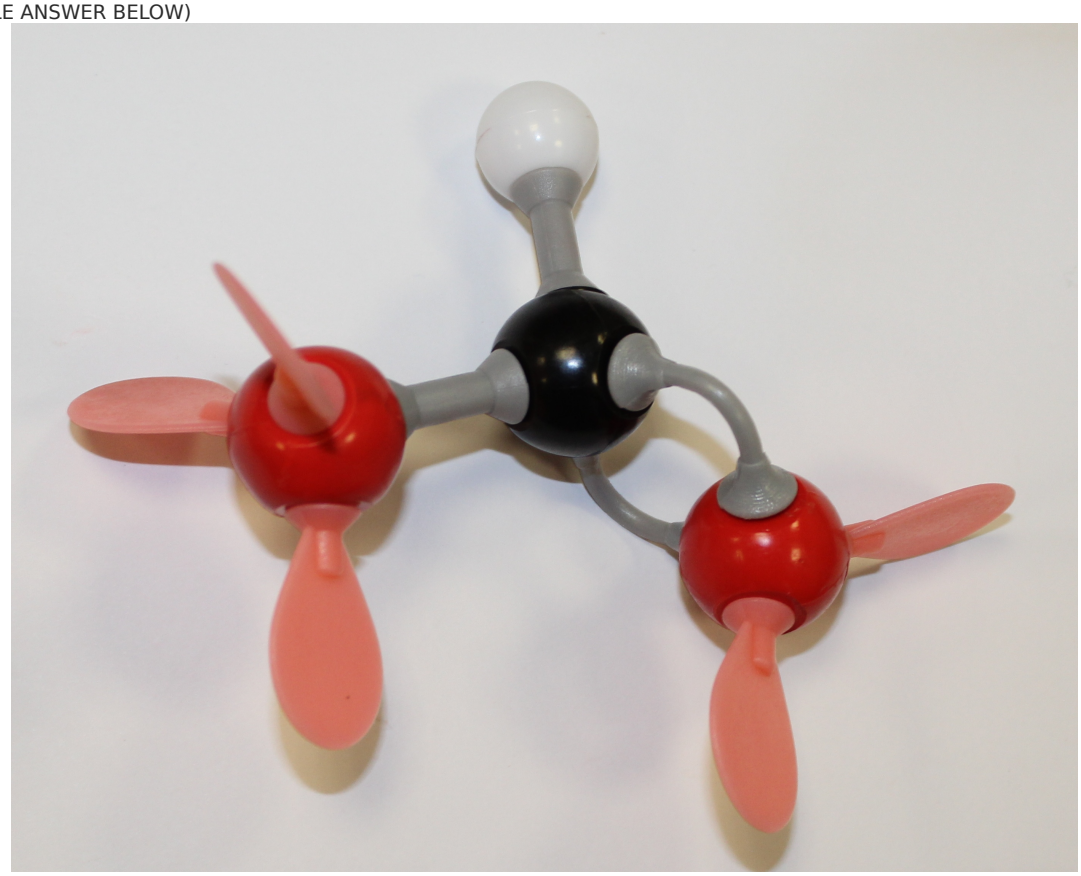


Photo 2: Molecular Model of CHO_2^-

(SAMPLE ANSWER BELOW)



Exercise 2

Which, if any, of the substances had resonance structures? How many resonance structures did each substance have?

In the practice section of part 1, CHO_2^- had two resonance structures. There were two other substances with resonance
structures: NO_2^- and SO_2. Each substance had two resonance structures.

Both chlorine and fluorine are represented by a green modeling piece that has 4 holes. Is using the same piece for two different atoms acceptable? Why or why not?

Student answers may vary.
Students may indicate that this is acceptable for the purpose of simple models. Chlorine and fluorine are both in group VIIA of the periodic table. They can both share electrons to fulfill the octet rule. For example, they form two similar but different molecules: carbon tetrachloride and carbon tetrafluoride.
Students might also defend that using the same modeling piece is not acceptable since chlorine is larger than fluorine. They may also indicate differences in magnetic force due to number of electrons. Students may defend that third period elements, such as chlorine, are capable of forming expanded octets.

Explain why only the lone pairs on the central atom are taken into consideration when predicting molecular shape. What substances from the lab activity have more than one central atom?

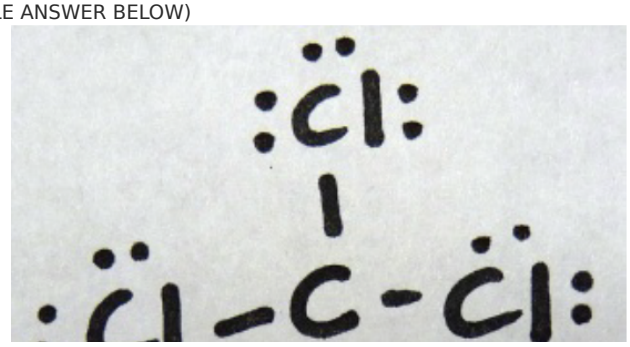
In some molecules, such as molecules 7, 8 and 9 in the activity, one of the outer atoms is also bonded to other atoms, giving these molecules two central atoms. The shape around each of these atoms can be predicted using VSEPR. In these cases, the shape of the entire molecule is a described using both central atoms. For example, CH_3NH_2 consists of a carbon atom bonded to four other atoms, three hydrogen atoms and one nitrogen atom, making this part of the molecule tetrahedral. The nitrogen atom has three bonds to two hydrogen atoms and one carbon atom plus

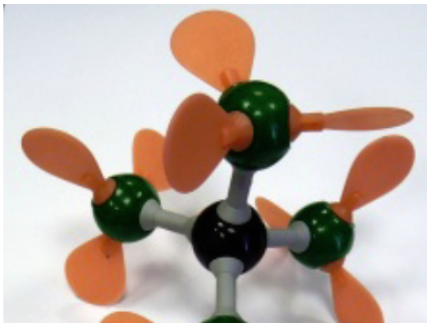
a lone pair, making the nitrogen the center of a trigonal pyramid. Both of these shapes make up the shape of the molecule: the shape of methylamine is tetrahedral around the carbon atom and trigonal pyramidal around the nitrogen atom.

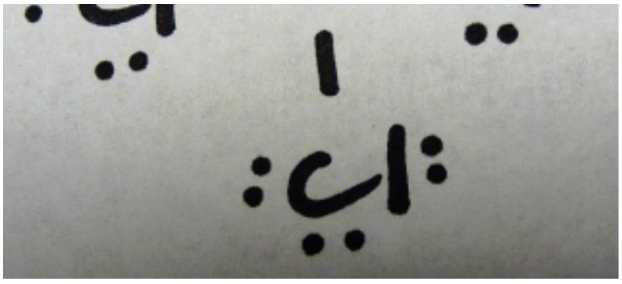
Data Table 2: VSEPR Names and Atoms
(SAMPLE ANSWER BELOW)

Molecule or Ion	Number of Valence Electrons	Total number of atoms and sets of lone pairs surrounding central atom(s)	Structure Geometry (Name)
CCl_4	32	4	Tetrahedral
H_2O	8	4	Bent
CO_2	16	2	Linear
H_2O_2	14	Each O has 4	Both O's- Bent
CH_4	8	4	Tetrahedral
C_2H_4	12	Each C has 3	Both C's- Trigonal planar
CH_2O	12	3	Trigonal planar
CH_3OH	14	C has 4; O has 4	C- Tetrahedral; O- Bent
CH_3NH_2	14	C has 4; N has 4	C- Tetrahedral; N- Trigonal pyramidal
NF_3	26	4	Trigonal pyramidal
NH_3	8	4	Trigonal pyramidal
$[NH_4]^+$	8	4	Tetrahedral
$[NO_2]^-$	18	3	Bent
SO_2	18	3	Bent
OF_2	20	4	Bent
H_2S	8	4	Bent
SF_6	48	6	Octahedral
ICl_5	42	6	Square pyramidal

Photo 3: CCl4 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)







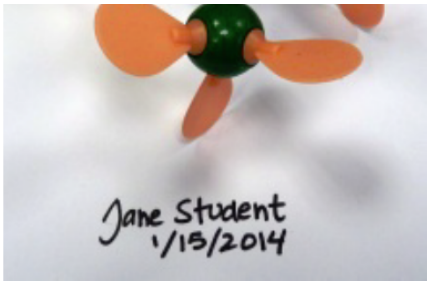
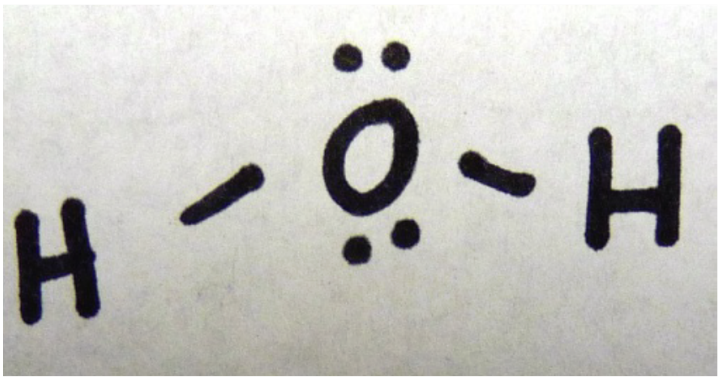


Photo 4: H2O Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



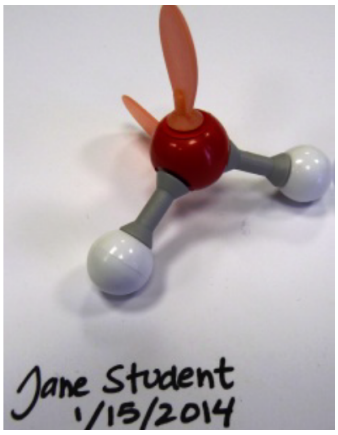
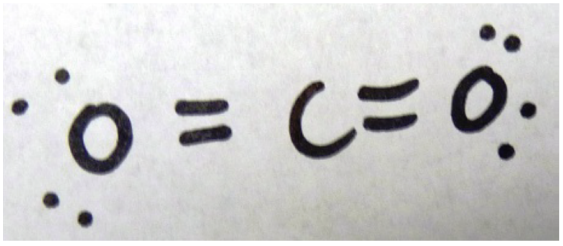


Photo 5: CO2 Lewis Structure and VSEPR Model

(SAMPLE ANSWER BELOW)



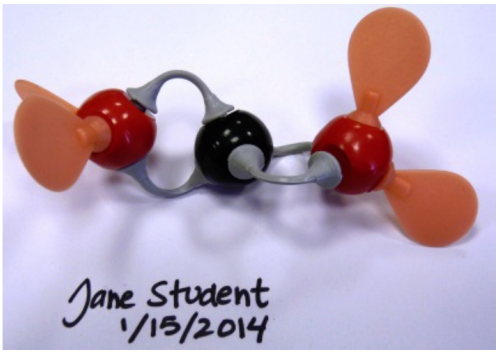
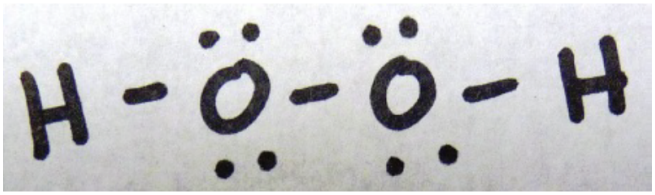


Photo 6: H2O2 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



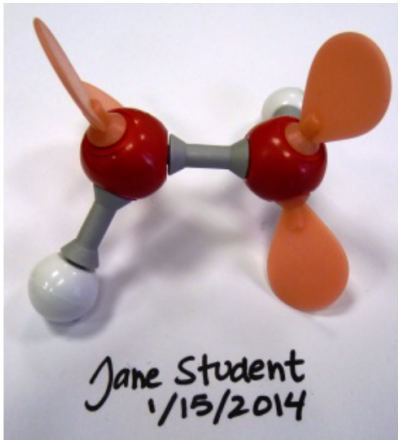


Photo 7: CH4 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)

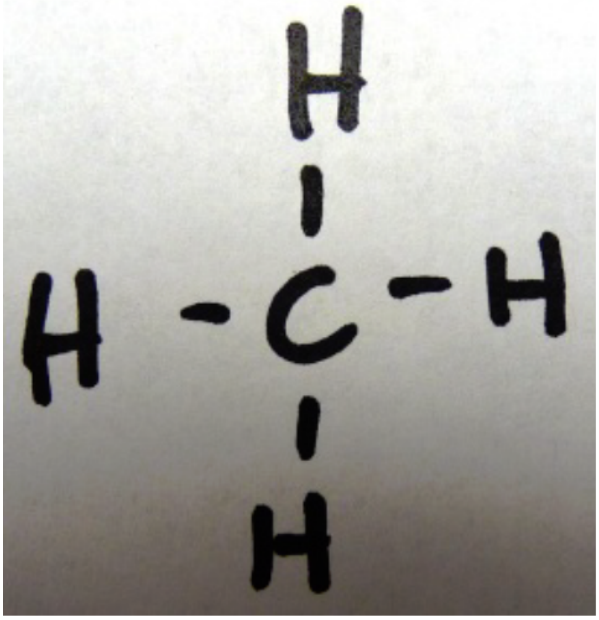


Photo 8: C2H4 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)

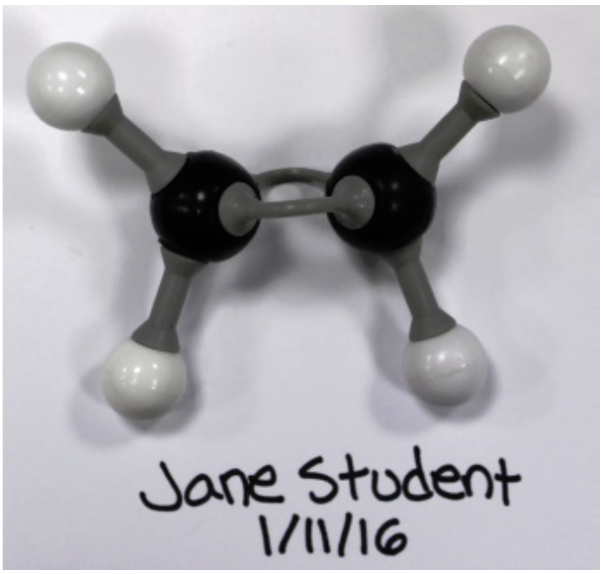
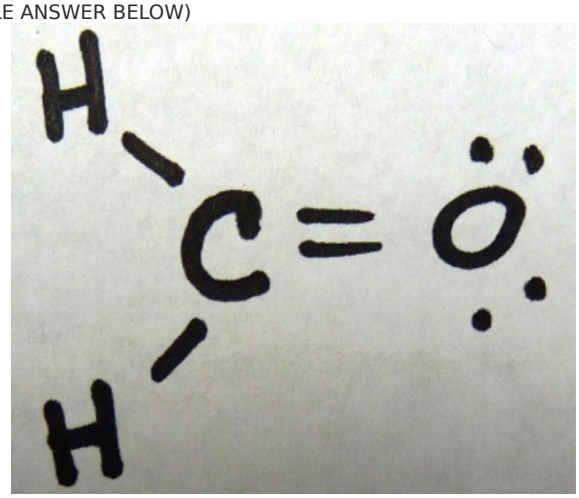


Photo 9: CH2O Lewis Structure and VSEPR Model

(SAMPLE ANSWER BELOW)



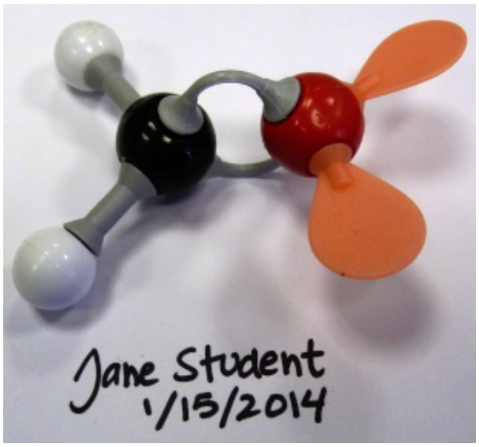
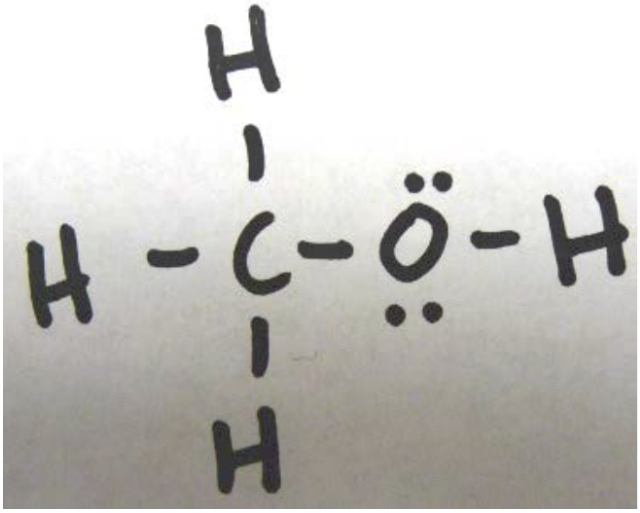


Photo 10: CH3OH Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



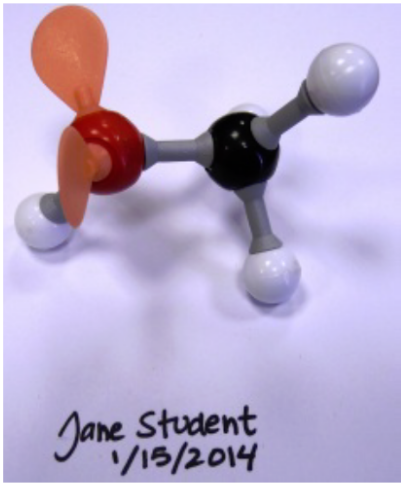
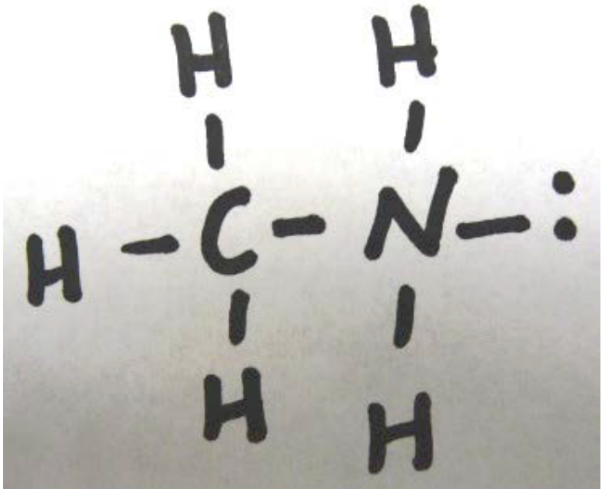


Photo 11: CH3NH2 Lewis Structure and VSEPR Model

(SAMPLE ANSWER BELOW)



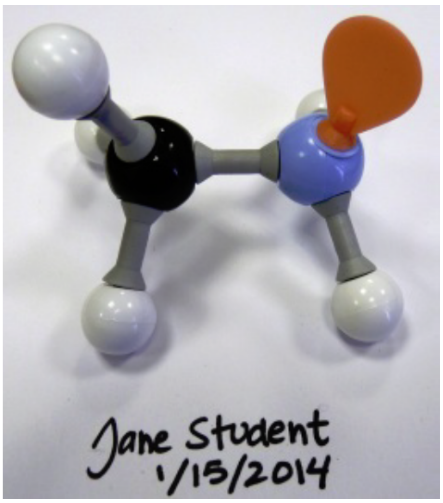
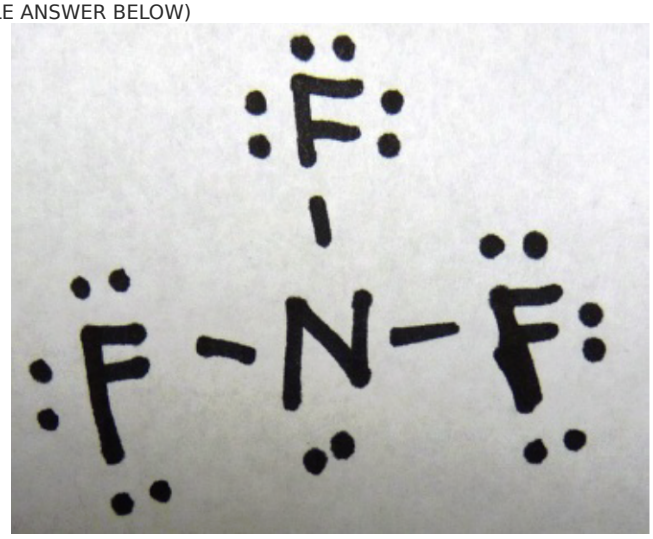


Photo 12: NF3 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



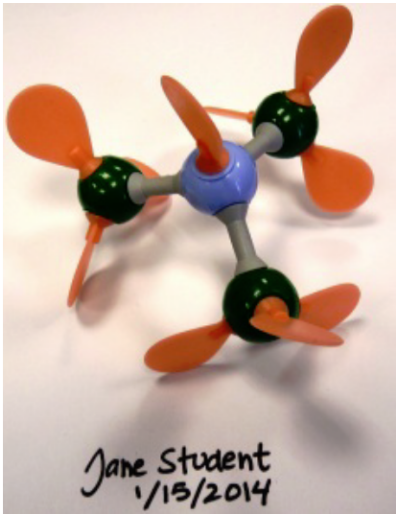
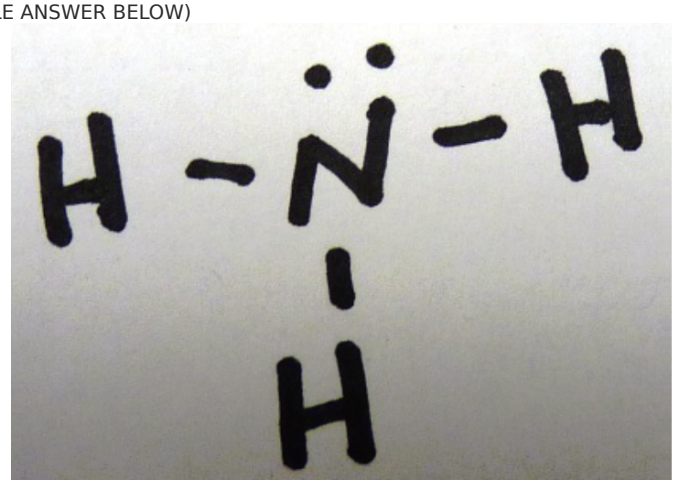


Photo 13: NH3 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



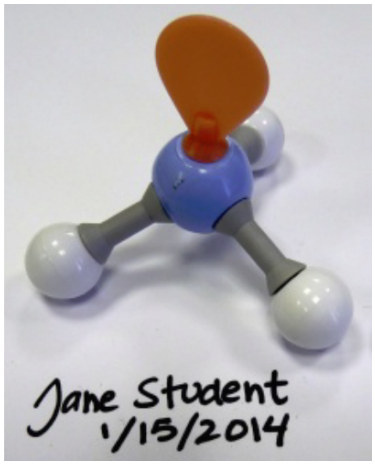
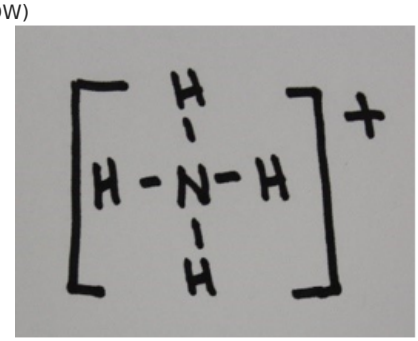


Photo 14: [NH4]+ Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



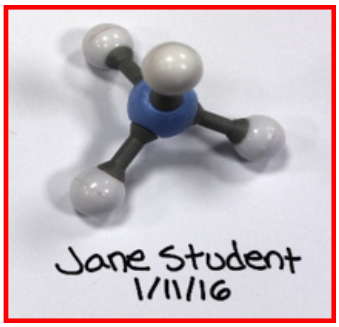


Photo 15: [NO2]- Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)

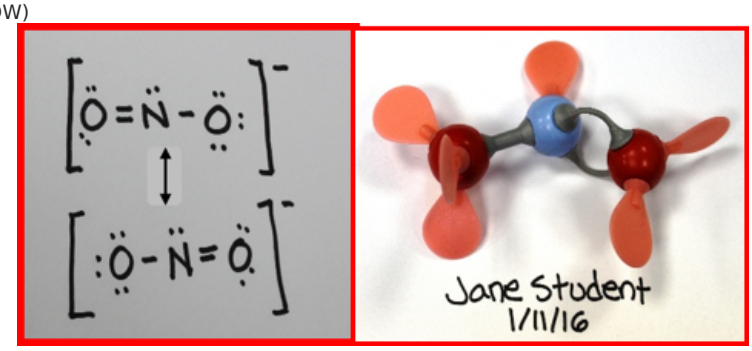
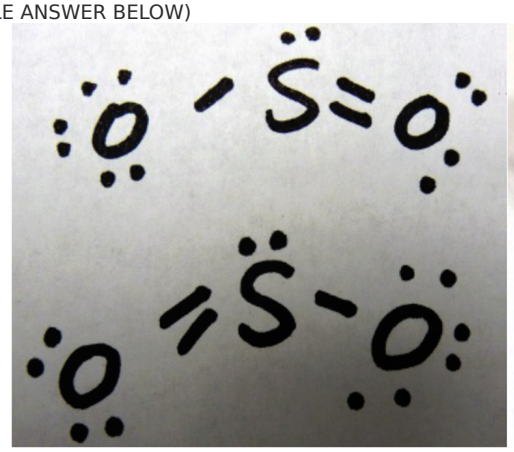


Photo 16: SO2 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



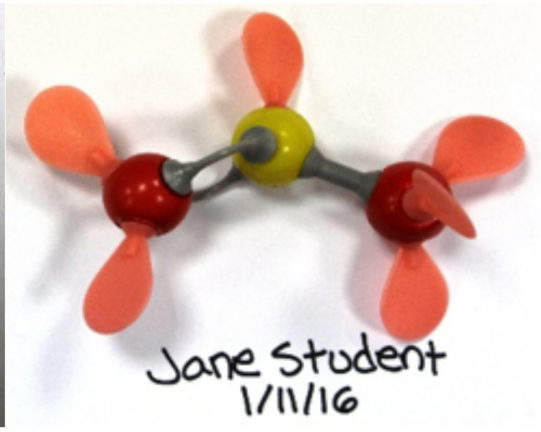
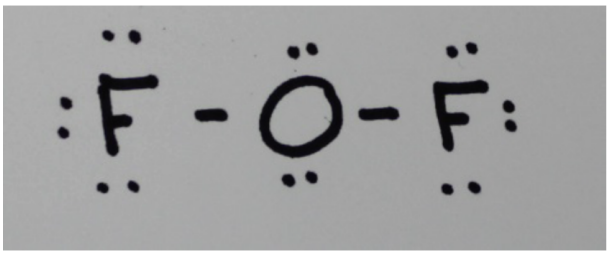


Photo 17: OF2 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



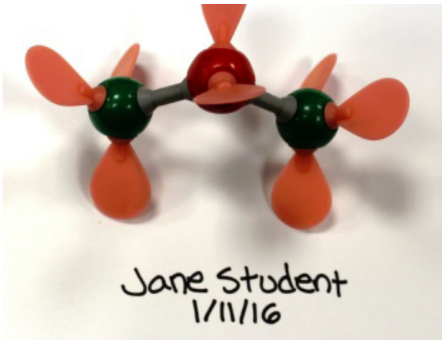


Photo 18: H2S Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)

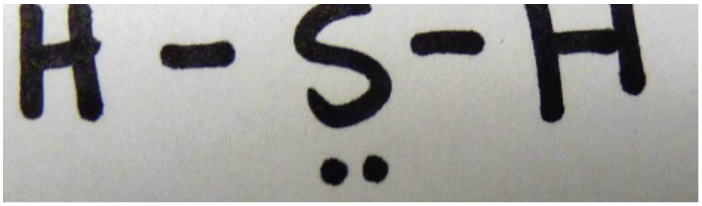
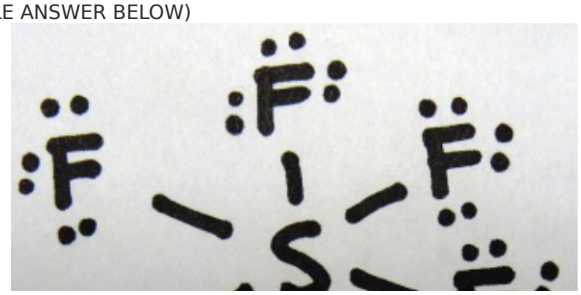
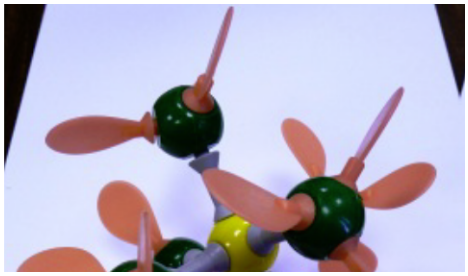


Photo 19: SF6 Lewis Structure and VSEPR Model

(SAMPLE ANSWER BELOW)





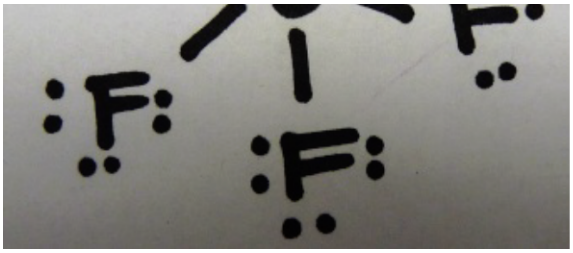
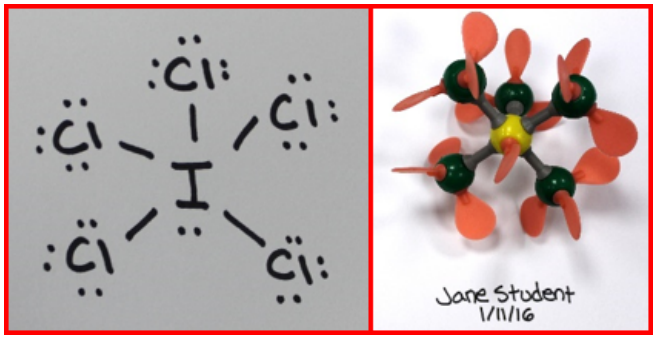


Photo 20: ICl5 Lewis Structure and VSEPR Model
(SAMPLE ANSWER BELOW)



Competency Review

Different structural modifications of an element are called _____.

- allotropes ✔
- valences
- pairs
- octets

Valence electrons include all electrons of an atom.

- True
- False ✔

Valence electrons that are not shared between two atoms are called ____.

- doublets
- lone pairs ✔
- octets
- electron deficient

The duet rule is based upon the observation that atoms are most stable when surrounded by eight valence electrons.

- True
- False ✔

The ____ of a molecule visually describes the two-dimensional arrangement of atoms and valence electrons in a molecule.

- localized electron model
- charges
- Lewis structure ✔

The first step in creating a Lewis structure is to determine the total number of valence electrons for the entire molecule.

- True ✔
- False

The valence shell electron pair repulsion (VSEPR) model _____.

- describes the three-dimensional arrangement of the atoms in a molecule ✔
- states that two negatively charged particles (electrons) will always repel one another with equal and opposite forces
- ensures bonding through shared valence electron pairs
- is the illustrated definition of the octet rule but not the duet rule

In a molecular modeling kit, a black ball with 4 holes most likely represents the element _____.

- hydrogen
- carbon ✔
- magnesium
- sulfur

The Lewis structure for H_2O includes double bonds.

- True
- False ✔

Some compounds have more than one Lewis structure.

- True ✔
- False

Alkali metals are a group located at the far left of the periodic table; alkali metals have _____ valence electron(s).

- 1 ✔
- 2
- 6
- 7

Carbon dioxide has a _____ geometric structure.

- tetrahedral
- octahedral
- trigonal planar
- linear ✔

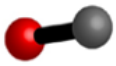
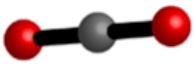
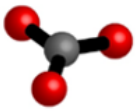
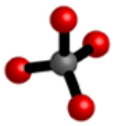
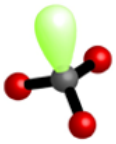
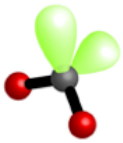
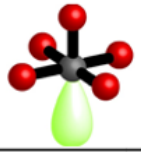
SF_6 has a _____ geometric structure.

- tetrahedral
- octahedral ✔
- trigonal planar
- linear

Extension Questions

For each molecular shape, identify the number of bonds around the central atom and the number of lone pairs around the central atom.
(SAMPLE ANSWER BELOW)

For each molecular shape, identify the number of bonds around the central atom and the number of lone pairs around the central atom.

Number of Bonds Around the Central Atom	Number of Lone Pairs Around the Central Atom	Molecular Geometries	
1	0		Linear
2	0		Linear
3	0		Trigonal planar
4	0		Tetrahedral
3	1		Trigonal pyramidal
2	2		Bent
5	0		Trigonal bipyramidal
6	0		Octahedral
5	1		Square pyramidal