Drawing Lewis Structures

1. Add up all of the valence electrons for the atoms involved in bonding

2. Write the symbols for the elements and show connectivity with single bonds (2 electrons shared).
   a. The central atom is typically the one there is only one of or the fewest of.
   b. If there is one of several atoms, they will usually be written in order.
   c. H is always terminal

3. Complete the octet for the atoms bonded to the central atom (NOT FOR HYDROGEN).

4. Place the leftover electrons on the central atom.

5. If octet is not satisfied on the central atom then form double or triple bonds as needed.

NOTE: We will only be concerned with molecules that follow the octet rule. We will not worry about exceptions to the rule. Some exceptions are discussed in your book in section 5.2.

Molecular Shape (Geometry)

VSEPR Theory: The repulsions between electrons will result in the placement of electron pairs (bonding or lone pairs) as far apart as possible in 3-D space. This causes molecules to take on very predictable shapes.

TABLE 5.1 Molecular Geometry Around Atoms with 2, 3, and 4 Charge Clouds

NUMBER OF BONDS	NUMBER OF LONE PAIRS	TOTAL NUMBER OF CHARGE CLOUDS	MOLECULAR GEOMETRY	EXAMPLE
2	0	2	Linear	O=C=O
3	0	3	Planar triangular	H, H, C=O
2	1		Bent	O, O, S
4	0	4	Tetrahedral	H, H, C, H, H
3	1		Pyramidal	H, H, N, H
2	2		Bent	H, H, O

Draw Lewis Structures and Predict Molecular Shapes

1. NH_3

2. H_2O

3. $CHCl_3$

4. CO_2

5. HCN

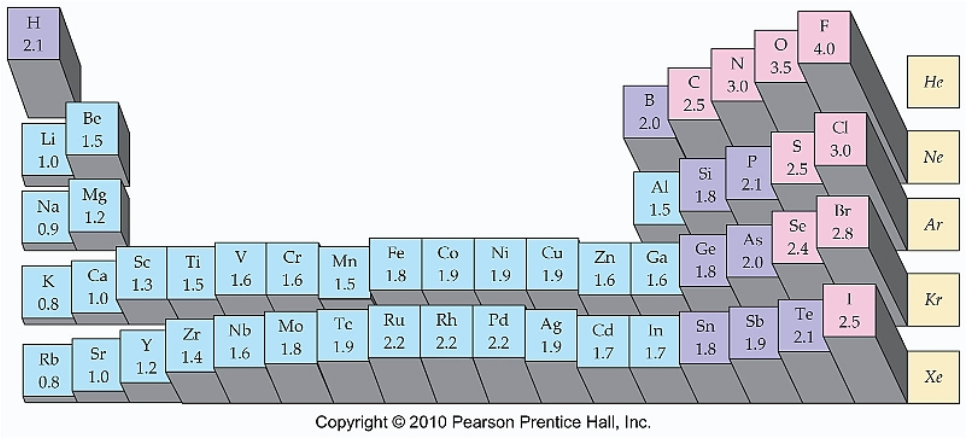
Polar Bonds

- Electronegativity refers to an atoms ability to pull electrons that are shared in a covalent bond to itself.

- Bonds are either nonpolar covalent, polar covalent or ionic.
  - Nonpolar covalent bonds occur when the two atoms sharing electrons share evenly. This occurs when the two atoms have similar electronegativity values. So long as the difference in electronegativity is less than 0.5 we will consider the bond to be nonpolar.

  - Polar covalent bonds occur when the two atoms sharing electrons share unevenly. This occurs when one atom has a much higher electronegativity than the other. We will consider electronegativity differences of 0.5-1.9 to be polar covalent.

  - Ionic bonds occur when electrons are transferred from one atom to another to form ions. This occurs when the electronegativity values of the two atoms are drastically different, as is usually the case when metals react with nonmetals. We will consider an electronegativity difference of 2.0 or greater to be ionic.



Polar Molecules

Just because a molecule contains polar bonds does not mean that the overall molecule is polar. To determine if the molecule is polar we must consider the shape/geometry of the molecule.

a. If a molecule contains no polar bonds than the molecule is nonpolar.

b. If a molecule contains polar bonds that are equal and opposite in direction, than those polar bonds cancel out and the molecule is nonpolar.

c. If a molecule contains polar bonds that are not equal and opposite in direction, than those polar bonds do not cancel out and the molecule is polar.

Examples:

1. CO_2

2. H_2O

3. $CHCl_3$

4. NH_3

5. CH_4

Intermolecular Forces of Attraction

Ideal gases have no attractive forces. Real gases will exhibit very weak attractive forces.

Liquids and solids have significant attractive forces for one another. Whether the attractions are strong or weak depends on the type of attraction and the size of the molecules involved.

Intermolecular forces of attraction refers to the forces of attraction that exist between molecules. Ionic compounds do not have intermolecular forces of attraction because they are not made up of molecules.

Ionic compounds have electrostatic forces: Strong attractive forces between oppositely charged ions.

Molecular compounds have intermolecular forces of attraction:

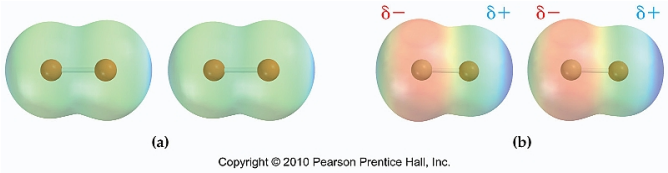
1) **London Dispersion Forces:** Weakest attractive force between the electrons of one molecule, ion or atom and the nuclei of another molecule, ion, or atom.

2) **Dipolar Forces (dipole-dipole):** Attractive forces between the partial positive charge of one dipole and the partial negative charge of another dipole.

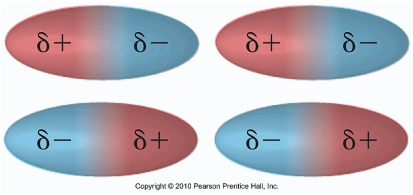
3) **Hydrogen bonding:** Special type of dipolar attractive force that exists between a hydrogen atom and two highly EN atoms (usually F, N or O). Hydrogen bonding is not a covalent bond!

IFAs

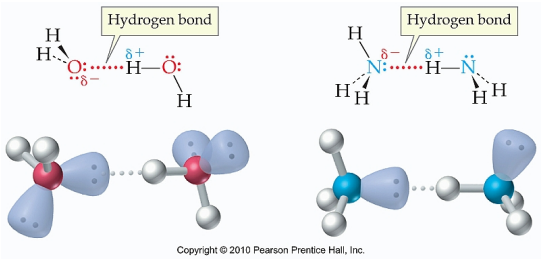
- **London Dispersion Forces:** Weakest attractive force that result from instantaneous dipoles forming in nonpolar molecules. The larger the molecules size, the more polarized it may become, thus increasing the strength of the LDF.



- **Dipolar Forces (ion-dipole, dipole-dipole):** Attractive forces between the partial positive charge of one dipole and the partial negative charge of another dipole.



- **a**
- **H-bonding Forces:** Special type of dipolar attractive force that exists between a hydrogen atom and two highly EN atoms (usually F, N or O). a



Predicting IFAs

Problems:

For the following, draw the Lewis structure, predict the molecular geometry, indicate partial positive and negative charge build-up (if any), and tell if the molecule is polar or nonpolar. Finally, predict the type of IFAs that would exist in a sample of each pure substance.

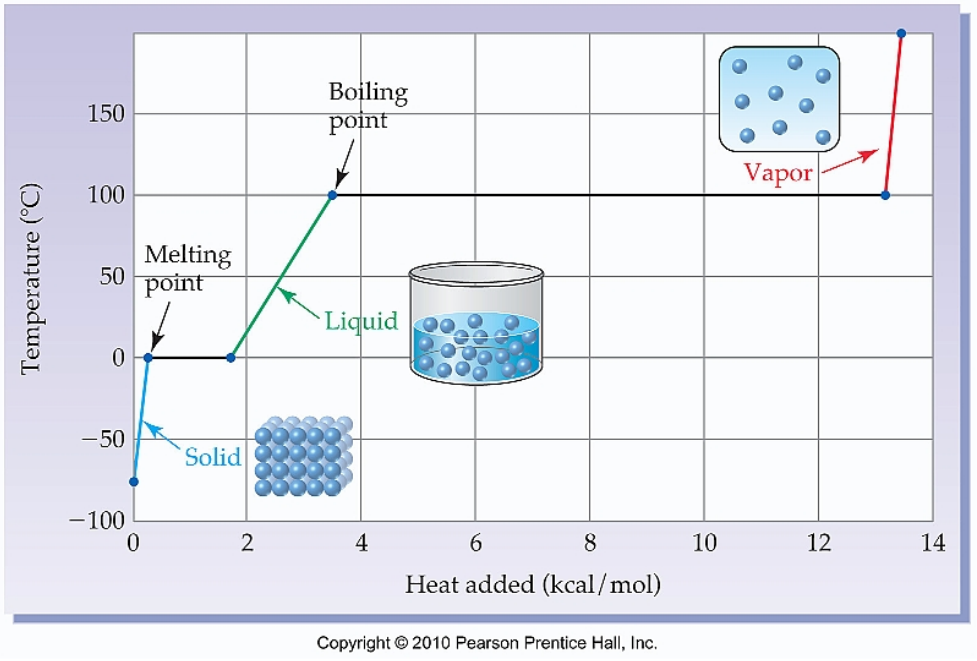
1. CF_4

2. F_2

3. $CH_3CH_2CH_2CH_2OH$

Arrange the three substances from highest to lowest boiling and melting point.

Change of State

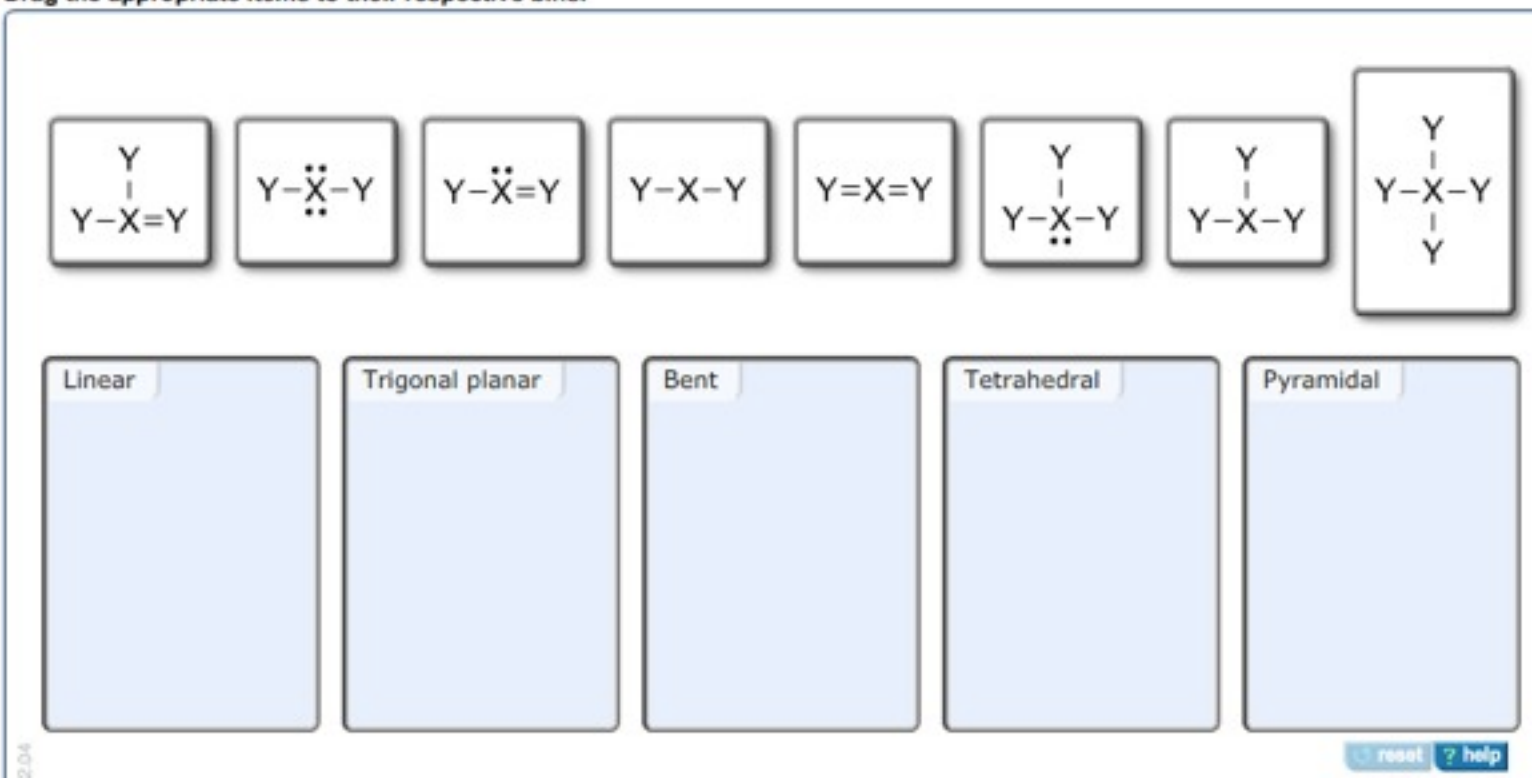


Classify these molecules as polar or nonpolar.

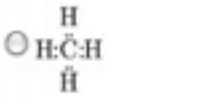
HF, BCl_3, H_2O, CH_3Cl, CCl_4, H_2

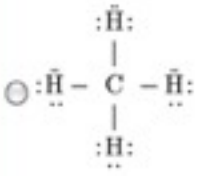
If the sulfur dichloride molecule, SCl_2 , were to form, what would its structure look like?

Drag the appropriate items to their respective bins.

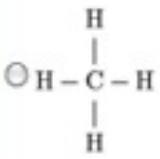


Which representation of a methane molecule is **not** correct? (A methane molecule is composed of one carbon atom and four hydrogen atoms.)





CH_4



none of the above

A chemical bond formed when two atoms share six electrons is a _____ bond; it is best described as _____.
single; ionic
single; covalent
double; covalent
triple; covalent
double; ionic

In forming covalent bonds where the octet rule is obeyed, sulfur usually forms _____ bonds and chlorine usually forms _____ bonds.
six; seven
two; two
two; one
one; one
one; two

The total number of valence electrons in a molecule of SOF_2 is
20
24
18
26
22

A molecule in which the central atom has no lone pairs and forms four single bonds is said to have a _____ shape.
planar
linear
bent
tetrahedral
pyramidal

A molecule in which the central atom forms three single bonds and has one lone pair is said to have a _____ shape.
pyramidal
bent
planar
tetrahedral
linear

A molecule in which the central atom forms one double bond and two single bonds is said to have a _____ shape.
tetrahedral
bent
trigonal planar
pyramidal
linear

What is the molecular geometry of PH3?
tetrahedral
bent
trigonal pyramidal
trigonal planar
linear

According to VSEPR theory, a molecule with three charge clouds including one lone pair would have a _____ shape.
bent
trigonal planar t
linear
tetrahedral
pyramidal

Which element listed is the least electronegative?
nitrogen
fluorine
oxygen
hydrogen
chlorine

Which element listed is the most electronegative?
sodium
bromine
iodine
chlorine
aluminum

A bond where the electrons are shared equally is called a(n) _____ bond.
non-polar covalent
ionic
polar covalent
coordinate covalent
none of the above

A bond where the electrons are shared unequally is called a(n) _____ bond.
ionic
non-polar covalent
coordinate covalent
polar covalent
none of the above

Consider the molecule $SiCl_4$. The electronegativity values for Si and Cl are 1.8 and 3.0, respectively. Based on these values and on consideration of molecular geometry, the Si-Cl bond is _____ and the molecule is _____.

polar; polar
non-polar; polar
polar; non-polar
non-polar; non-polar
none of the above

The carbon dioxide molecule is linear. The electronegativities of C and O are 2.5 and 3.5, respectively. Based on these values and on consideration of molecular geometry, the C-O bond is _____ and the molecule is _____.

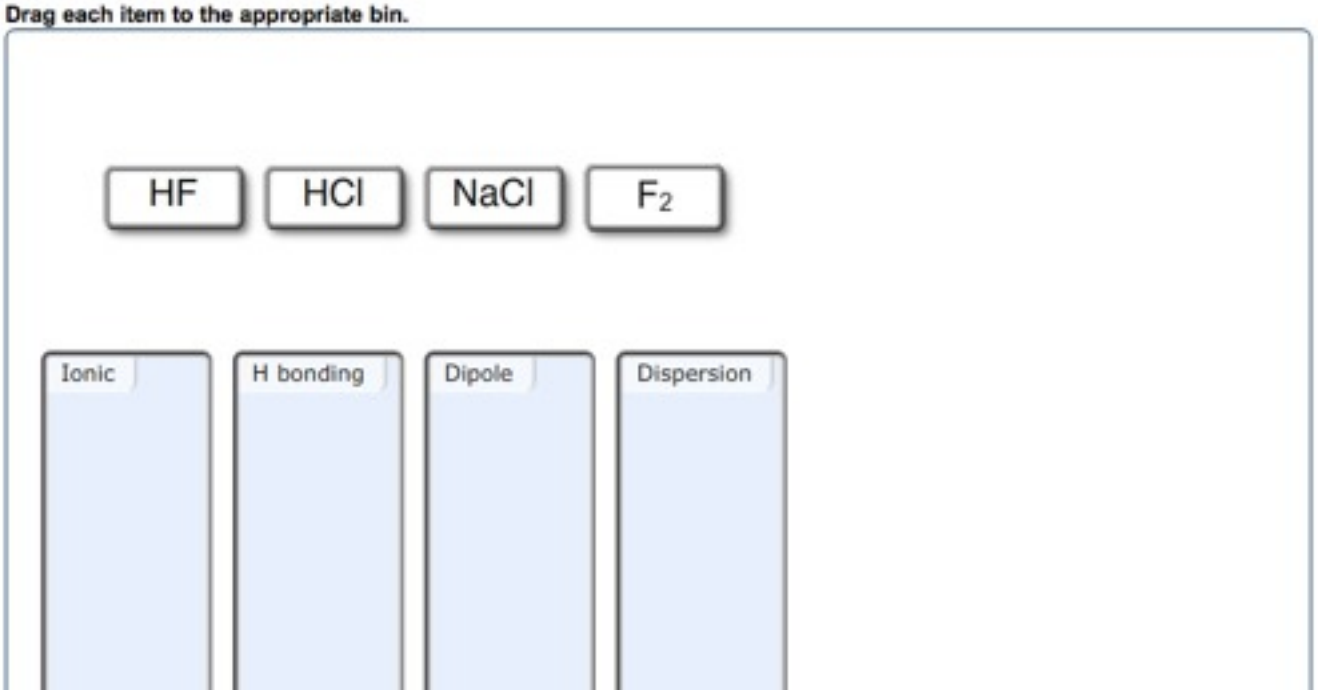
non-polar; polar
non-polar; non-polar
polar; non-polar
polar; polar
none of the above

How many double bonds are there in a molecule of SF2?

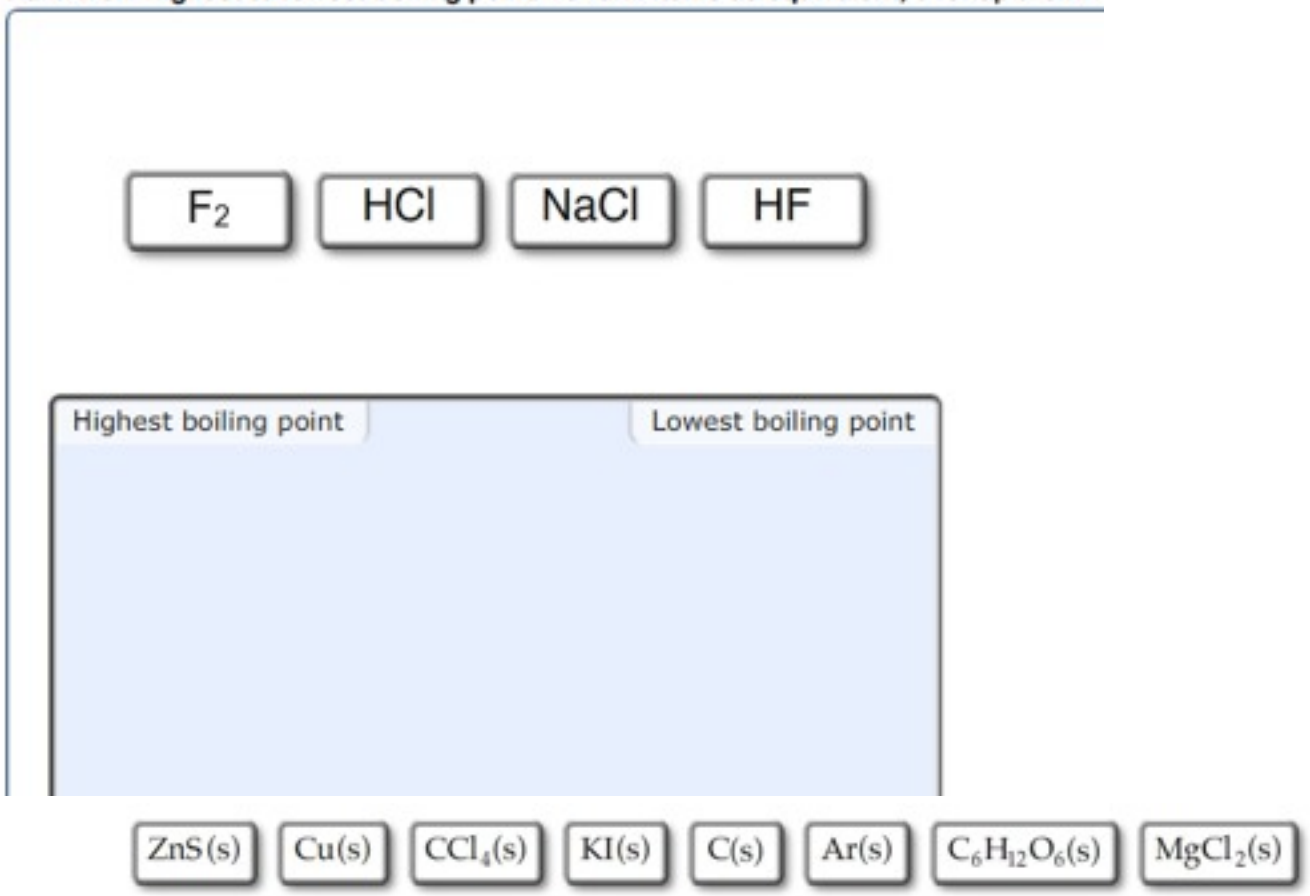
0
1
2
3
4

The four major attractive forces between particles are ionic bonds, dipole-dipole attractions, hydrogen bonds, and dispersion forces. Consider the compounds below, and classify each by its predominant attractive or intermolecular force among atoms or molecules of the same type.

Drag each item to the appropriate bin.



Rank from highest to lowest boiling point. To rank items as equivalent, overlap them.



Which molecule will undergo only London dispersion forces when interacting with other molecules of the same kind?

C_2H_5OH
CH_2Cl_2
HF
$NaC_2H_3O_2$
C_4H_{10}

Which intermolecular force is characteristic of compounds with low molar mass, which are liquids at room temperature and have relatively high boiling points?

covalent bonds
ionic bonds
dipole-dipole forces
hydrogen bonds
london forces

Which is the best description of hydrogen bonding?

The polarity associated with a bond between hydrogen and a small electronegative atom to which it is bonded
The unique chemical bonds between hydrogen and any other atom in the same molecule
The temporary attraction between hydrogen atoms on different molecules resulting from shifts in electron density
The association between hydrogen of one molecule and a region of another molecule which has become negative due to temporary shifts in electron density
The association between a hydrogen atom which is somewhat positive because it is bonded to a small electronegative atom and an atom of O, N or F on another molecule

Which of the following cannot have hydrogen bonds?

CH_3NH_2
H_2O
NH_3
HF
HCl