Chapter 6 Goals

Major Goals of Chapter 6:

1. Identify the difference between ionic (CH5) & covalent (CH6) substances.
2. Learn the rules for naming covalent substances using prefixes and —ide endings.
3. Learn and apply the rules for drawing correct Lewis dot structures.
4. Apply the concept of electronegativity in identifying bond dipoles.
5. Apply VSEPR theory to determine the shapes of ideal and nonideal geometries.
6. Determine whether a molecule is polar or nonpolar from its geometry.

Before viewing this powerpoint, read the Chapter 6 Review:

6.1 Names & Formulas of Covalent Compounds

6.2 Covalent Bonds & Electron-Dot Formulas

6.3 Multiple Covalent Bonds & Resonance

6.4. Shapes of Molecules & Ions (VSEPR Theory)

6.5 Polarity Molecules

Section 6.1- Names & Formulas of Covalent Compounds

1) Unlike ionic salts, covalent compounds need prefixes in their name
2) Covalent compounds consist of nonmetals (e.g., F O N Cl Br I S C H)

Covalent Compounds

nonmetals-nonmetals

X–X

Use of prefixes

use prefix to indicate the number of <u>nonmetal</u> atoms

1 mono
2 di
3 tri
4 tetra
5 penta
6 hexa
7 hepta
8 octa
9 nona
10 deca

use suffix -ide for ending of the last element in the formula

Covalent Compounds

Covalent Compounds
nonmetals–nonmetals
X—X

Use of prefixes

use prefix to indicate the number of nonmetal atoms

1 mono
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5 penta
6 hexa
7 hepta
8 octa
9 nona
10 deca

use suffix -ide for ending of the last element in the formula

CO_2

carbon dioxide

H_2S

dihydrogen sulfide (g)

as an acid in aqueous solution

hydrosulfuric acid (aq)

C_4H_8

tetracarbon octahydride

S_2Br_6

disulfur hexabromide

Covalent Compounds

Covalent Compounds
nonmetals–nonmetals
X–X

Use of prefixes

use prefix to indicate the number of nonmetal atoms

1 mono
2 di
3 tri
4 tetra
5 penta
6 hexa
7 hepta
8 octa
9 nona
10 deca

use suffix -ide for ending of the last element in the formula

SO_2
sulfur dioxide
(smog)

N_2O
dinitrogen oxide
better known as
nitrous oxide
laughing gas

P_2O_5
diphosphorus pentaoxide

P_5O_{10}
pentaphosphorus decaoxide

Covalent Compounds

Covalent Compounds
nonmetals-nonmetals
X—X

Use of prefixes

use prefix to indicate the number of <u>nonmetal</u> atoms

1 mono
2 di
3 tri
4 tetra
5 penta
6 hexa
7 hepta
8 octa
9 nona
10 deca

use suffix -ide for ending of the last element in the formula

NI_3
nitrogen triiodide

N_2O_4
dinitrogen tetraoxide

PF_5
phosphorus pentafluoride

As_3O_7
triarsenic heptaoxide

Acids

$HClO_4$ > H_2SO_4 > HCl > HNO_3 >> H_3PO_4 > $HC_2H_3O_2$

as a pure compound
hydrogen listed first

Acids
hydrogen-nonmetals
H–X

Acids named as a pure compound

acid as a gas
name using
covalent rules

hydrogen perchlorate
dihydrogen sulfate
hydrogen chloride
hydrogen nitrate
trihydrogen phosphate
hydrogen acetate

use prefix to indicate the number of hydrogens

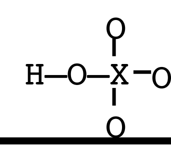
1 mono
2 di
3 tri
4 tetra
5 penta
6 hexa
7 hepta
8 octa
9 nona
10 deca

aqueous solution
acid dissolved in H_2O

aqueous acids
suffix name change

suffix -ate changes to –ic

oxy acids



hydrohalic acids
atomic acids

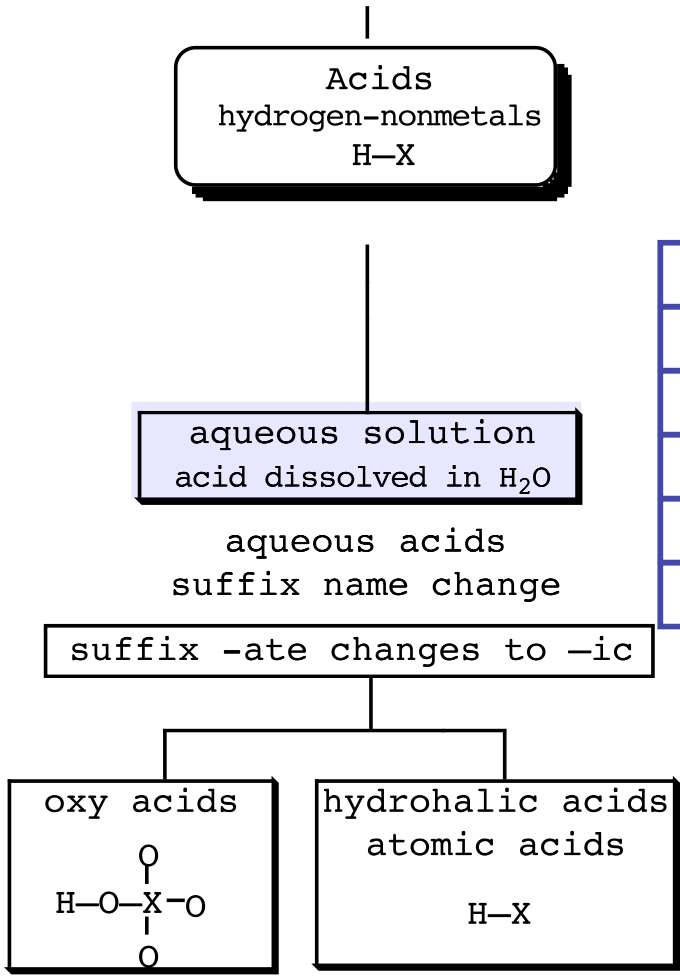
H–X

Please Note: An acid has hydrogen listed first in its chemical formula.

Acids

$HClO_4$ > H_2SO_4 > HCl > HNO_3 >> H_3PO_4 > $HC_2H_3O_2$

as an aqueous solution

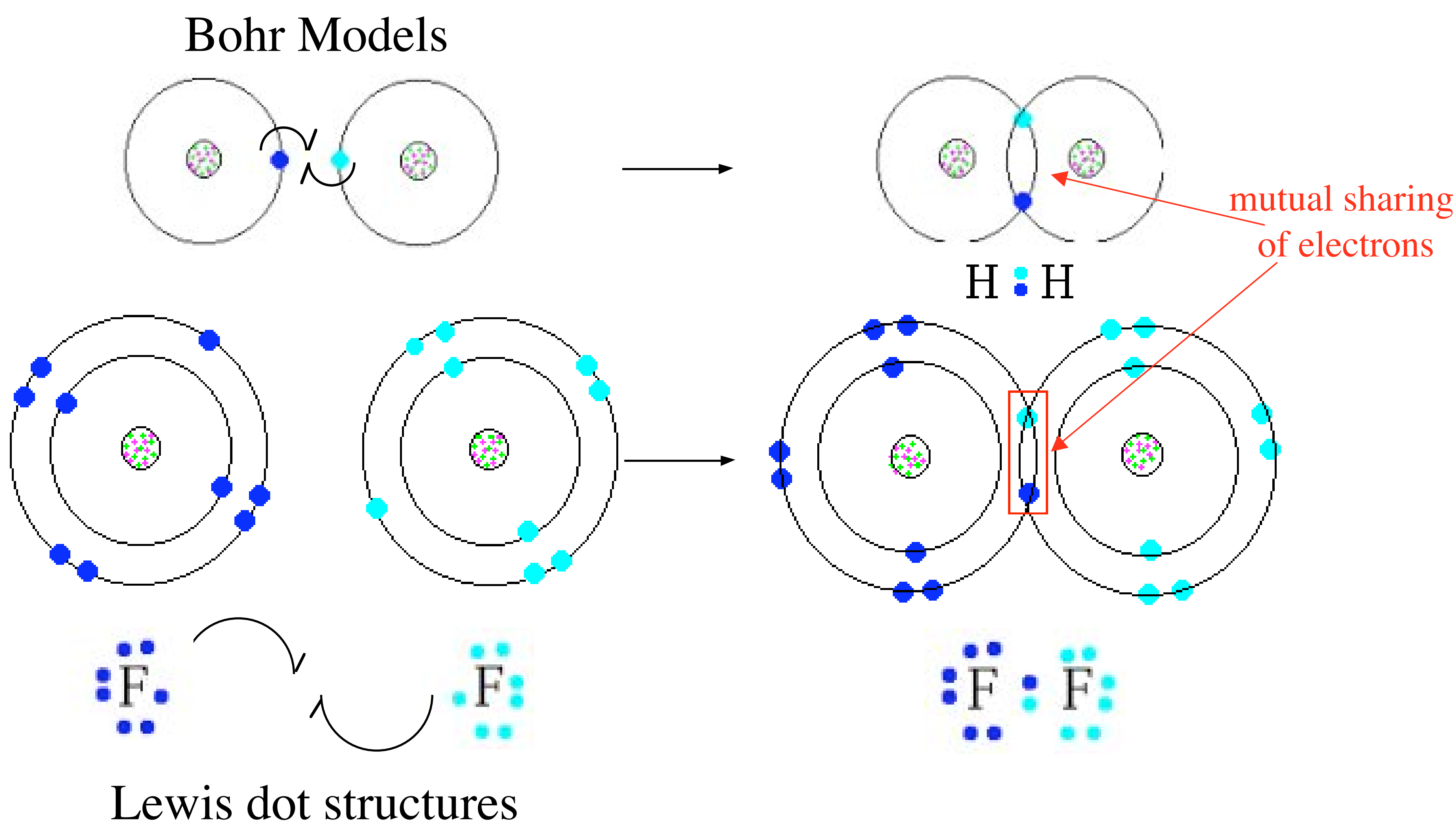


Acids named as a pure compound	Acids named as an aqueous solution
hydrogen perchlorate	perchloric acid
dihydrogen sulfate	sulfuric acid
hydrogen chloride	hydrochloric acid
hydrogen nitrate	nitric acid
trihydrogen phosphate	phosphoric acid
hydrogen acetate	acetic acid

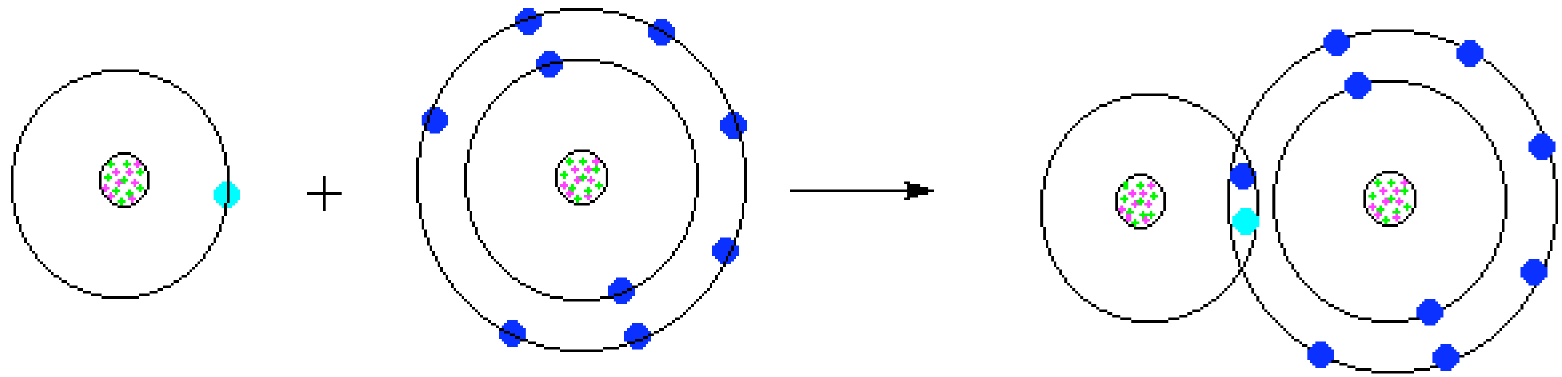
Note: An acid dissolved in water (aqueous) has a new but familiar name.

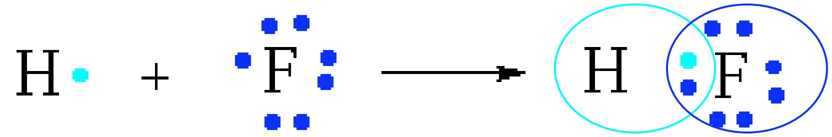
Section 6.2 - Covalent Bonds & Electron-Dot Formulas

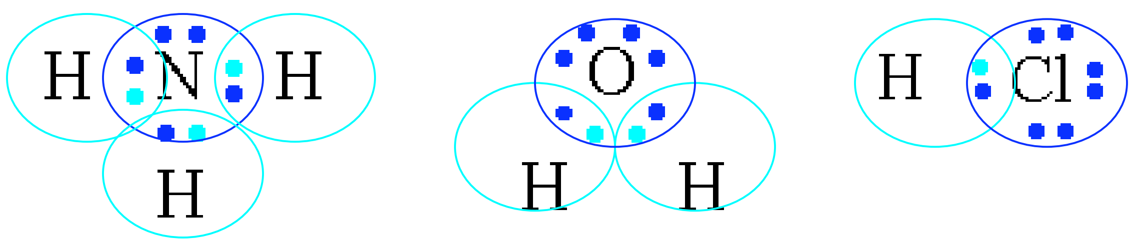
1) Unlike ionic salts, covalent compounds share electrons between atoms to achieve extra stability associated with 8 valence electrons.
2) Covalent compounds consist of nonmetals (e.g., F O N Cl Br I S C H)



Section 6.2 - Covalent Bonds & Electron-Dot Formulas

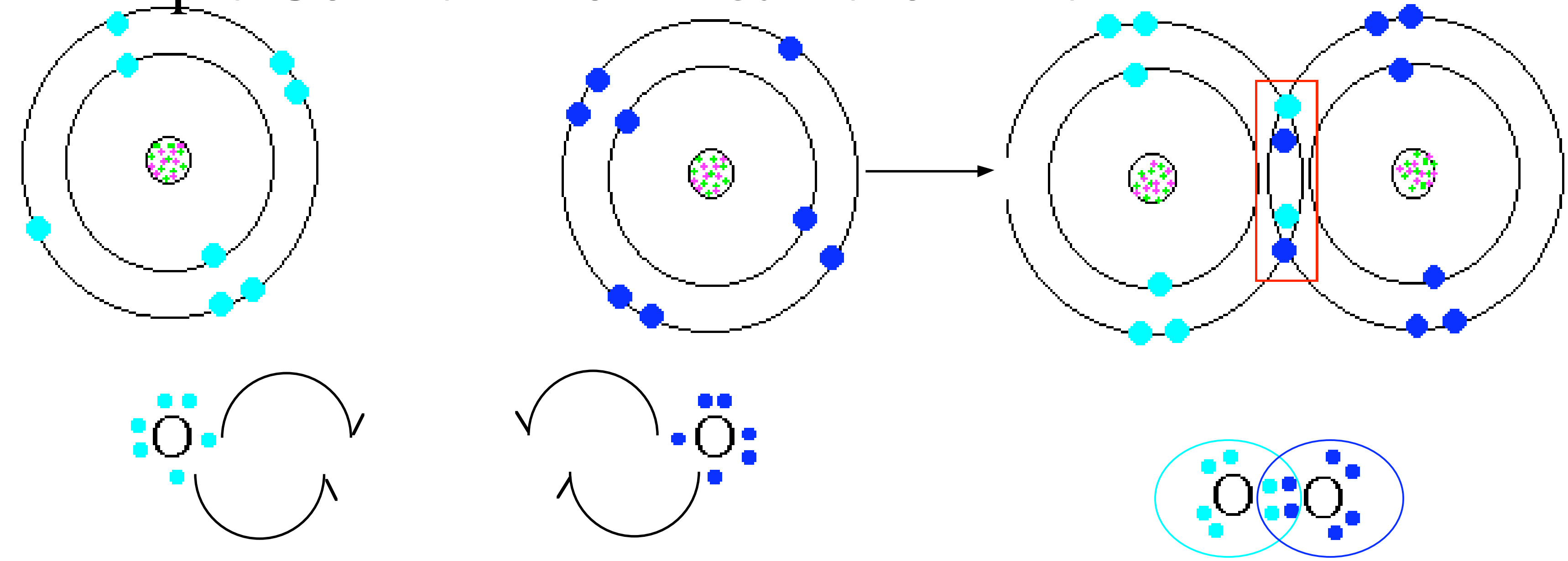


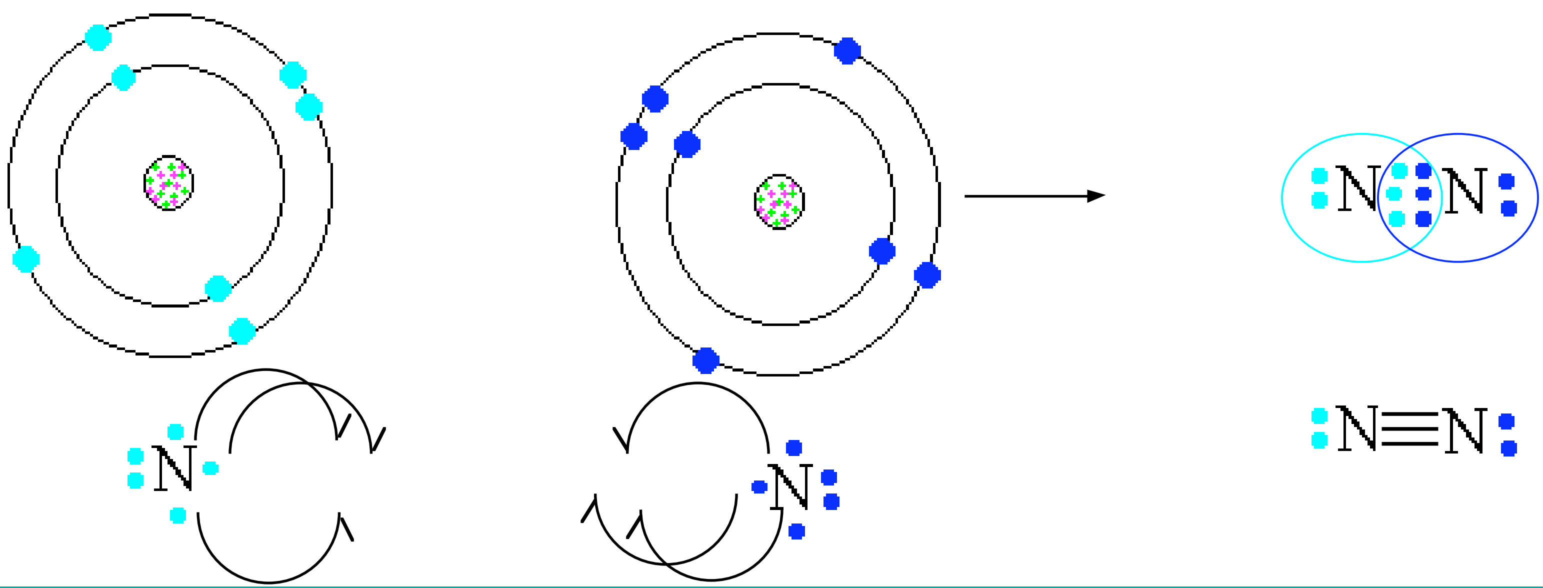




Note: Hydrogen wants a duet and the other nonmetals want an “octet.”

6.3 Multiple Covalent Bonds & Resonance

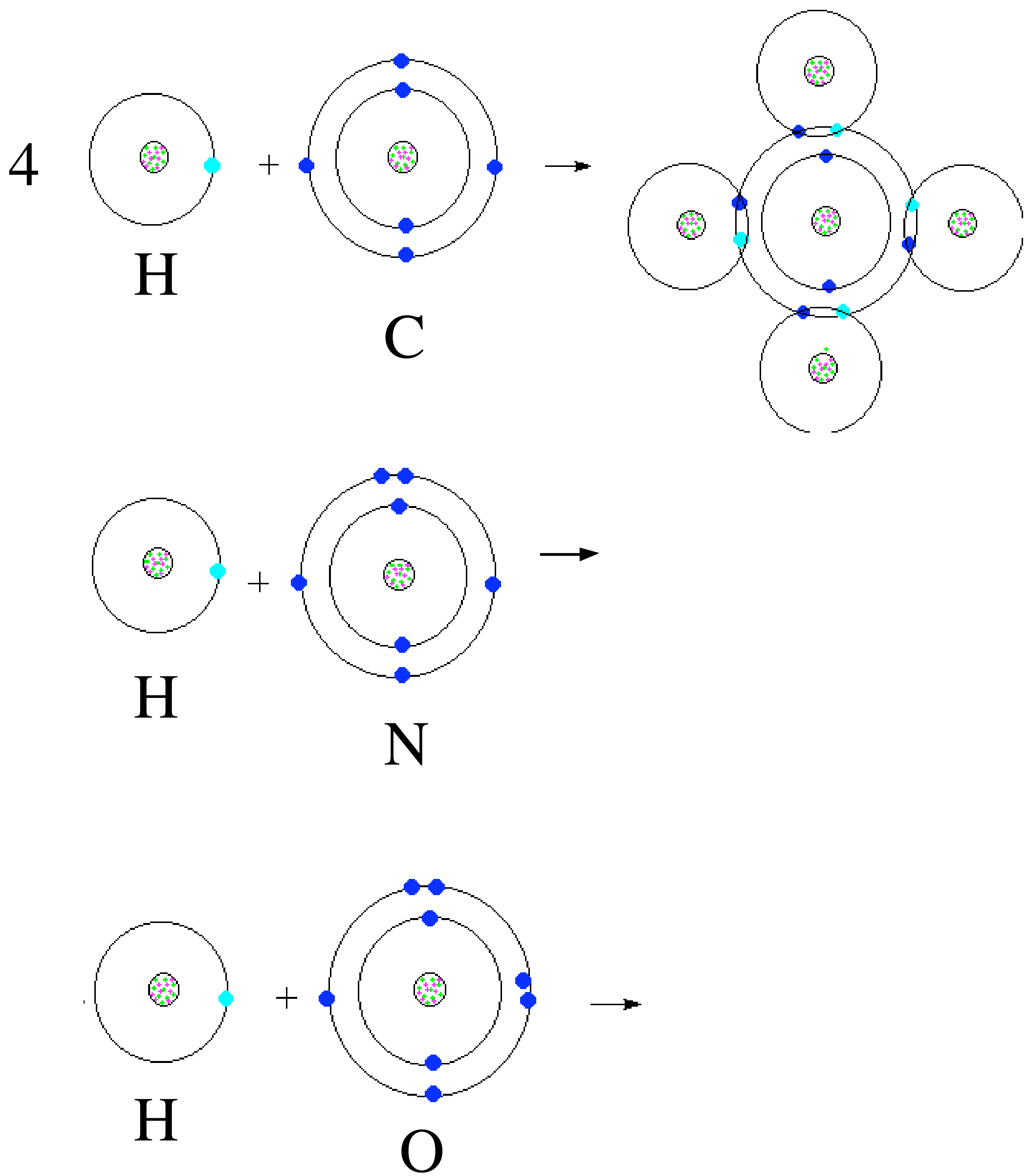




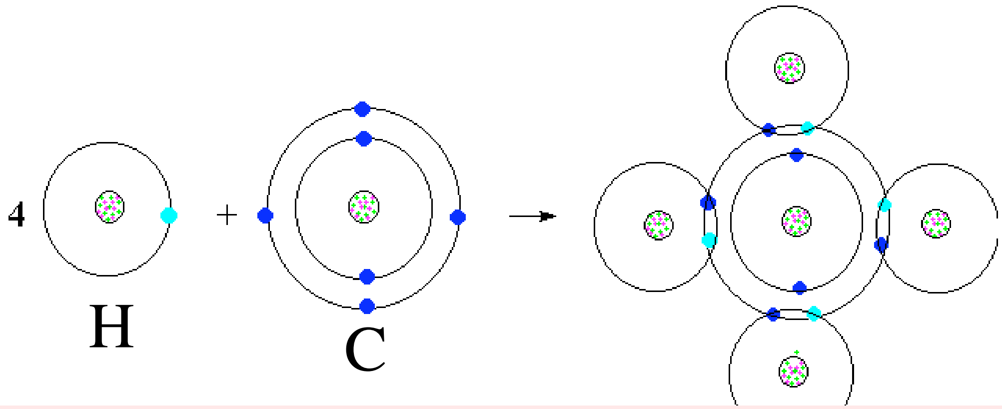
Note: resonance means the movement of electrons

Please identify the atoms represented by each Bohr model

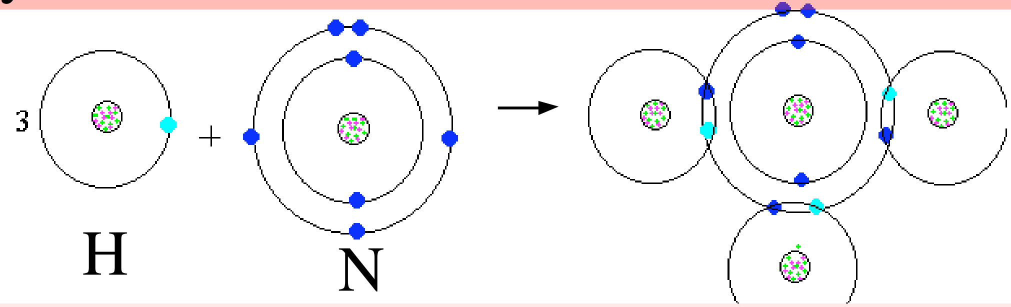
Carbon will bond to how many hydrogens in order to achieve an “<u>octet</u>?”



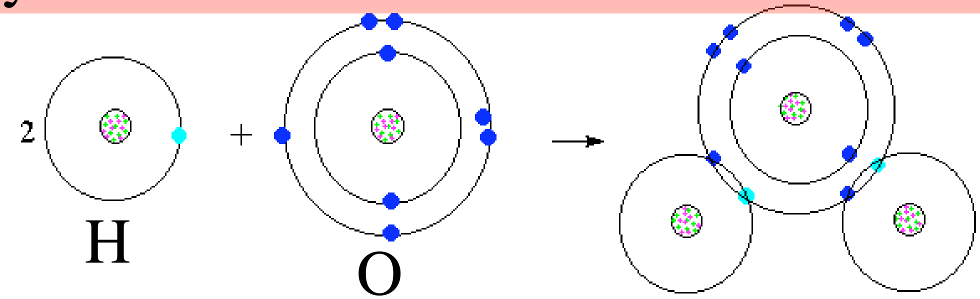
Carbon in group four always wants to make four bonds.



Nitrogen in group five wants to bond to three hydrogens; nitrogen gains extra stability associated with 8 valence electrons in its outermost shell.



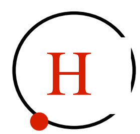
Oxygen in group six wants to bond to two hydrogens; oxygen gains extra stability associated with 8 valence electrons in its outermost shell.

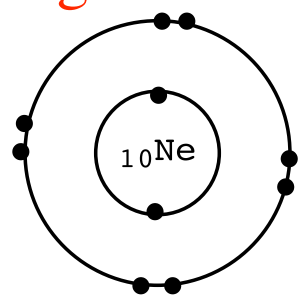


Please note the addition of the red colored valence (outermost) electron by the incoming hydrogen atom which will be shared by both atoms.

Covalent Bonding (sharing electrons to achieve noble gas electron configuration)

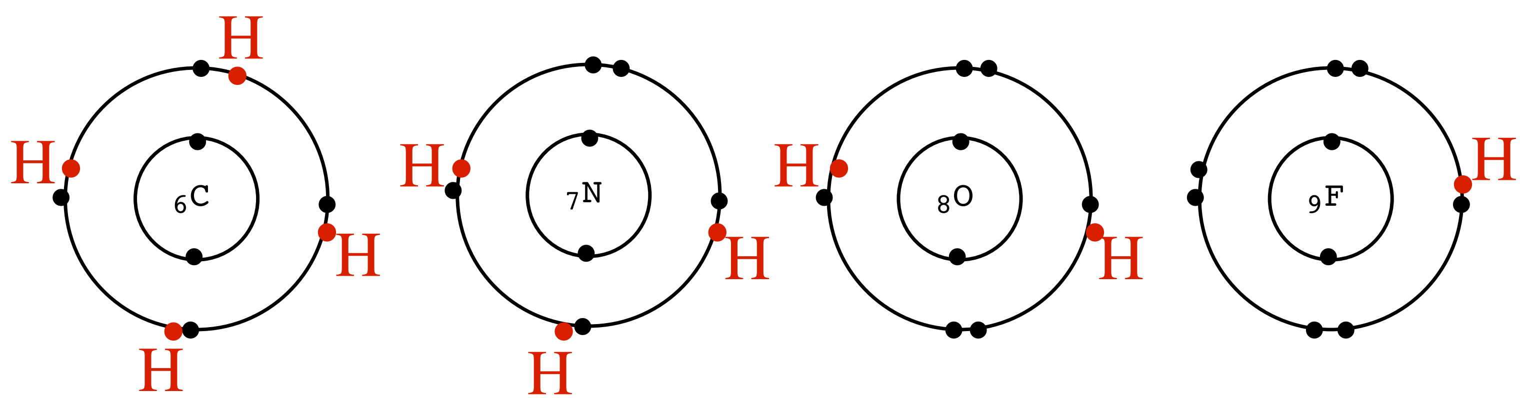
nonmetals bond to hydrogen to achieve noble gas e- configuration of the noble gas in their period (row)





Addition of hydrogen

Achieving an OCTET valence



CH_4 methane gas

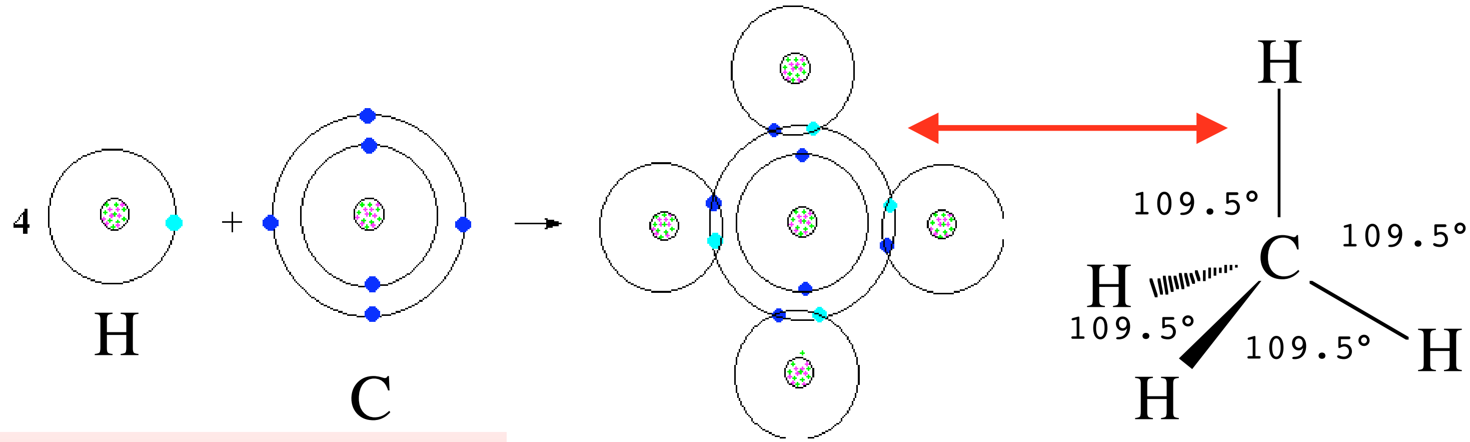
NH_3 ammonia gas

H_2O water

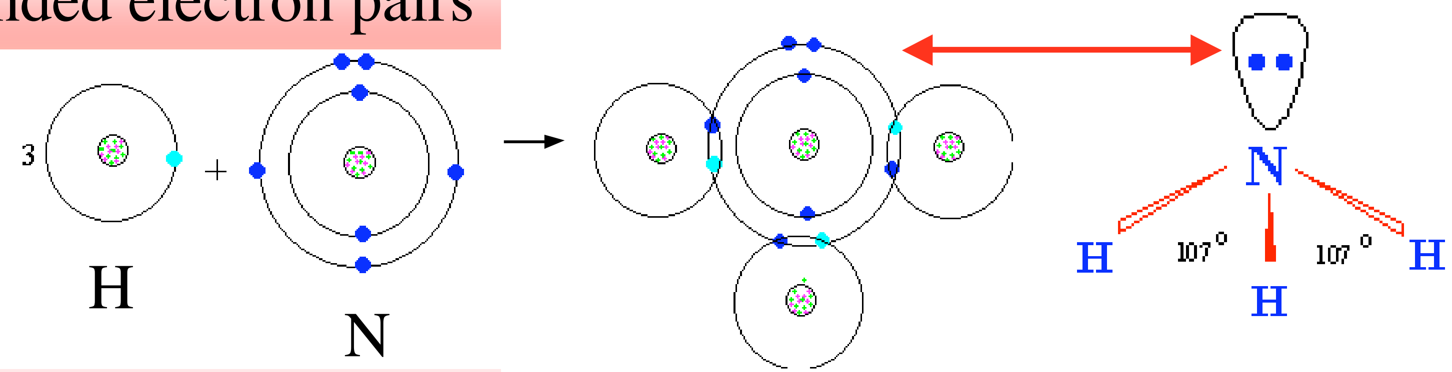
HF hydrogen fluoride

molecules of nonmetals hydrides

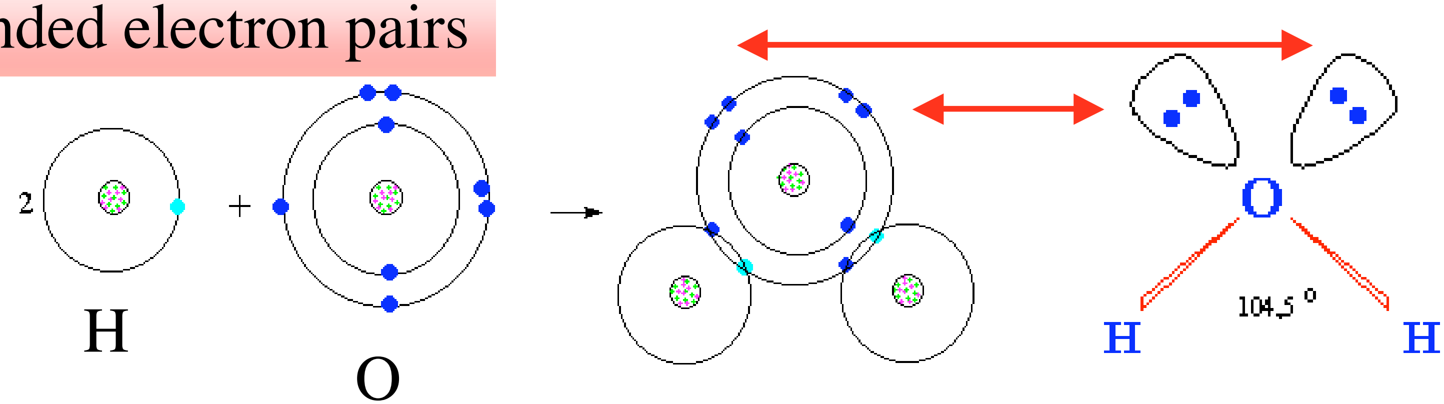
Please note a single bond (–) represents two electrons being covalently shared chemically between two nonmetal atoms



Note nonbonded electron pairs

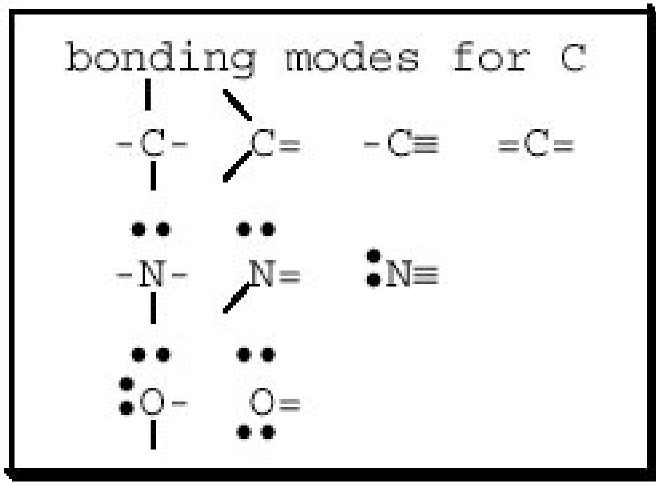


Note nonbonded electron pairs



6.3 Multiple Covalent Bonds & Resonance

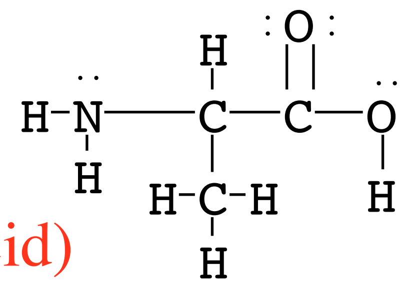
Organic Compounds
carbon-nonmetals
C–X



1. Carbon always will have four bonds to it.

For any organic molecule:

$C_3H_7NO_2$



alanine (an alpha amino acid)

a. nitrogen will have three bonds to it.

b. oxygen will have two bonds to it.

c. hydrogen will ALWAYS have one bond

Compare the above bonding modes to the observed bonding in alanine.

Organic molecules have carbon listed first in their chemical formulas

6.3 Multiple Covalent Bonds & Resonance

6.3 Multiple Covalent Bonds & Resonance

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Lewis Dot Structures

Dr.Gergens - SD Mesa College

Things to keep in mind when drawing Lewis structure

1. Always count valence electrons

2. Know the preferred number of bonds to these elements

C	N	O	F	H
4	3	2	1	1

3. N O , these elements may have a variable number of bonds

N	O
(2)	(1)
(4)	(3)

4. If the substance has hydrogen list first in its formula:
   a. the substance is characterized as an acid, and
   b. the H will be bound to oxygen in the substance's structure

5. Use, F O N Cl Br I S C H for determining bond polarity

6.3 Multiple Covalent Bonds & Resonance

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Here are the rules for drawing Lewis Dot structures.

1. Calculate the total number of valence electrons.
2. Assemble the bonding framework.
3. Connect the other atoms to the central by drawing a single line. Each line represents a single bond made up of two electrons being shared between two atoms.
4. Give the outer most atoms, EXCEPT for hydrogen, three sets of paired electrons.
5. Count valence electrons in your provisional structure. See if all valence electrons calculate in step 1 are present.
6. Add missing electrons to the central atom.
7. Apply the octet rule to check to see that each atom has eight electrons surrounding it.
8. Share neighboring electrons by moving electrons to satisfy the octet about each atom.
9. Place a bracket around ions, followed by ion charge.

CH_4

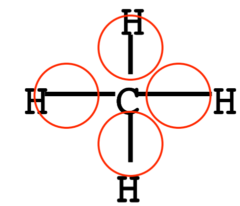
group #

1C • 4 = 4

4 H • 1 = 4

+ ______________

VE = 8



Done

Organic molecules have carbon listed first in their chemical formulas

6.3 Multiple Covalent Bonds & Resonance

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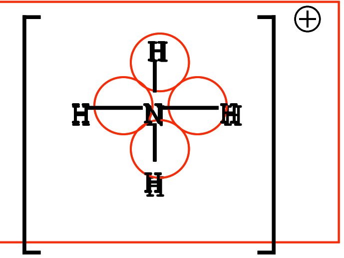
8. Share neighboring electrons by moving electrons to satisfy the octet about each atom.
9. Place a bracket around ions, followed by ion charge.

$NH_4^{\oplus}$

	group #		
1N	• 5	=	5
4 H	• 1	=	4
+ 1 ⊕		=	-1
	VE	=	8



Done

Note: the 1+ charge means you are "1 electron short;" <u>must subtract</u> 1.

6.3 Multiple Covalent Bonds & Resonance

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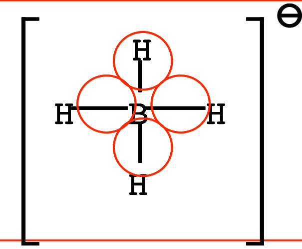
9. Place a bracket around ions, followed by ion charge.

$BH_3^{\ominus}$

group #

	1B • 3	=	3
	4 H • 1	=	4
+	1 ⊖	=	1
	VE	=	8



Done

Note: the 1- charge means you have "1 electron extra;" <u>must add</u> 1.

6.3 Multiple Covalent Bonds & Resonance

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3. Connect the other atoms to the central by drawing a single line Each line represents a single bond made up of two electrons being shared between two atoms.
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7. Apply the octet rule to check to see that each atom has eight electrons surrounding it.
8. Share neighboring electrons by moving electrons to satisfy the octet about each atom.
9. Place a bracket around ions, followed by ion charge.

CO_2

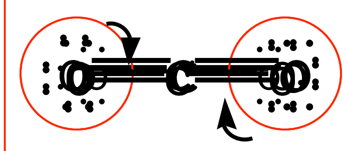
group #

$1C \cdot 4 = 4$

$2O \cdot 6 = 12$

+

$VE = 16$



Done

Note: Carbon <u>always</u> wants four bonds. Its neighboring O atoms will share with it their electrons.

6.3 Multiple Covalent Bonds & Resonance

1. Calculate the total number of valence electrons.
2. Assemble the bonding framework.
3. Connect the other atoms to the central by drawing a single line. Each line represents a single bond made up of two electrons being shared between two atoms.
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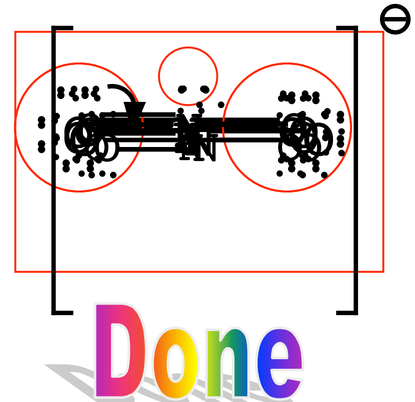
6. Add missing electrons to the central atom.
7. Apply the octet rule to check to see that each atom has eight electrons surrounding it.
8. Share neighboring electrons by moving electrons to satisfy the octet about each atom.
9. Place a bracket around ions, followed by ion charge.

$NO_2^{\ominus}$

	group #		
1 N	• 5	=	5
2 O	• 6	=	12
+ 1 e^-		=	1
	VE	=	18



Note: Neighboring nonmetal atoms are willing to share their electrons so that every atom will achieve a full-octet.

Section 6.4 Shapes of Molecules & Ions (VSEPR Theory)

The shape of a molecule is determined from its Lewis dot structure and the arrangement of all atoms and nonbonded electrons pairs around each atom.

Valence Shell Electron Pair Repulsions means that

1) The theory only considers valence electrons in the outermost (valence) shell in a Lewis Dot structure.
2) Electrons like to pair up and repel.
3) Electrons are negatively charge. Electron pairs and atoms move as far away from each other as possible to achieve a geometry where there is the least amount of unfavorable repulsion between electrons & atoms.
4) VSEPR is an empirical theory based purely on common sense. Another empirical theory is, “All birds have feathers, thus all animals with feathers must be birds.”

Section 6.4 Shapes of Molecules & Ions (VSEPR Theory)

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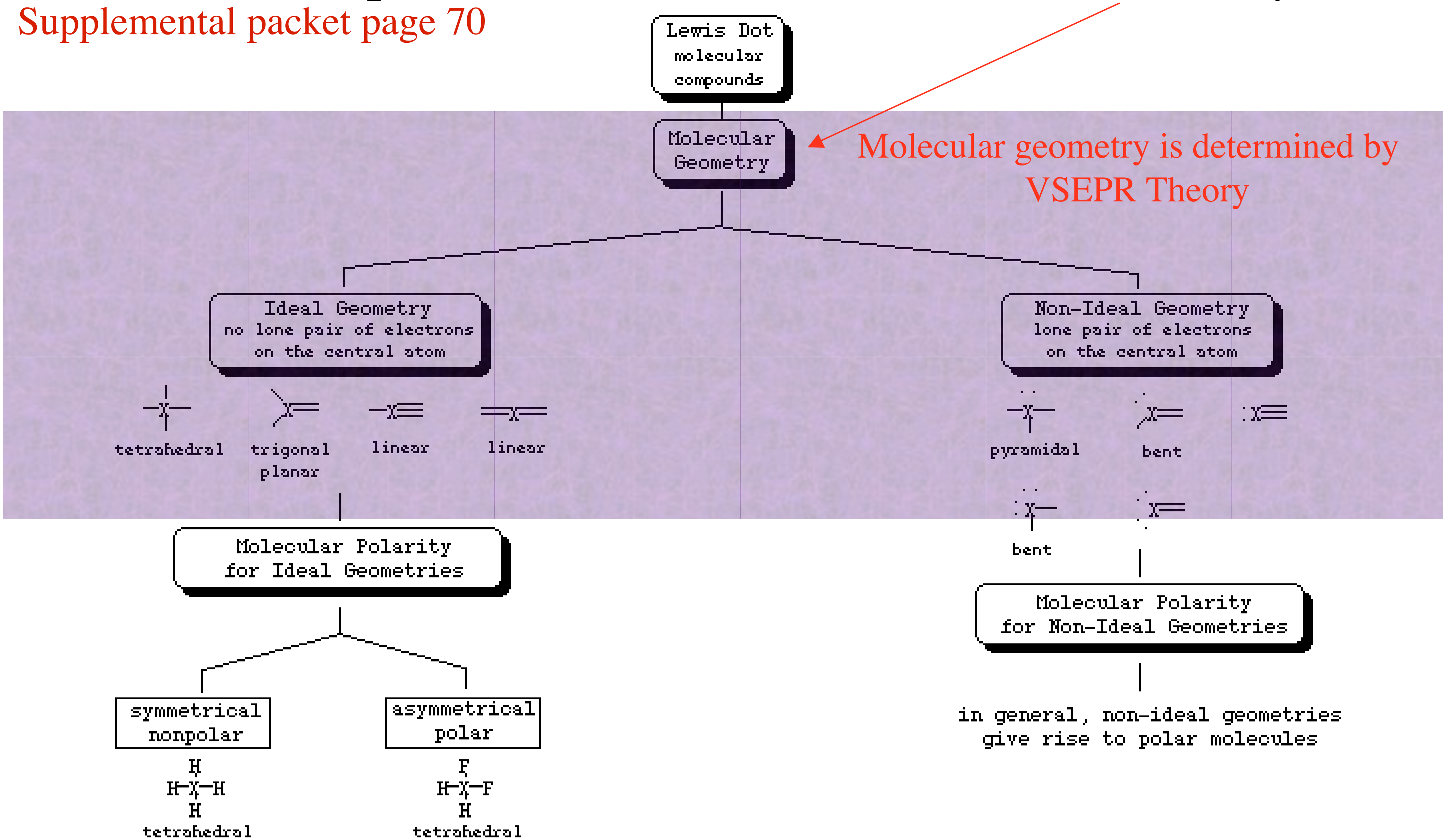

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VSEPR = valence shell electron pair repulsion

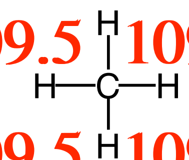
Determine the angles between bonds, name the geometry about the central atom and give the its hybridization.

Ideal bonding for carbon = Four bonds to carbon = Four bonding modes

Ideal Geometries

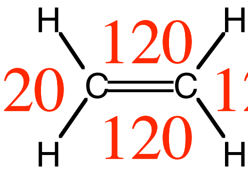
bond angles

109.5 109.5

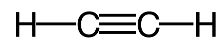


109.5 109.5

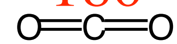
120 120 120 120



180



180

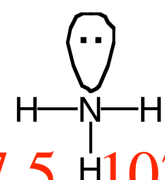


geometric name: tetrahedral | trigonal planar | linear | linear

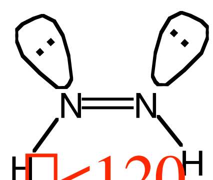
Ideal bonding angles for carbon

Non-Ideal Geometries

bond angles



107.5 107.5

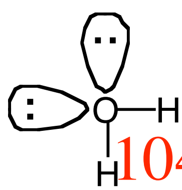


□<120

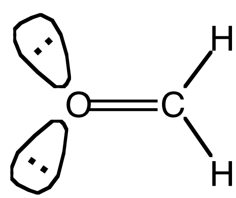
geometric name: pyramidal or trigonal pyramid | bent

Bond angles are less than ideal angle
Electron pair occupies a lot of space &
is held close to nucleus of central atom

bond angles

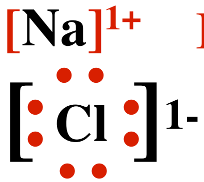


104.5



geometric name

bent

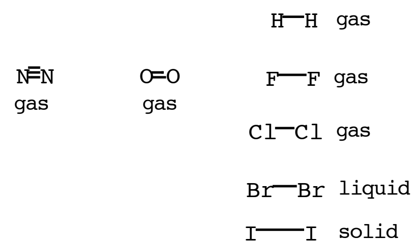


Ionic substances

Ionic compounds are held together by strong electrical forces between oppositely charged ions (e.g., Na^+, Cl^-). These forces are referred to as **ionic bonds**. Typically, ionic compounds (**ionic salts**) have relative high melting points (mp NaCl = 801 °C).and exist physically as solids at room temperature. It takes a lot of energy to break an ionic bond. Can you give additional examples of ionic compounds?

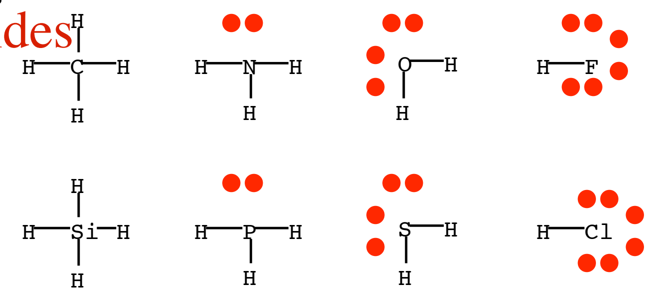
Molecular compounds. Two or more atoms may combine with one another to form an uncharged molecule. The atoms involved are unusually those of nonmetallic elements. Within the molecule, atoms are held to one another by strong forces called **covalent bonds**.

diatomic molecules - there are **seven diatomic molecules** that behave as discrete units. The physical states for these molecules at room temperature are variable.



molecules with multiple bonding patterns

molecules of nonmetals hydrides



Summary

What is the favorite charge of these elements as ions? Indicate charge. Is there a relationship between the type of element that likes to have positive charge? a negative charge?

	Li	Be	B	C	N	O	F
ion charge:	1+	2+	3+	4-	3-	2-	1-

How many atoms will each element bond to in order to be stable? Indicate the number of bonds that each element will make.

	Li	Be	B	C	N	O	F
number of bonds:	1	2	3	4	3	2	1

Is there a relationship between ion charge and the number of bonds an element will make? If so, describe the relationship.

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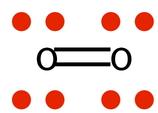
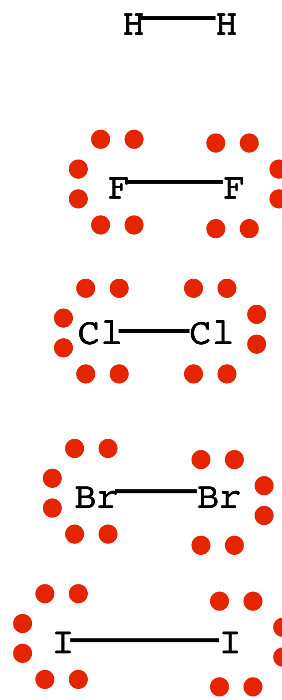
gas



gas



gas

gas

gas

liquid

solid

To these molecules,

Add missing

nonbonding pair of electrons

Molecular Polarity

Molecular Polarity can only be evaluated if

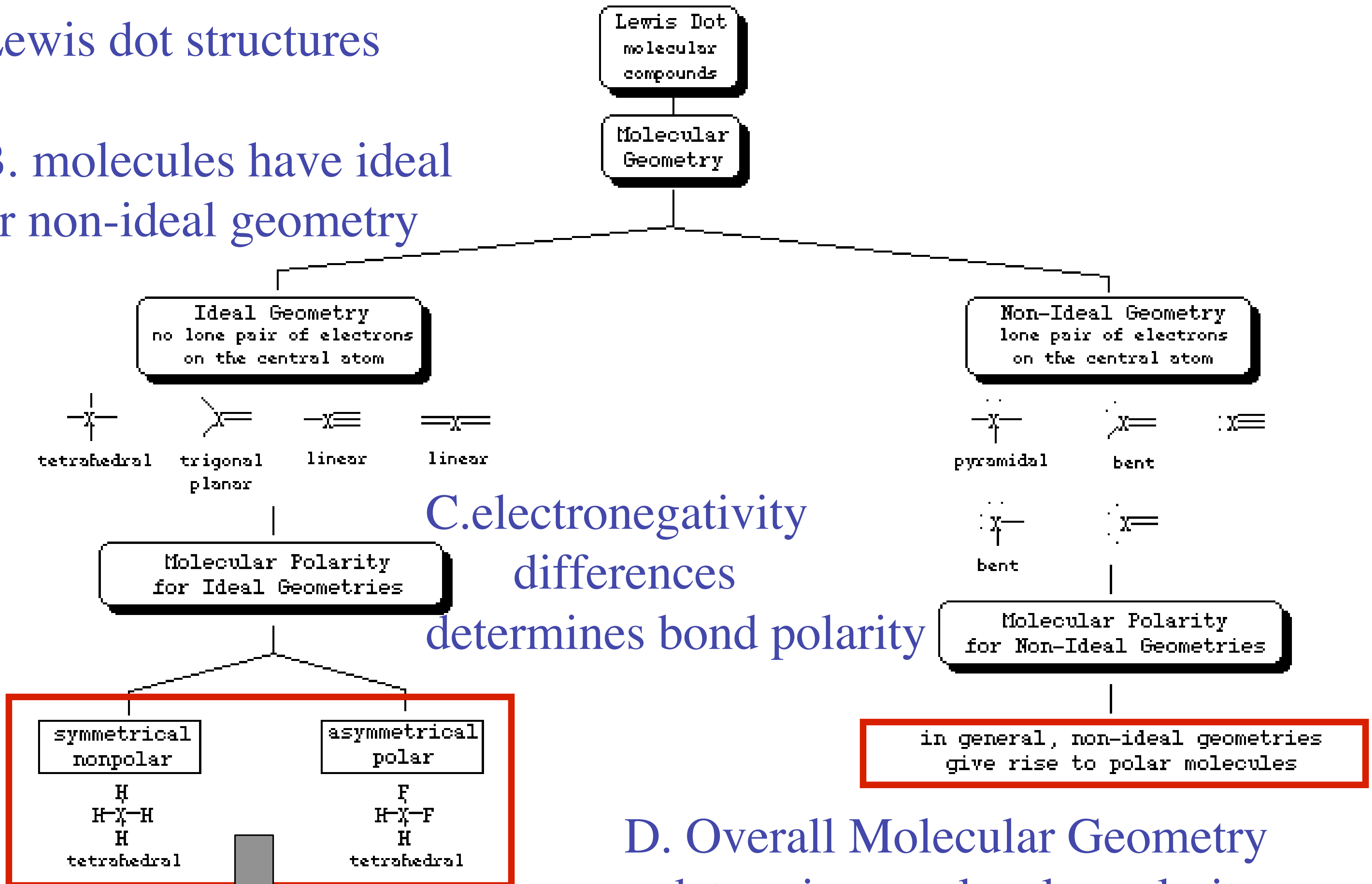
1) A Lewis dot structure for a molecule is drawn correctly
2) bond dipoles are correctly located using FONClBrISCH and
3) the geometry (ideal or non-ideal) about each atom in the structure is correctly specified.

The thought process for evaluating molecular polarity is summarized on the concept map on the next slide

Supplemental packet page 66

A. Be able to draw Lewis dot structures

B. molecules have ideal or non-ideal geometry



C. electronegativity differences determines bond polarity

D. Overall Molecular Geometry determines molecular polarity

These ideas are described on the next two slides

Section 6.6 - Bond of Polarity

Supplemental packet page 65

Bond Polarity is all about UNEQUAL SHARING of electrons in a covalent bond. Our analysis of bond polarity will be based upon an electronegativity trend. The definition of electronegativity is, "the ability for atom to pull electrons toward itself in a covalent bond." This may cause an UNEQUAL SHARING of the electrons between atoms. An electronegativity trend, F O N Cl Br I S C H, can be used for determining **bond polarity** between two **nonmetal** atoms. Fluorine has been experimentally determine to be the most electronegative element of all the elements. It is small, has only two electron shells and has high effective nuclear charge. Memorize the trend and on the next slide will we see how to apply it in determining bond polarity.

F O N Cl Br I S C H

1. The elements of F O N Cl Br I S C H are all nonmetals.
2. F is the most electronegative element, hydrogen is the least in this trend

Electronegativity

Dr. Gergens - SD Mesa College

Electronegativity is a measure of the attractive force of a nucleus for electrons.

I. The Relationship Between Electronegativity and Bond Type

The difference in electronegativity between two nuclei involve in a bond determines the nature of the bond. If the two atoms differ in electronegativity by 0.0 (if they are the same element) the bond is nonpolar covalent. If the two atoms differ in electronegativity by more then 0.0 but less than 1.7, the bond is polar covalent. If the two atoms differ in electronegativity by 1.7 or more, the bond is ionic; this usually occurs between bonds between representative metals and nonmetals.

Describe the type of bond formed between the following pairs of atoms.

Na and F M + NM = ionic

H and C NM + NM = slightly polar covalent

Cl and C NM + NM = polar covalent

Br and Br NM + NM = pure covalent

Ca and Cl M + NM = ionic

Mg and O M + NM = ionic

Circle most, underline the least

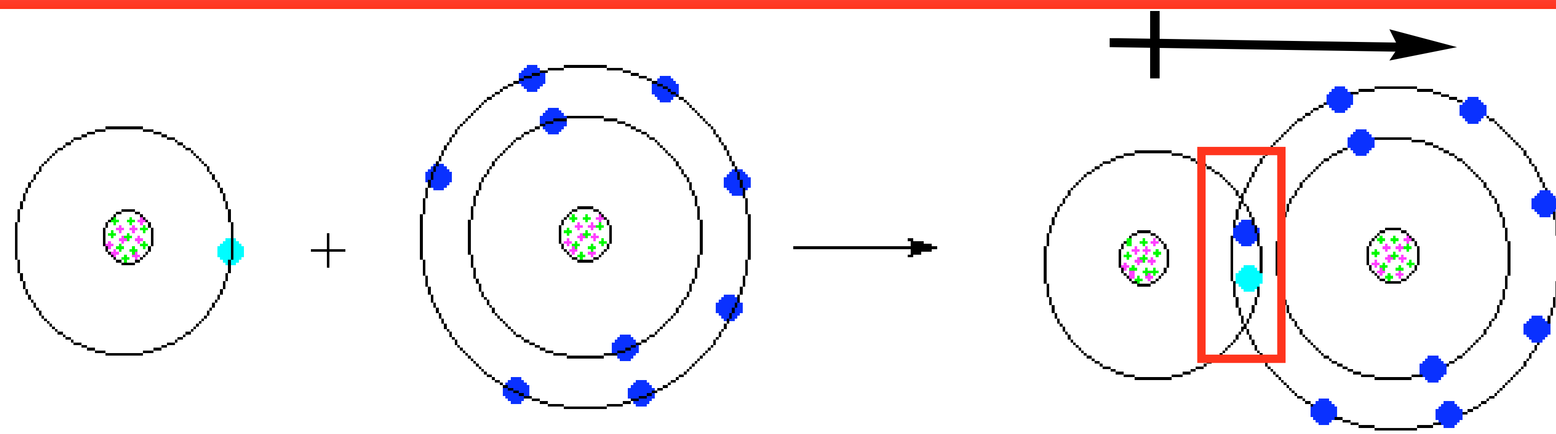
electronegative	radon	potassium	calcium	cesium
electronegative	Ra	S	B	H
polar	I–F	Cl–Br	I–Cl	
polar	C–C	C–H	N–H	O–H
polar	C– Br	C–I	C–F	C–O

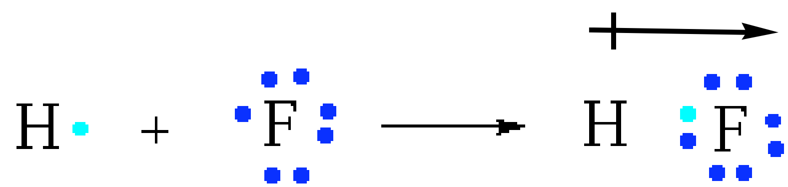
Draw in the dipole moment between the following pairs of atoms

C– Br   C–I   C–F   C=O

F O N Cl Br I S C H

The large difference in electronegativity between H—F requires that we draw in an arrow called a dipole.





Large difference in electronegativity between H—F most polar bond

F is more electronegative than H

F O N Cl Br I S C H

between C—F very polar bond

F O N Cl Br I S C H

Little difference in electronegativity values produces a less polar bond

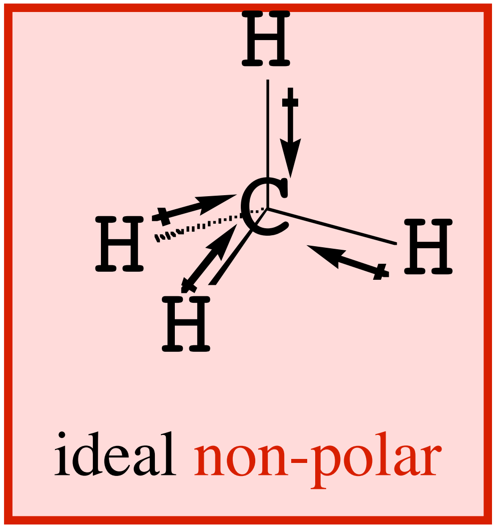
Equal Sharing between identical atoms, H-H, C-C, F-F

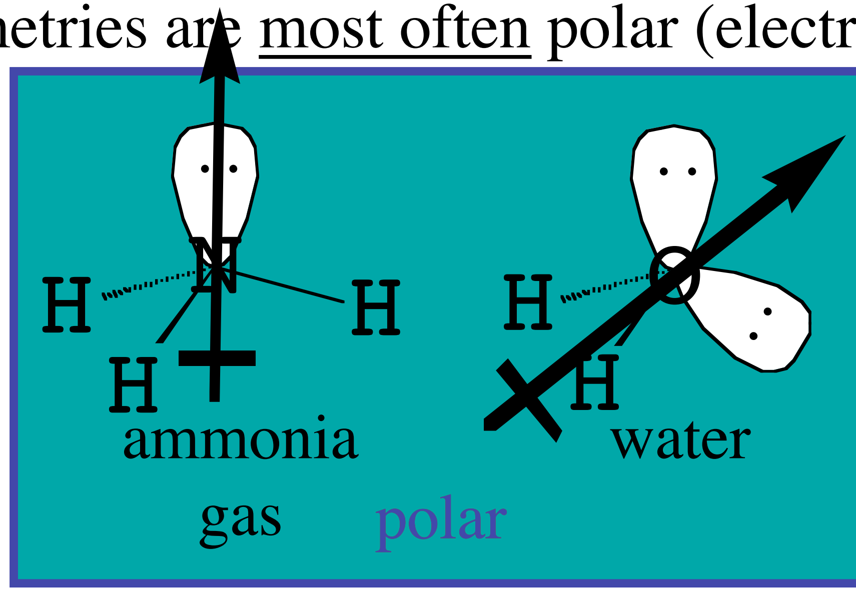
Equal sharing of electrons between two atoms produces a <u>nonpolar bond</u>

Molecular Substances (discrete units)

- Molecular Substances and Bond Polarity
  - Ideal geometries are generally nonpolar (no electron pairs)
  - Non-ideal geometries are <u>most often</u> polar (electron pairs)

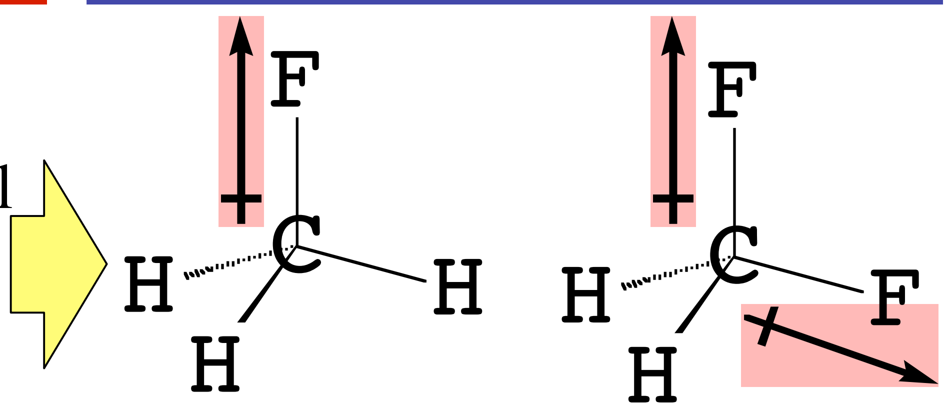
<u>**NO**</u>
Net
Dipole
Bond
Dipoles
Cancel





These
Molecules
Have a
<u>**Net**</u>
<u>**Dipole**</u>

<u>BUT</u>, these ideal geometries here are polar



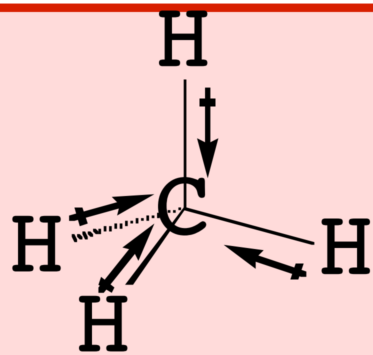
These
Molecules
Have a
<u>**Net**</u>
<u>**Dipole**</u>

Symmetric versus Asymmetric

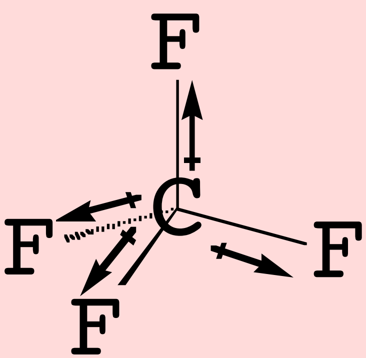
<u>Symmetrical</u> <u>arrangement</u>
of polar bonds
bond polarities cancel

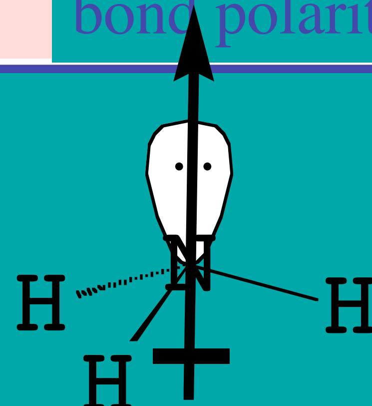
<u>Asymmetrical</u> <u>arrangement</u>
of polar bonds
bond polarities <u>don't</u> cancel

<u>NO</u>
Net
Dipole
Bond
Dipoles
Cancel

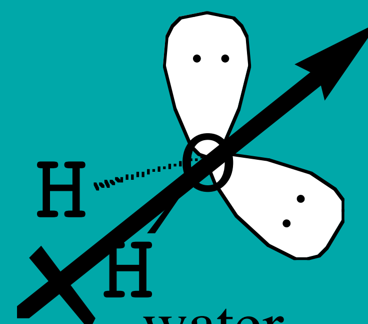


non-polar



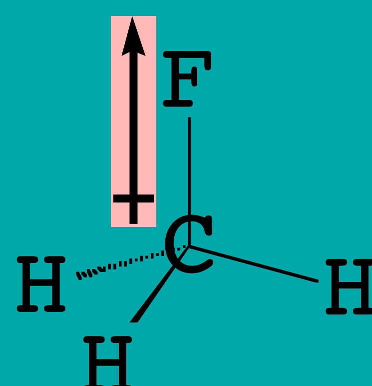


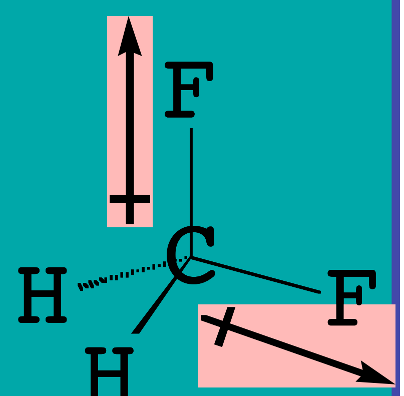
ammonia gas



water

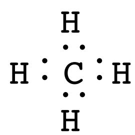
polar

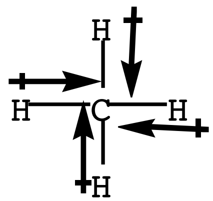




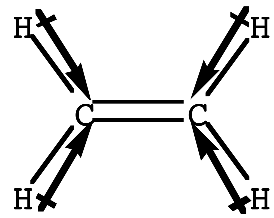
These
Molecules
Have a
<u>Net</u>
<u>Dipole</u>

Draw in bond dipole for each bond

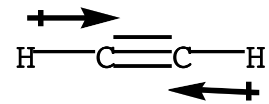




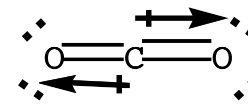
methane gas



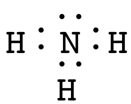
ethylene gas

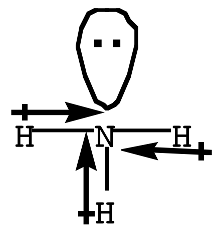


acetylene gas

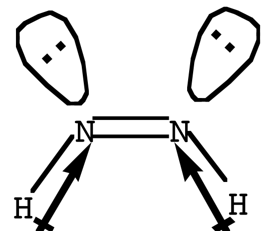


carbon dioxide gas



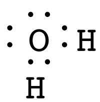


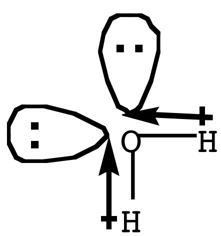
ammonia gas



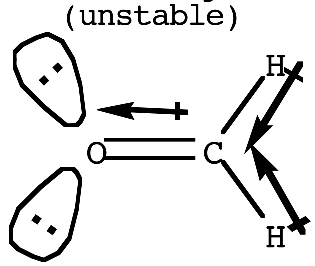
diazene gas (unstable)

nitrogen gas



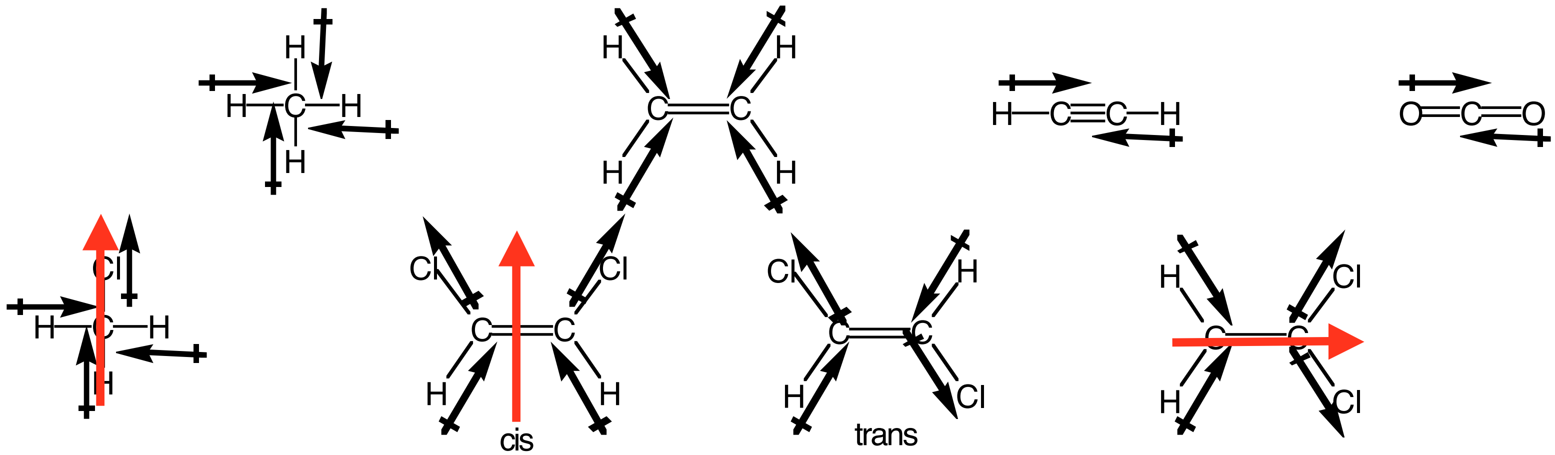


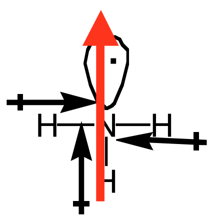
water liquid

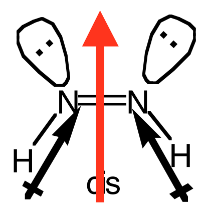


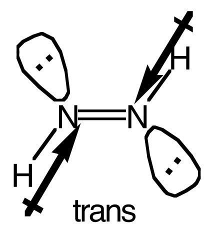
formaldehyde gas

determining the bond polarity between two disimilar atoms in a chemical bond. Draw in all bond dipole moments and the overall dipole moment if the molecule is polar.



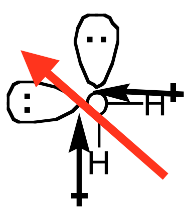


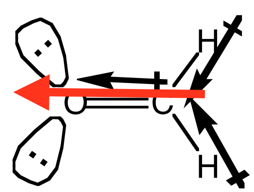




Find the molecules which have an <u>unequal distribution of dipoles</u>?

An <u>unequal distribution</u> of dipoles will produce a polar molecule



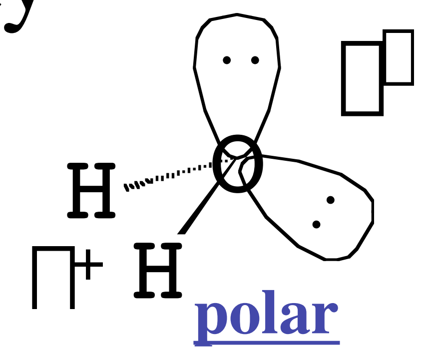


Section 6.6 - Polarity of Molecules

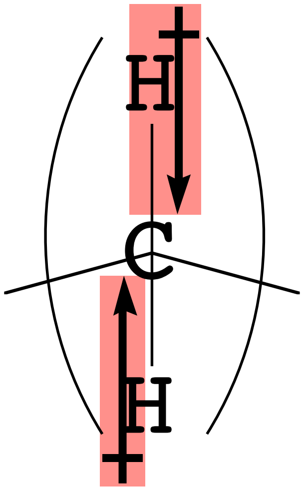
Molecular Polarity & Solubility

- The solubility of substance in water, a polar solvent, can be used as a gauge to determine whether a molecule is polar. "Like will dissolve Like." Thus if sugar dissolves in water, sugar must be polar. This common sense approach based on simple physical observations can be used to evaluate a substance's polarity. It is summarized below:
- Solubility (solute/solvent interactions) to gauge molecular polarity
  - "Like will dissolve Like"
    - Polar solutes will have highest solubility in polar solvents
    - Nonpolar solutes will have highest solubility in nonpolar solvents
    - Polar solutes will have lowest solubility in nonpolar solvents
    - Nonpolar solutes will have lowest solubility in polar solvents

Molecular substance solubility in water
"Like dissolves Like"
to gauge Molecular Polarity

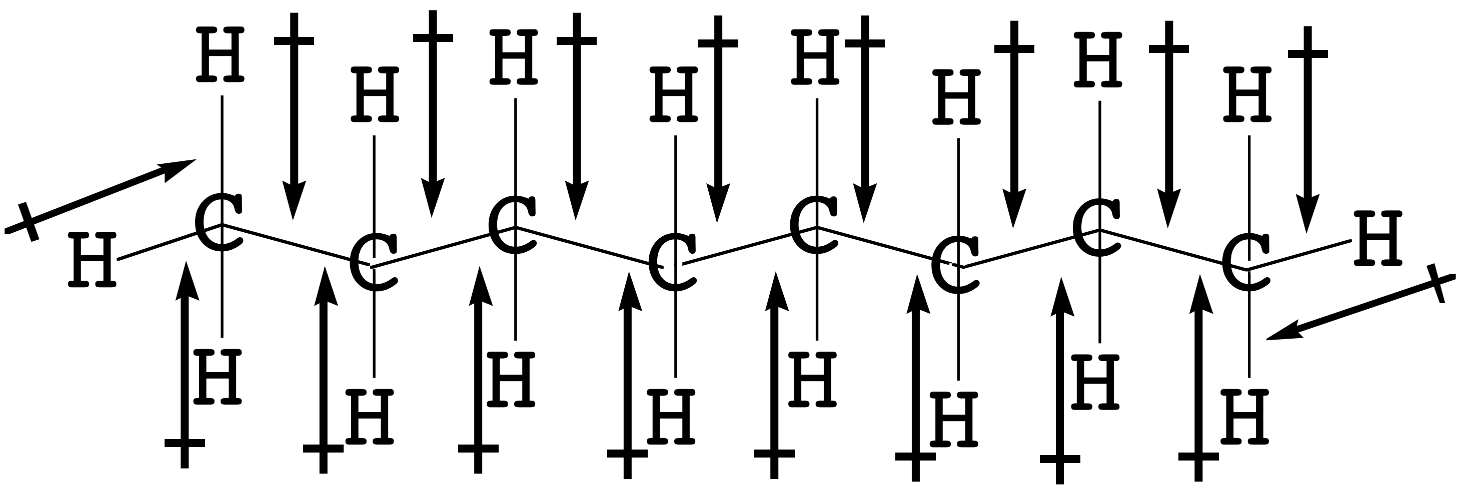


- Sugar dissolves in water
  - Thus sugar molecules must be polar
- Methanol CH_3OH dissolves in water
  - Thus methanol molecules must be polar
- Gasoline $-(CH_2)-$ does not dissolve in water
  - Thus gasoline molecules must be NONPOLAR



A gasoline molecule is an organic hydrocarbon made of repeating –(CH_2)– units and is non-polar; <u>no</u> net dipole

<u>hydrocarbons are non-polar</u>



C_8H_{18}

A gasoline hydrocarbon

All dipoles cancel

Organic molecules have carbon listed first in their chemical formulas