MS1 & 2: Lesson 3

Outcome: *Examine the role of valence electrons in the formation of chemical bonds*
Indicators:

h. Predict the arrangement of atoms and draw Lewis structures (electron dot structures) to represent covalent- and ionic-bonded molecules. (S)

i. Predict the geometry and draw the shapes of molecules with a single central atom using valence shell electron pair repulsion (VSEPR) theory. (K, S)

j. Predict the nature of chemical bonds within a molecule using the property of electronegativity. (K, S)

Outcome: *Investigate how the properties of materials are dependent on their underlying intermolecular and intramolecular forces.*
Indicators:

a. Predict the polarity of molecules using the property of electronegativity and VSEPR theory. (K, S)

b. Differentiate between the different types of intermolecular (i.e., van der Waals [i.e., London dispersion, dipole-dipole, hydrogen bonding and ion dipole], ionic crystal and network-covalent) and intramolecular (i.e., nonpolar covalent, polar-covalent, ionic and metallic) forces. (K)

c. Recognize that a material's chemical and physical properties are dependent on the type of bonds and the forces between atoms, molecules or ions. (K)

d. Identify and describe some properties (e.g., melting point, solubility, thermal conductivity, electrical conductivity, hardness, heat capacity, tensile strength, surface tension, reactivity with acids and bases, flammability, flame tests and odour) of ionic and molecular compounds, metals and network covalent substances. (S)

VSEPR

What do the molecules really look like?

Next we will look at what a molecule looks like in 3 dimensional space. We use molecular ___________________________and VSEPR Theory. VSEPR stands for ____. The VSEPR theory determines the ___________________________ of a molecule by looking at the electrons surrounding the central atom and whether they are shared pairs (bonded) or unbonded pairs.

Determine Molecular geometry using VSEPR:

1. Determine the lewis dot formula
2. Determine the total number of electron pairs around the central atom
3. Use the table provided to determine the electron pair geometry
4. Use the table provided to determine the shape
5. Use the diagram chart to draw a 3D diagram

VSEPR Chart			
Total pairs of e^- around central atom	**Number of bonded pairs**	**Electron Pair geometry**	**Molecular geometry**
2	2	Linear	Linear
3	2	Trigonal Planar	Bent
3	3	Trigonal Planar	Trigonal Planar
4	2	Tetrahedral	Bent
4	3	Tetrahedral	Trigonal Pyramidal
4	4	Tetrahedral	Tetrahedral
5	2	Trigonal Bipyramidal	Linear
5	3	Trigonal Bipyramidal	T-Shaped
5	4	Trigonal Bipyramidal	Seesaw
5	5	Trigonal Bipyramidal	Trigonal Bipyramidal
6	2	Octahedral	Linear
6	3	Octahedral	T-Shaped
6	4	Octahedral	Square Planar
6	5	Octahedral	Square Pyramidal
6	6	Octahedral	Octahedral

VSEPR Geometry 3D diagrams:


Going into the page

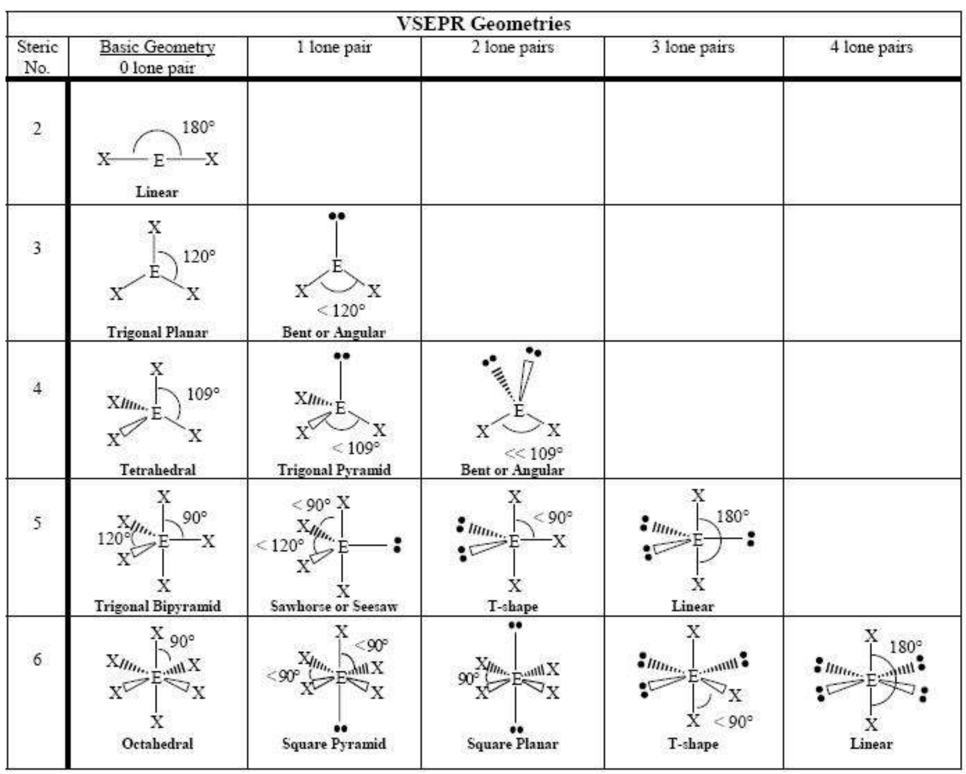

Coming out of the page

In plane with the page

E = Central Atom

X =Bonded Atom

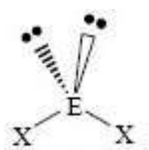
• • = Unbonded pair of electrons



Example 1: OF_2

Oxygen has ______ pairs of electrons around it, ______ are bonded ______ are unbonded, so it has a geometry of ____.

The 3D drawing for tetrahedral bent is:



So you just need to fill in the atoms where they belong:

Example 2: PCl_3

PCl_3 has ______ pairs of electrons around it, ______ of the pairs are bonded. This means that PCl_3 has a geometry of ____.

Sometimes in a double or triple bond you have to assume that the atom has only one shared pair of electrons in order to get the proper geometry.

CS_2

Even though this actually has ________ shared pairs of electrons and all are bonding electrons, the shape is linear. In this molecule we act as though carbon's double bonded pairs of electrons are only 1 shared pair.

Molecules that Break the Octet Rule:

Normally assume that atoms want to have _____ valence electrons, however sometimes atoms like to have more. In situations like this we say that the atom _________________________ the octet rule. In this class you will always be told if an element breaks the octet rule.

XeF_4

Xe has _____ valence electron and Fluorine has _______,

This molecule has _______ pairs of electrons around it, and _______ of them are involved in bonds so it's geometry is ____.

3D drawing:

Balloon Molecules Assignment

Create the molecules assigned to your group using the balloons provided. There are different coloured balloons. Assign one colour to represent the bonded electron pairs and the other to represent the unbonded electron pairs. Make sure you specify which is which.

Create your molecules so that it is stable enough to get knocked over and still maintain its shape. You will be provided with tape, string and balloons. After you have created your molecule with the balloons, label it with masking tape. Label the chemical formula, geometries and your names. You then need to make a 3 dimensional drawing of each of your molecules (not drawings of the balloons). Use the dashed and solid triangles to represent the atoms that go into the page and the atoms that come out of the page. Each member of your group should submit a drawing of **both molecules**. On the paper you hand in, write down which balloon colors represent bonded electrons and which represent lone pairs. Don`t forget your names!

When you have finished building and drawing your molecules, you need to find a space on the counter and place all of your molecule representations together. You can then work on the "VSEPR" assignment. **(See VSEPR assignment)**

Electronegativity

- Electronegativity is the ability of an atom to ____________________ electrons to it when bonded
- The electronegativity scale was created by ___________________________________in 1922 to help develop a better understanding of chemical bonds
- We can compare electronegativity values between atoms to determine the type of ____________________ that will form between them.
- An element with a ______________ electronegativity value is really good at attracting electrons and an element with a low electronegativity is not.
- In general, electronegativity ____________________ as you move from left to right across the periodic table and ____________________ as you move from top to bottom.

Electronegativity difference	Most probable bond type
0.0-0.4	Nonpolar covalent
0.4-1.0	Moderately polar covalent
1.0-1.7(ish)	Very polar covalent
>1.7	ionic

Electronegativity values of the elements (Pauling scale)

H 2.1																	He
Li 1.0	Be 1.5											B 2.0	C 2.5	N 3.0	O 3.5	F 4.0	Ne
Na 0.9	Mg 1.2											Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0	Ar
K 0.8	Ca 1.0	Sc 1.3	Ti 1.5	V 1.6	Cr 1.6	Mn 1.5	Fe 1.8	Co 1.8	Ni 1.8	Cu 1.9	Zn 1.6	Ga 1.6	Ge 1.8	As 2.0	Se 2.4	Br 2.8	Kr 3.0
Rb 0.8	Sr 1.0	Y 1.2	Zr 1.4	Nb 1.6	Mo 1.8	Tc 1.9	Ru 2.2	Rh 2.2	Pd 2.2	Ag 1.9	Cd 1.7	In 1.7	Sn 1.8	Sb 1.9	Te 2.1	I 2.5	Xe 2.6
Cs 0.7	Ba 0.9	La 1.1	Hf 1.3	Ta 1.5	W 1.7	Re 1.9	Os 2.2	Ir 2.2	Pt 2.2	Au 2.4	Hg 1.9	Ti 1.8	Pb 1.8	Bi 1.9	Po 2.0	At 2.2	Rn 2.4
Fr 0.7	Ra 0.7	Ac 1.1															

Ce 1.1	Pr 1.1	Nd 1.1	Pm 1.1	Sm 1.1	Eu 1.1	Gd 1.1	Tb 1.1	Dy 1.1	Ho 1.1	Er 1.1	Tm 1.1	Yb 1.1	Lu 1.2
Th 1.3	Pa 1.5	U 1.7	Np 1.3	Pu 1.3	Am 1.3	Cm 1.3	Bk 1.3	Cf 1.3	Es 1.3	Fm 1.3	Md 1.3	No 1.3	Lr

Non Polar Bonds

- If both atoms have an equal (or approximately equal) ______________ on the electrons (same electronegativity), the bond is considered to be non-polar.
- Diatomic molecules are non-polar because they are made up of two atoms of ____________________ element with the same electronegativity and therefore both atoms have equal pull on electrons.
- Ex. Cl_2

Electronegativity difference:

Polar Bonds

- When two covalently bonded atoms have a significant electronegativity difference (between 0.4 and 1.7) the electrons are shared ______________________.
- The atom with the higher electronegativity attracts electrons ________________________ and therefore gains a slightly ______________________ charge. The atom with the lower electronegativity gains a slightly ______________________ charge.
- The slightly positive and slightly negative parts of the molecule are called poles. Because polar covalent molecules contain a positive pole and a negative pole, they are called ______________________.
- Ex. HCl

  Electronegativity difference:

- Since many molecules have more than one bond we have to consider ________________________ in a molecule to determine polarity.
- The shape of a molecule determines the polarity of the molecule. If the molecule contains polar bonds and the shape is ______________________ the molecule will be non polar. If there is ______________________ the molecule could be polar.
- Ex. CO_2 vs H_2O

See Polarity Assignment

Intermolecular Forces

- Inter is latin for "______________________"
- These are the forces that occur between ______________________ (rather than within).
- Intermolecular forces are ______________________ than intramolecular forces.
- The two types of intermolecular forces we will look at are Van Der Waals and hydrogen bonds.

A. Van Der Waals

- The two weakest intermolecular forces are both classified as Van Der Waals forces

Dipole Interactions

- This is when one polar molecule is ______________________ to another polar molecule
- The slightly negative atom from one polar molecule is ______________________ to a slightly positive atom from another polar molecule.
- These dipole interactions are similar to ______________________ bonds, but much weaker

Dipole Interactions occur in _____________ covalent molecules

Dispersion Forces:

- These are the ______________________intermolecular force
- Dispersion forces occur between both polar and nonpolar molecules.
- When the moving electrons happen to be ______________________ on the side of the molecule closest to a neighboring molecule their electrical forces influence the neighboring molecules electrons to be momentarily more on the opposite side. This shift causes a ______________________ attraction between the two molecules.
- Dispersion forces generally get stronger as the number of electrons in the molecule increases.

Dispersion forces occur in __________________ covalent molecules

B. Hydrogen Bonds

- Hydrogen bonds are weak bonds formed by the attractions of slightly negative atoms to the slightly positive ____________________ when bonded covalently.
- Hydrogen bonds occur between hydrogen, and ______________________, ____________________, ________________________.
- Hydrogen bonds are also called ____________________
- Because hydrogen has a low electronegativity, when it pairs up with one of the high electronegativity elements ____________________, a highly polar molecule is created.
- Hydrogen bonds are a very strong dipole force.
- Hydrogen bonds are weaker than covalent bonds but ____________________ than van der waals.
- Hydrogen bonds help to explain the high melting and boiling point of water, the low density of ice, the unusually high surface tension of water and the unusually high heat capacity of water.

H-bonds occur in covalent molecules with _____________________________________

https://youtu.be/PVL24HAesnc ***See Intermolecular Forces Assignment***

Properties of Covalent Compounds

- Intermolecular interactions affect the physical properties of covalent compounds

Molecular Solids:

- Most covalent compounds have ______________________ melting and boiling points compared to ionic compounds.

Network Solids:

- Some covalent compounds have ______________________ melting points or decompose without melting at all. These stable substances are network solids, where all of the atoms are covalently bonded to one another.

- Melting a network solid would require ____________________ covalent bonds thoughout the entire solid.

Properties Summary:

Type of Solid	Interaction	Properties	Examples
Ionic	I____________________	• ________________ Melting Point, • ______________________, • ______________________, • Often ______________________ in water.	NaCl, MgO
Metallic	____________________ Bonding	• ______________________ Hardness and Melting Point (depending upon strength of metallic bonding), • ______________________, • usually not _____________________.	Fe, Mg
Molecular	____________________ Bonding, ____________________, Dispersion	• ______________________ Melting Point, • ______________________, • can be ______________________.	H_2, CO_2
Network	____________________ Bonding	• ______________________ Melting Point, • ______________________, • ______________________, • tend not to ______________________ in water.	Some forms of C, SiO_2

Bond types summary:
https://youtu.be/QXT4OVM4vXI?list=PL8dPuuaLjXtPHzzYuWy6fYEaX9mQQ8oGr

See Types of Solids Assignment

Name: ____________________________

VSEPR Assign

Determine the electron pair geometry and the molecular geometry for the following, then draw the 3D structure of the molecule:

Follow Octet:

CH_4

NF_3

PH_3

SBr_2

Break the Octet:

XeH_2

$ArCl_4$

NH_5

FCl_3

OBr_4

Name:________________

Polarity Assignment

1. How must electronegativities compare is a covalent bond between them is polar?

2. Using only their relative position on the periodic table, arrange the following elements in order of increasing electronegativity: K Cs Br Fe Ca F Cl

3. Predict what type of bond (non-polar covalent, polar covalent, or ionic) would form between the following. If only the bond is given (not the molecular formula) assume asymmetry.

   a. Ca-S
   b. H-F
   c. P-H
   d. C-Cl
   e. C-O
   f. Li-Cl
   g. N_2
   h. NH_3
   i. H_2O
   j. FeO

4. Determine whether the following molecules are polar or non polar:

   a. Hydrogen bromide, HBr
   b. Nitrogen gas, N_2
   c. Hydrogen sulfide, H_2S
   d. Ethane, C_2H_6
   e. Tetrachloroethene, C_2Cl_4
   f. Phosphine PH_3

Name:____________________________

Intermolecular Forces Assignment

Determine whether the following molecules will have polar bonds, dipole interactions, dispersion forces, or H-bonds. Be sure to include all forces (i.e. there may be more than one that applies), If the molecule is polar, draw the dipole(s).

1. NH_3
2. I_2
3. CH_4
4. O_2
5. H_2O
6. HBr
7. HOOH
8. CH_3Cl
9. Depict a hydrogen bond between a water molecule and an ammonia molecule.

Name:______________________

Types of Solids Assignment

Determine if the following compounds are metallic solids, ionic solids, network atomic solids, molecular solids, or amorphous solids based on their properties. These are all actual chemical compounds.

1) This material forms crumbly crystals and has a melting point of 16.6^0 Celsius. It has a low density in solid form.

______________________________ (acetic acid)

2) This material forms very hard colorless crystals. It does not dissolve in water and burns at high temperatures.

______________________________ (diamond, C-C bond)

3) This material forms colorless crystals that have a melting point of 661^0 C. It is hard, brittle, and dissolves well in water.

______________________________ (sodium iodide)

4) This material forms silver crystals that do not dissolve in water and have a melting point of 1414^0 C. This material is very hard and is not a good conductor of electricity.

______________________________ (silicon)

5) This material is hard and melts at a temperature of 1610^0 C. It dissolves only with difficulty in very reactive acids and doesn't conduct electricity when molten. It forms colorless crystals.

______________________________ (quartz)

6) This material is soft and doesn't form crystals. It has a melting point of 660^0 C. It doesn't dissolve in water. It is used as a structural material in the construction of airplanes and rockets.

______________________________ (aluminum)

Name:____________________

Intermolecular Forces Flow Chart (Hand in)

Design a flow chart to indicate what types of intermolecular forces would be present in a compound if you knew the **chemical formula.**

Name:______________

Unknown Solids Flow Chart (Hand in)

Create a flowchart you could use to determine the bond types present in an unknown solid (network, covalent, metallic or ionic) using only the testable properties (not the chemical formula).