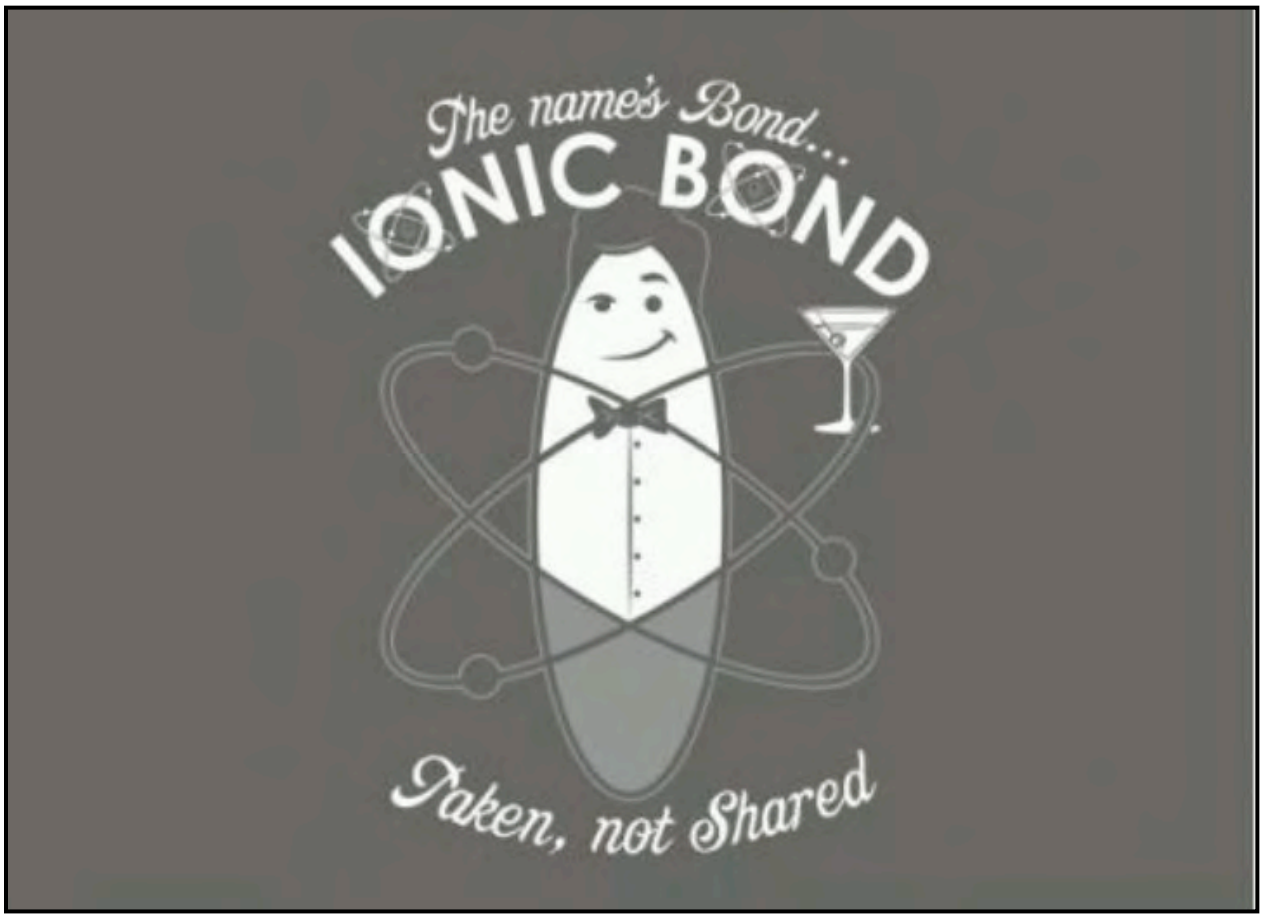
Name:

Regents Chemistry: Dr. Shanzer

Practice Packet

Chapter 9: Chemical Bonding



Chapter 9: Bonding Vocabulary

Molecule – a COVALENTLY bonded substance; can be atoms of the same element (Ex: diatomic elements/molecules); molecular substance = covalent substanc

Compound – a substance composed of two or more atoms from different elements CHEMICALLY bonded together

Bond – forces of attraction that hold atoms together in a molecule or compound

Octet Rule – atoms bond together in order to have 8 electrons in their valence shell

Exothermic – energy is RELEASED as a product of a chemical reaction

Endothermic – energy is CONSUMED as a product of a chemical reaction

Ionic Bond – chemical bond involving the TRANSFER of electrons between a metal and nonmetal atom (metals lose, nonmetals gain); electronegativity difference between elements typically GREATER than 1.7

Covalent Bond – chemical bond involving the SHARING of electrons between two nonmetal atoms; electronegativity difference between elements typically LESS than 1.7

Oxidation number – the "charge" an element has within a compound

Polyatomic ions – atoms of two or more elements chemically bonded together and having a NET CHARGE

Polar molecule – a covalent molecule with an unequal sharing of electrons; contains atoms of two different nonmetal elements (all covalent compounds that are NOT diatoms)

Nonpolar molecules – a molecule with symmetrical/equal sharing of electrons

Intermolecular forces (IMF's) – weak forces between molecules that hold the molecules to one another; not actually chemical bonds

Chemical Bonding

Video Lesson 91.

Objectives

- Describe the 2 major types of chemical bonds in terms of electrons.
- Describe the properties of ionic and covalent bonding

Chemical Bonds

- Chemical bond is the force between atoms or ions
- Atoms will **gain**, **lose**, or **share electrons** to achieve the same electron configurations as the noble gases

Bond Energy – Bond Formation

- Bond formation is spontaneous
  - Energy is release when bonds are formed
    - EXOTHERMIC
    - Atoms go from high energy to lower energy
    - Creating bonds creates stability

$$A + B \rightarrow AB + \text{Energy}$$
$$\text{(heat)}$$
$$\text{(560 kJ)}$$

Bond Energy – Bond Breaking

- Breaking bonds is not spontaneous
  - Energy is required/absorbed/consume
  - ENDOTHERMIC

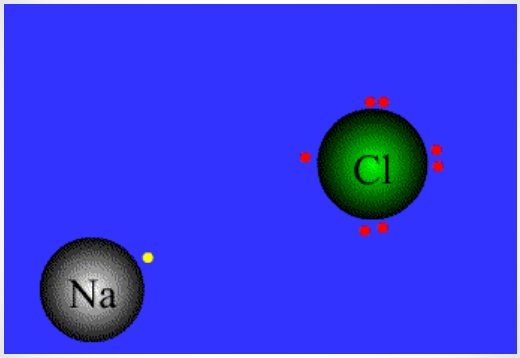
$$BC + \text{energy} \rightarrow B + C$$
$$\text{(heat)}$$
$$\text{(600 kJ)}$$

Bond Types

- Ionic Bonds
  - Bonds that involve IONS
- Covalent Bonds
  - Bonds between nonmetals
  - Molecules
- Metallic Bonds
  - Bonds that hold metals together.

Ionic Bonds

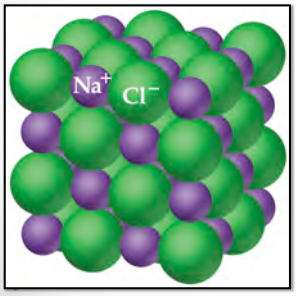
- Bond formed between ions
  - Metals bonded to nonmetals
  - Compound that contain polyatmoic ions
- Involves **a transfer of electrons**
- Electronegativity difference typically greater than 1.7 (subtraction)
  - The greater the difference the more ionic character



Properties of Ionic Compounds

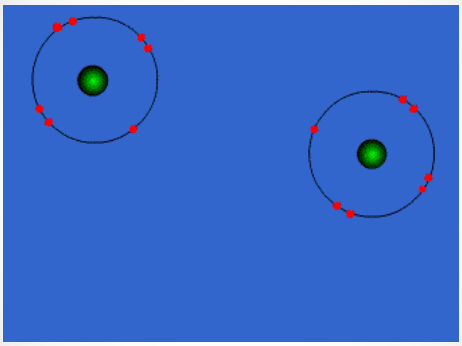
- Very strong bond
- High melting points and high boiling points
- Hard
- Form crystal lattice shape (regular geometric pattern)
- Electrolytes
  - Can conduct electricity in solution (aq)

Crystalline Structure



Covalent Bonds

- Found in molecular substances.
- **Involves a sharing of electron pairs**.
- Nonmetals bonded to nonmetals
  - Or diatomic elements
    - Br_2 I_2 N_2 Cl_2 H_2 O_2 F_2
- Similar electronegativities



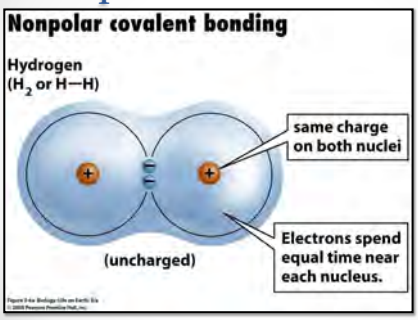
Properties of Covalent Bonds

- Weaker bonds than ionic bonds
- Low melting and low boiling points
- Do not form electrolytes
- Typically soft

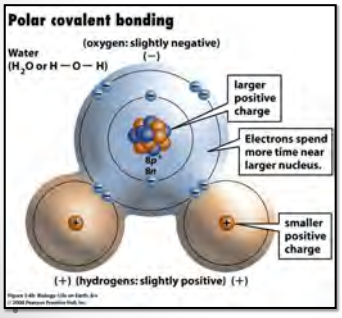
Types of Covalent Bonds

Nonpolar Covalent Bonds	Polar Covalent Bonds
• Form between atoms with the same electronegativity • Electrons are shared equally • H_2	• Form between nonmetals with different electronegativity • Electrons are shared unequally

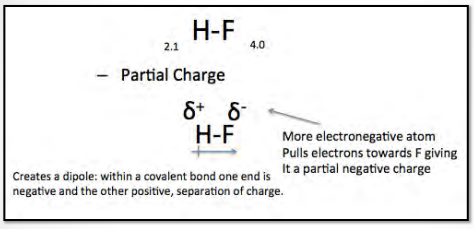
Nonpolar Covalent Bonds



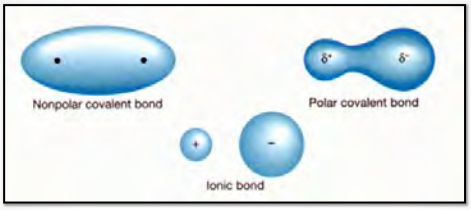
Polar Covalent Bond



Partial Charge



Summary



Lewis Dot Diagrams

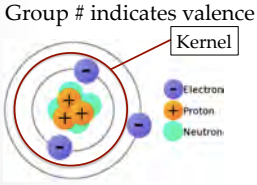
Chemistry 200
Video Lesson 9.2

Objective:

How do we show the arrangement of electrons for Ionic and Molecular substances using Lewis Dot Diagrams? (Lewis Structures)

Valence electrons – electrons in the outermost shell of an atom or ion

- Establish chemical characteristics of elements
- The only electrons shown in Lewis electron dot structures
- Group # indicates valence e^- except for Helium

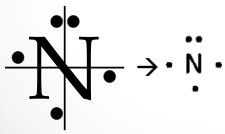


Lewis Structures or Dot Diagrams

Atoms

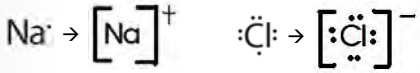
- Determine valence electron number
- Write the symbol for the element
- Place a dot on each side of the symbol for each electron

Nitrogen → 5 valence e⁻



Ions

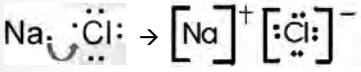
- ***Cations***(+) lose valence e^- & ***Anions***(-) gain valence e^-
- Place [ ] around the symbol & indicate the charge :



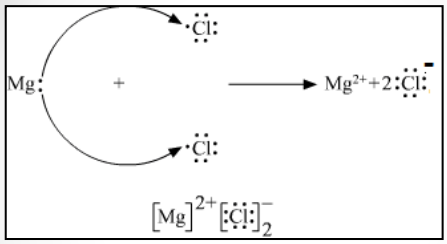
Creating Lewis Dot Diagrams for molecules

Ionic

- create dot diagrams for each ion and put them together
- use subscripts if more than one cation or anion



Lewis dot diagram for **$MgCl_2$**



Molecular

Step 1

Obtain the sum of the **valence** electrons from all of the atoms. Do not worry about keeping track of which electrons come from which atoms. It is the total number of valence electrons that is important. Be attentive to the charge if applicable.

Step 2

Use one pair of electrons to form a bond btwn each pair of bound atoms. For convenience, a line (instead of a pair of dots) is generally used to indicate each pair of bonding electrons. The atom w/ the smallest electronegativity is usually in the middle. Oxygen tends not to be the central atom. Hydrogen is **never** the central atom because it only forms one bond.

Step 3

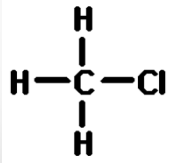
Arrange the remaining electrons to satisfy the **duet** rule for hydrogen & the **octet** rule for each of the other atoms. If each atom does not have an octet of electrons around it & there are still electrons to be assigned, consider a multiple bond.

Draw a Lewis Dot structure for **CH_3Cl**

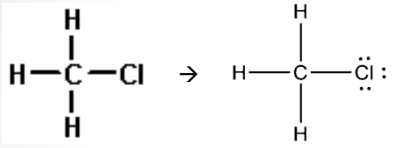
1. Total number of valence e^- for the atoms in the compound.
   C = 4
   3H = 3 → Total 14 e^-
   Cl = 7

   must have this amount on your diagram when completed

2. Put most electronegative element in the center & connect all atoms to it using bond lines, one line for each e^- pair.



3. Complete diagram using the Octet & Duet Rules



Draw a Lewis dot diagram for O_2

Each oxygen atom has 6 valence e^-, therefore O_2 has a total of 12 valence e^-.

1. O – O This leaves 10 e^- left to use
2.  There are a total of 12 valence e^- which is all that can be used. Apply Octet rule.
3.  Now we have an Octet around each oxygen atom

ALWAYS COUNT BONDS & ELECTRON PAIRS WHEN FINISHED!!! PLEASE

Molecular Shapes & Polarity

Chemistry 200
Video Lesson 9.3

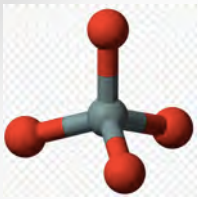
Objective:

How do we determine the shape and polarity of a molecule?

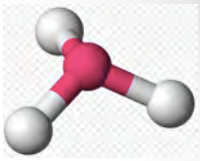
Shapes of Molecules (VSEPR - Valence Shell Electron Pair Repulsion)

VSEPR Theory is just a fancy model used to identify the shape of a molecule in 3 dimensions. The theory is based on the fact that atoms AND unbonded (lone) pairs of electrons found on the CENTRAL atom repel each other. As a result, the 3 dimensional shape of a molecule is simply the result of electron clouds getting as far away from each other as possible while still being bonded to a central atom. This should make sense since electrons are negative & repel each other

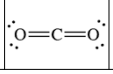
Name of Shape	Number of atoms bonded to the central atom	Number of unshared pairs of electrons on the central atom	Shape	Examples
Tetrahedral	4	0		CH_4 CH_3I CCl_4
Trigonal Pyramidal	3	1		NH_3 PH_3



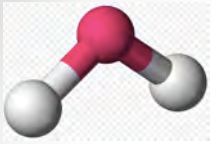
Tetrahedral



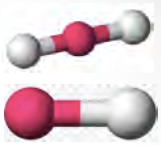
Trigonal Pyramidal

Name of Shape	Number of atoms bonded to the central atom	Number of unshared pairs of electrons on the central atom	Shape	Examples
Bent	2	2		H_2O H_2S
Linear	2	0		CO_2

* H-F is linear



Bent



Linear

Polarity within a Molecule

Polar Molecule: A molecule that has an overall slight (+) & (-) side. For a molecule to be polar, it must meet 2 important criteria:

1. It must contain polar covalent bonds
   AND
2. It must have an asymmetrical (uneven) charge distribution

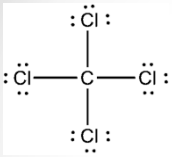
Failing either of these (or both) means the molecule is **NONPOLAR**

Nonpolar Molecule: A molecule that lacks an overall (+) &(-) side. Nonpolar molecules are created when a molecule lacks polar bonds or has a symmetrical (even) charge distribution

Determinining Polarity w/in a Molecule

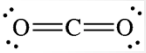
- Ionic molecules are always polar
- look at the shape & central atom of the molecule
- the shape **MUST** permit a net displacement of charge (one end positive & one end negative) to be polar
- if all polar bonds w/in a molecule are **equal**, the molecule is nonpolar

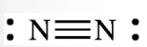
Nonpolar Molecule



Polar bonds

Symmetrical charge distribution

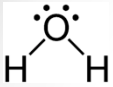


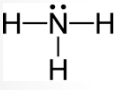


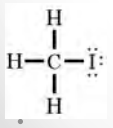
Nonpolar bonds

Symmetrical charge distribution

Polar Molecules







Polar bonds

Asymmetrical charge distribution

Intermolecular Forces

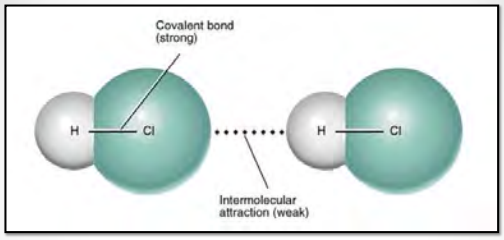
Video Lesson 9.4

Objectives

- Evaluate the strength and type of intermolecular forces of attraction.

Intermolecular Forces (IMF's)

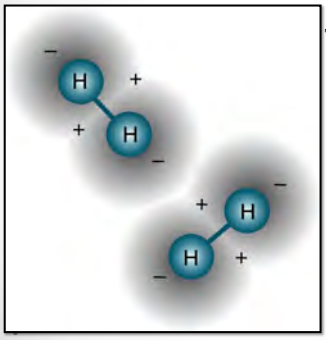
- Only in covalent molecules
- Weak forces that act BETWEEN molecules
- Only exist in Gas and liquid phase
- Much weaker than chemical bonds
- IMF's ARE NOT BONDS!!!



Types of Intermolecular Forces

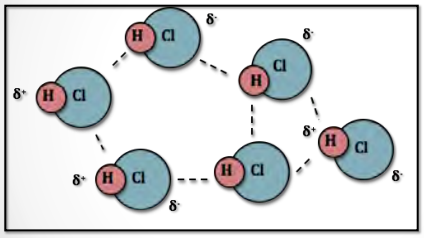
- Van der Waal's Attraction
  - Weakest of All IMF's
  - Nonpolar molecules only
  - H-H
- Dipole – Dipole Interaction
  - Two poles – positive and negative
  - Hydrogen Bonding
    - Strongest
    - HFON

Van der Waals Attraction

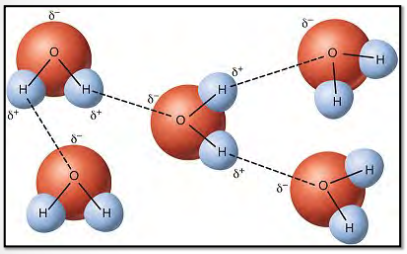


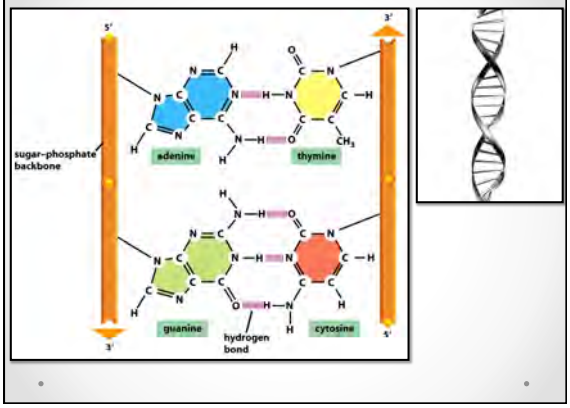
Temporary dipoles

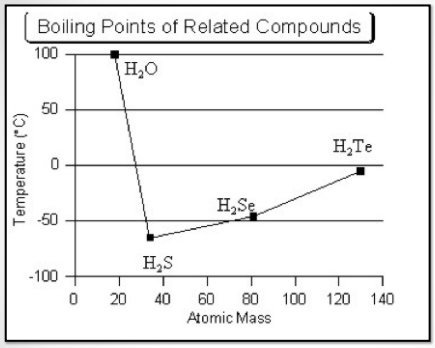
Dipole – Dipole Interactions



Hydrogen Bonding







Sketch Notes

Video Lesson 9.1: Bonding

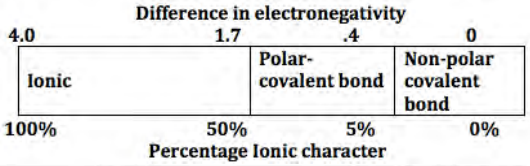
Ionic Bond	between a Metal and Non-Metal	(M + NM)
Covalent Bond	between a Non-Metal and Non-Metal	(NM + NM)
Metallic Bond	between a Metal and Metal	(M+ M)

Determine if the elements in the following compounds are metals or non-metals. Describe the type of bonding that occurs in the compound.

Compound	**Element 1 (metal or non-metal?)**	**Element 2 (metal or non-metal?)**	**Bond Type**
NO_2	N = non-metal	O = non-metal	covalent
NaCl			
SO_2			
PO_4^{3-}			
$MgBr_2$			
CaO			
H_2O			
K_2O			
Cu-Zn alloy			
O_2			
$CuCl_2$			
NO_2^-			
TiO_2			
HF			
Rb_2S			
Au-Ag mixture			
Fe_2O_3			

Types of Chemical Bonds:
Classify the following compounds as ionic (metal + nonmetal), covalent (nonmetal + nonmetal) or both (compound containing a polyatomic ion).

1. $CaCl_2$ _____
2. CO_2 _____
3. H_2O _____
4. $BaSO_4$ _____
5. K_2O _____
6. NaF _____
7. Na_2CO_3 _____
8. CH_4 _____
9. SO_3 _____
10. LiBr _____
11. MgO _____
12. NH_4Cl _____
13. HCl _____
14. KI _____
15. NaOH _____
16. NO_2 _____
17. $AlPO_4$ _____
18. $FeCl_3$ _____
19. P_2O_5 _____
20. N_2O_3 _____



Bonding between	More Electronegative element and value	Less Electronegative element and value	Difference in electronegativity	Bond Type
Sulfur and Hydrogen				
Sulfur and cesium				
Chlorine and bromine				
Calcium and chlorine				
Oxygen and hydrogen				
Nitrogen and hydrogen				
Iodine and iodine				
Copper and sulfur				
Hydrogen and fluorine				
Carbon and oxygen				

Bond Types

1. Two molecules of HBr collide and then form H_2 and Br_2. During the collision, the bonds in the HBr molecules are

   1) broken as energy is absorbed
   2) broken as energy is released
   3) formed as energy is absorbed
   4) formed as energy is release

2. Given the balanced equation representing a reaction:

   $$O_2 \rightarrow O + O$$

   What occurs during this reaction?

   1) Energy is absorbed as bonds are broken.
   2) Energy is absorbed as bonds are formed.
   3) Energy is released as bonds are broken.
   4) Energy is released as bonds are formed.

3. What occurs as two atoms of fluorine combine to become a molecule of fluorine?

   1) A bond is formed as energy is absorbed.
   2) A bond is formed as energy is released.
   3) A bond is broken as energy is absorbed.
   4) A bond is broken as energy is released.

4. Which formulas represent one ionic compound and one molecular compound?

   1) N_2 and SO_2
   2) Cl_2 and H_2S
   3) $BaCl_2$ and N_2O_4
   4) $NaOH$ and $BaSO_4$

5. Which element forms an ionic compound when it reacts with lithium?

   1) K 2) Fe 3) Kr 4) Br

6. Which type of substance can conduct electricity in the liquid phase but *not* in the solid phase?

   1) ionic compound
   2) molecular compound
   3) metallic element
   4) nonmetallic element

7. A molecular compound is formed when a chemical reaction occurs between atoms of

   1) chlorine and sodium
   2) chlorine and yttrium
   3) oxygen and hydrogen
   4) oxygen and magnesium

8. Which compound has both ionic and covalent bonding?

   1) $CaCO_3$ 2) CH_2Cl_2
   3) CH_3OH 4) $C_6H_{12}O_6$

9. Which formula represents a molecular compound?

   1) Kr 2) LiOH
   3) N_2O_4 4) NaI

10. Which characteristic is a property of molecular substances?

    1) good heat conductivity
    2) good electrical conductivity
    3) low melting point
    4) high melting point

11. Which type of bond is found between atoms of solid cobalt?

    1) nonpolar covalent
    2) polar covalent
    3) metallic
    4) ionic

12. A solid substance is an excellent conductor of electricity. The chemical bonds in this substance are most likely

    1) ionic, because the valence electrons are shared between atoms
    2) ionic, because the valence electrons are mobile
    3) metallic, because the valence electrons are stationary
    4) metallic, because the valence electrons are mobile

Video Lesson 9.2: Lewis Structures

Lewis Dot Diagrams for Molecular substances

Step 1
Obtain the sum of the **valence** electrons from all of the atoms. Do not worry about keeping track of which electrons come from which atoms. It is the total number of valence electrons that is important. Be attentive to the charge if applicable.

Step 2
Use one pair of electrons to form a bond btwn each pair of bound atoms. For convenience, a line (instead of a pair of dots) is generally used to indicate each pair of bonding electrons. The atom w/ the smallest electronegativity is usually in the middle. Oxygen tends not to be the central atom. Hydrogen is **never** the central atom because it only forms one bond.

Step 3
Arrange the remaining electrons to satisfy the **duet** rule for hydrogen & the **octet** rule for each of the other atoms. If each atom does not have an octet of electrons around it & there are still electrons to be assigned, consider a multiple bond.

Draw Lewis Dot Diagrams for the following substances:

CH_4	**CH_3Cl**	**NH_3**	**H_2O**
HBr	**F_2**	**O_2**	**N_2**
CO_2	**C_2H_2**	**CCl_4**	**PCl_3**

PO_4^{-3} ClO_3^{-1} NH_4^{+1}

NaF **Li_2S** **$MgCl_2$** **Al_2O_3**

Video Lesson 9.3: Molecular Shapes and Polarity

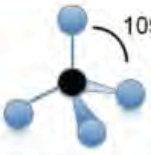
Read This!

The **VSEPR (Valence Shell Electron Pair Repulsion) Theory** helps predict the shapes of molecules and is based on the premise that electrons around a central atom repel each other. **Electron domains** are areas of high electron density such as bonds (single, double or triple) and lone-pairs of electrons. In simple terms VSEPR means that all electron bonding domains and electron nonbonding domains around a central atom need to be positioned as far apart as possible in *three-dimensional* space.

1. VSEPR theory specifies "valence shell" electrons. Explain why these are the most critical electrons for determining molecular shape.

2. In the VSEPR theory, what is repelling what?

Based on the information in the *Read This!* section, sketch one of the molecular shapes shown below in each of the boxes provided in Model 1.

Three-Dimensional Molecular Shapes	Linear 	Trigonal planar 
Tetrahedral 	Pyramidal 	Bent 

Chemical Bonding Lewis Dot Structures

Indicate the number of valence electrons for each. Write the correct Lewis electron dot structure for each.

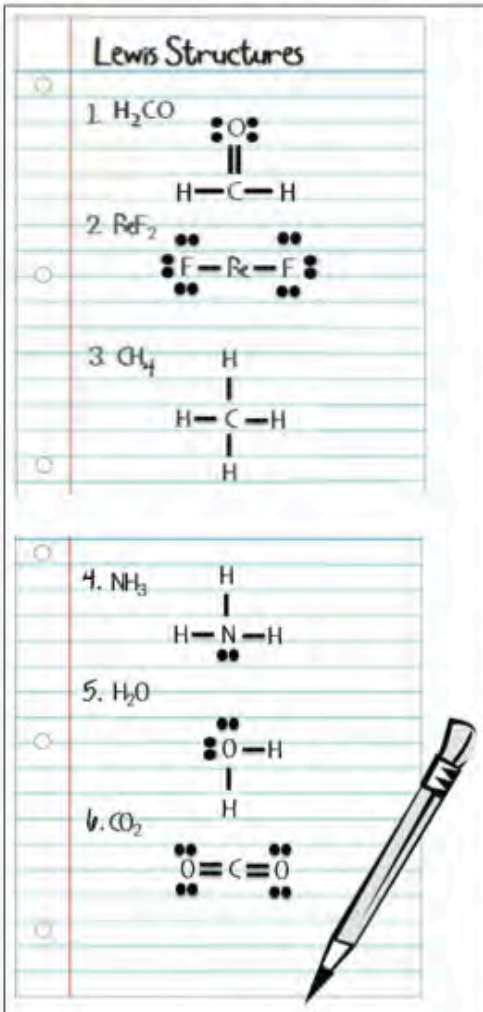
F # valence electrons = _____	O # valence electrons = _____	K # valence electrons = _____
F^{-1} # valence electrons = _____	O^{2-} # valence electrons = _____	Al^{3+} # valence electrons = _____
HF # valence electrons = _____	$CaCl_2$ # valence electrons = _____	NH_3 # valence electrons = _____
SO_4^{2-} # valence electrons = _____	CO # valence electrons = _____	Li_2O # valence electrons = _____

NF_3 # valence electrons = _____	PO_4^{3-} # valence electrons = _____	CBr_4 # valence electrons = _____

Why?

When you draw a Lewis structure for a molecule on paper, you are making a two-dimensional representation of the atoms. In reality however, molecules are not flat—they are *three*-dimensional. The true shape of a molecule is important because it determines many physical and chemical properties for the substance. In this activity you will learn how to predict molecular shapes.

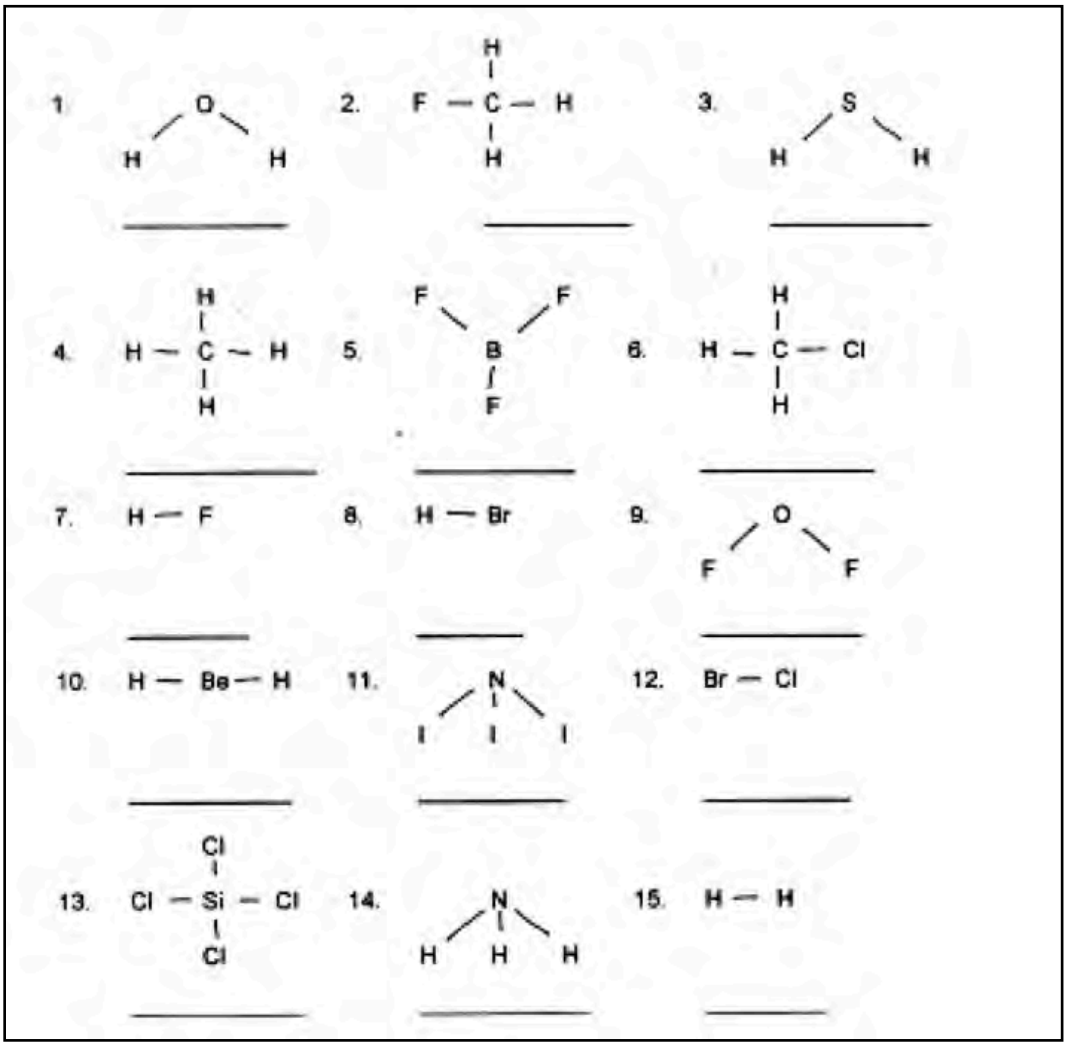
Model 1 – Lewis Structures



Lone pair = ••

H_2CO 3 electron domains (3 bonding, 0 nonbonding)	**3-D Molecular Shape**
BeF_2 2 electron domains (2 bonding, 0 nonbonding)	
CH_4 4 electron domains (4 bonding, 0 nonbonding)	
NH_3 4 electron domains (3 bonding, 1 nonbonding)	
H_2O 4 electron domains (2 bonding, 2 nonbonding)	
CO_2 2 electron domains (2 bonding, 0 nonbonding)	

For each molecule below, identify their shape and determine if they are polar or nonpolar molecules.



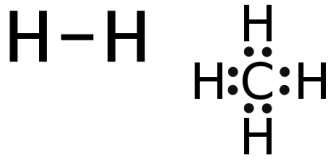
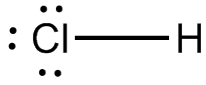
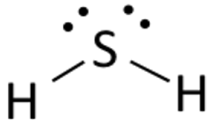
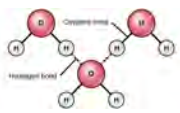
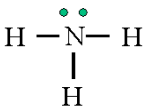
Draw Lewis Dot Diagrams, determine the shape, molecular polarity and bond type for each of the following substances:

N_2	HF	H_2O

CO_2	H_2S	NH_3
CH_4	CH_3Cl	O_2
PO_4^{-3}	ClO_3^{-1}	NH_4^{+1}

Video Lesson 9.4: Intermolecular Forces

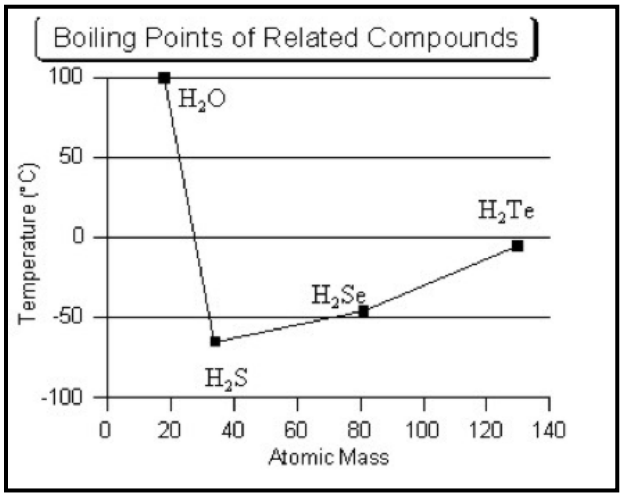
Intermolecular Forces of Attraction Summary

Van der Waal's Attraction	Dipole- Dipole Attraction	Hydrogen Bonds
(weak)	(medium)	(very strong)
• Weak attractions found between nonpolar molecules • Temporary dipole due to asymmetrical distribution of electrons • The electron cloud is always moving • Examples 	• Attraction between polar molecules that occur with oppositely charged regions of the neighboring molecule • Examples  	• FON • Very strong attraction between molecules where the hydrogen atom of one molecule is attracted to the F, O or N atom in another molecule • Responsible for the high BP of water • Examples  

The graph on the right shows the boiling point of compounds of hydrogen and them members of group 16.

1. What is the electronegativity difference in each compound?

2. How can the differences in boiling point be explained?



Intramolecular Bonds

(within a molecule)

TYPES of SUBSTANCES

IONIC BONDS

- Bonds formed by the transfer of electrons
- Generally have an EN difference of more than 1.7
- Generally compounds of metals & nonmetals
- Hard, crystalline solide w/ high M.P. Poor conductors as solids, good conductors in aqueous soln.
- Ex: $NaCl$, CuF_2, Na_2SO_4

COVALENT BONDS

Polar

- Formed by unequal sharing of electrons
- EN diff. btwn 0 & 1.7

Nonpolar

- Formed by equal sharing of electrons
- EN diff. of 0

- Both kinds of covalent bonds are found in nonmetallic elements & compounds composed of nonmetals.
- When properties of substances w/covalent bonds are studied they can be divided into 2 grps

Molecular Substances

At room temp. are gases, liquids or solids w/ low M.P.
Poor conductors always ex: H_2O, H_2, HCl, CH_4, CH_3Cl

METALLIC BONDS

- Bonds formed by the extreme mobility of electrons.
- A metal can be pictured as a collection of positive ions in a ***sea of mobile electrons***
- Solids at room temp. except Hg.
- Good conductors as solids & liquids.
- Have luster
- Ex: Cu, Fe, Hg, Na

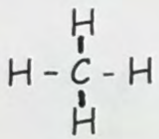
Intermolecular Forces of Attraction

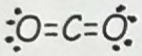
When one looks at the attraction that exists **between** molecules, they see that there are 3 different types:

Van der Waal's Attraction

(weak)

- Weak attractions found btwn nonpolar molecules or noble gases
- Temporary dipole due to asymmetrical distribution of the electrons.
- The electron cloud is always moving, (+) & (-) areas of the molecule
- Ex: H - H



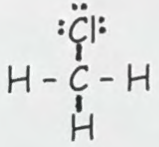


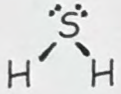
Dipole-Diploe Attraction

(dipoles are polar molecules)

(medium)

- Attraction btwn polar molecules that occur w/ oppositely charged regions of the neighboring molecules
- Ex: H - Cl



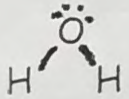


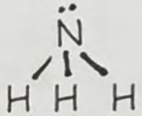
Hydrogen Bonds

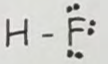
F.O.N.

(very strong)

- Very strong attraction btwn molecules where the Hydrogen atom of one molecule is attracted to the F, O or N atom in another molecule
- Responsible for the high B.P. of H_2O
- Ex:







Name: **Intermolecular Forces**

1. The boiling points, at standard pressure, of four compounds are given in the table below.

Boiling Points of Four Compounds

Compound	Boiling Point (°C)
H_2O	100.0
H_2S	−59.6
H_2Se	−41.3
H_2Te	−2.0

Which type of attraction can be used to explain the unusually high boiling point of H_2O?

1) ionic bonding
2) hydrogen bonding
3) polar covalent bonding
4) nonpolar covalent bonding

2. Hydrogen bonding is a type of

1) strong covalent bond
2) weak ionic bond
3) strong intermolecular force
4) weak intermolecular force

3. In which liquid is hydrogen bonding strongest?

1) $HF(\ell)$
2) $H_2(\ell)$
3) $CH_4(\ell)$
4) $NH_3(\ell)$

4. Which characteristic of the compound C_5H_{12} causes it to have a higher normal boiling point than C_2H_6?

1) The distance between molecules of C_5H_{12} is greater.
2) The force of attraction between molecules of C_5H_{12} is greater.
3) C_5H_{12} has a larger number of ionic bonds.
4) C_5H_{12} has a larger number of double bonds.

5. Which type of attraction results from the formation of weak momentary dipoles?

1) ionic
2) metallic
3) molecule-ion
4) van der Waals forces

6. Which statement explains why Br_2 is a liquid at STP and I_2 is a solid at STP?

1) Molecules of Br_2 are polar, and molecules of I_2 are nonpolar.
2) Molecules of I_2 are polar, and molecules of Br_2 are nonpolar.
3) Molecules of Br_2 have stronger intermolecular forces than molecules of I_2 .
4) Molecules of I_2 have stronger intermolecular forces than molecules of Br_2 .

7. Which statement explains why H_2O has a higher boiling point than N_2?

1) H_2O has greater molar mass than N_2.
2) H_2O has less molar mass than N_2.
3) H_2O has stronger intermolecular forces then N_2.
4) H_2O has weaker intermolecular forces than N_2.

8. The primary forces of attraction between water molecules in $H_2O(\ell)$ are

1) ionic bonds
2) hydrogen bonds
3) molecule-ion attractions
4) van der Waals forces

Name: **Bonding Review**

____ 1. Given the balanced equation representing a reaction:

$Cl_2 \rightarrow Cl + Cl$

What occurs during this reaction?

1) A bond is broken as energy is absorbed.
2) A bond is broken as energy is released.
3) A bond is formed as energy is absorbed.
4) A bond is formed as energy is released.

____ 2. Which statement describes what occurs as two atoms of bromine combine to become a molecule of bromine?

1) Energy is absorbed as a bond is formed.
2) Energy is absorbed as a bond is broken.
3) Energy is released as a bond is formed.
4) Energy is released as a bond is broken.

____ 3. Which of these elements has an atom with the most stable outer electron configuration?

1) Ne 2) Cl 3) Ca 4) Na

____ 4. When a sodium atom reacts with a chlorine atom to form a compound, the electron configurations of the ions forming the compound are the same as those in which noble gas atoms?

1) krypton and neon
2) krypton and argon
3) neon and helium
4) neon and argon

____ 5. Which element has an atom with the greatest attraction for electrons in a chemical bond?

1) As 2) Bi 3) N 4) P

____ 6. Based on electronegativity values, which type of elements tends to have the greatest attraction for electrons in a bond?

1) metals
2) metalloids
3) nonmetals
4) noble gases

____ 7. Which term indicates how strongly an atom attracts the electrons in a chemical bond?

1) alkalinity
2) atomic mass
3) electronegativity
4) activation energy

____ 8. Which bond is *least* polar?

1) As–Cl
2) Bi–Cl
3) P–Cl
4) N–Cl

____ 9. Given the electron dot diagram:

The electrons in the bond between hydrogen and fluorine are more strongly attracted to the atom of

1) hydrogen, which has the higher electronegativity
2) fluorine, which has the higher electronegativity
3) hydrogen, which has the lower electronegativity
4) fluorine, which has the lower electronegativity

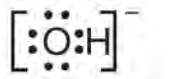
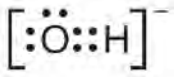
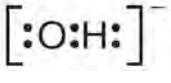
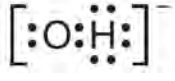
____ 10. An ionic compound is formed when there is a reaction between the elements

1) strontium and chlorine
2) hydrogen and chlorine
3) nitrogen and oxygen
4) sulfur and oxygen

____ 11. Which formula represents an ionic compound?

1) H_2
2) CH_4
3) CH_3OH
4) NH_4Cl

____ 12. Which Lewis electron-dot diagram correctly represents a hydroxide ion?

1) 
3) 
2) 
4) 

13. Which type of bond results when one or more valence electrons are transferred from one atom to another?

1) a hydrogen bond
2) an ionic bond
3) a nonpolar covalent bond
4) a polar covalent bond

14. Based on bond type, which compound has the highest melting point?

1) CH_3OH
2) C_6H_{14}
3) $CaCl_2$
4) CCl_4

15. Which substance is an electrolyte?

1) CH_3OH
2) $C_6H_{12}O_6$
3) H_2O
4) KOH

16. A solid substance was tested in the laboratory. The test results are listed below.
• dissolves in water
• is an electrolyte
• melts at a high temperature

Based on these results, the solid substance could be

1) Cu
2) $CuBr_2$
3) C
4) $C_6H_{12}O_6$

17. Which compound has both ionic and covalent bonding?

1) $CaCO_3$
2) CH_2C1_2
3) CH_3OH
4) $C_6H_{12}O_6$

18. Which element is composed of molecules that each contain a multiple covalent bond?

1) chlorine
2) fluorine
3) hydrogen
4) nitrogen

19. As a bond between a hydrogen atom and a sulfur atom is formed, electrons are

1) shared to form an ionic bond
2) shared to form a covalent bond
3) transferred to form an ionic bond
4) transferred to form a covalent bond

20. What is the total number of electrons shared in the bonds between the two carbon atoms in a the molecule shown below?

H—C≡C—H

1) 6 2) 2 3) 3 4) 8

21. Which formula represents a molecular compound?

1) Kr
2) LiOH
3) N_2O_4
4) NaI

22. In which material are the particles arranged in a regular geometric pattern?

1) $CO_2(g)$
2) NaCl(aq)
3) $H_2O(\ell)$
4) $C_{12}H_{22}O_{11}(s)$

23. What is the maximum number of covalent bonds that a carbon atom can form?

1) 1 2) 2 3) 3 4) 4

24. Which type of bond is found between atoms of solid cobalt?

1) nonpolar covalent
2) polar covalent
3) metallic
4) ionic

25. A solid substance is an excellent conductor of electricity. The chemical bonds in this substance are most likely

1) ionic, because the valence electrons are shared between atoms
2) ionic, because the valence electrons are mobile
3) metallic, because the valence electrons are stationary
4) metallic, because the valence electrons are mobile

26. Which substance contains metallic bonds?

1) $Hg(\ell)$
2) $H_2O(\ell)$
3) NaCl(s)
4) $C_6H_{12}O_6(s)$

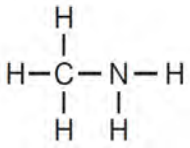
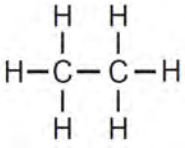
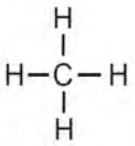
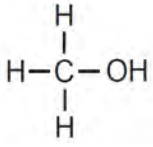
___ 27. A chemist performs the same tests on two homogeneous white crystalline solids, *A* and *B*. The results are shown in the table below.

	Solid A	Solid B
Melting Point	High, 801°C	Low, decomposes at 186°C
Solubility in H_2O (grams per 100.0 g H_2O at 0°C)	35.7	3.2
Electrical Conductivity (in aqueous solution)	Good conductor	Nonconductor

The results of these tests suggest that

1) both solids contain only ionic bonds
2) both solids contain only covalent bonds
3) solid *A* contains only covalent bonds and solid *B* contains only ionic bonds
4) solid *A* contains only ionic bonds and solid *B* contains only covalent bonds

___ 28. Which formula represents a molecule having a nonpolar covalent bond?

1) 
3) 
2) 
4) 

___ 29. The chemical bond between which two atoms is most polar?

1) C–N
2) H–H
3) S–Cl
4) Si–O

___ 30. Which compound has hydrogen bonding between its molecules?

1) CH_4
2) CaH_2
3) KH
4) NH_3

___ 31. Which formula represents a nonpolar molecule containing polar covalent bonds?

1) H_2O
2) CCl_4
3) NH_3
4) H_2

___ 32. Which formula represents a polar molecule?

1) H_2
2) H_2O
3) CO_2
4) CCL_4

___ 33. Which formula represents a nonpolar molecule?

1) HCl
2) H_2O
3) NH_3
4) CH_4

___ 34. At STP, fluorine is a gas and bromine is a liquid because, compared to fluorine, bromine has

1) stronger covalent bonds
2) stronger intermolecular forces
3) weaker covalent bonds
4) weaker intermolecular forces

___ 35. The four single bonds of a carbon atom in CH_4 are directed toward the corners of a

1) square
2) tetrahedron
3) rectangle
4) parallelogram

Base your answers to questions **36** and **37** on the information below.

Physical Properties of CF_4 and NH_3 at Standard Pressure

Compound	Melting Point (°C)	Boiling Point (°C)	Solubility in Water at 20.0°C
CF_4	−183.6	−127.8	insoluble
NH_3	−77.7	−33.3	soluble

____ 36. In the space *in your answer booklet*, draw a Lewis electron-dot diagram for CF_4.

____ 37. State evidence that indicates NH_3 has stronger intermolecular forces than CF_4.

Base your answers to questions **38** and **39** on the information below.

In 1864, the Solvay process was developed to make soda ash. One step in the process is represented by the balanced equation below.

$$NaCl + NH_3 + CO_2 + H2O \rightarrow NaHCO_3 + NH_4Cl$$

____ 38. In the space draw a Lewis electron-dot diagram for the reactant containing nitrogen in the equation.

____ 39. Explain, in terms of electronegativity difference, why the bond between hydrogen and oxygen in a water molecule is more polar than the bond between hydrogen and nitrogen in an ammonia molecule.

40. Draw a Lewis electron-dot diagram for a molecule of phosphorus trichloride, PCl_3