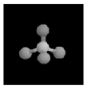
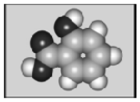
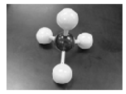
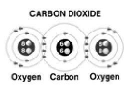
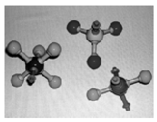
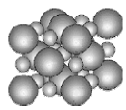




Chemical Bonds
&
Modeling



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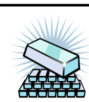
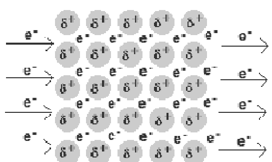
Metallic Bonding



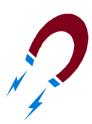
"Sea of Electrons" floating in metal cation matrix
Electrons not attached to any specific cation



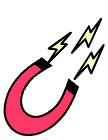
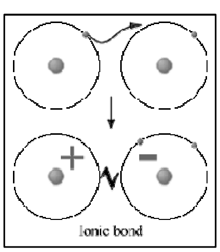

Explains current flow

LPT

Ionic Interactions



Total Transfer of electrons
Result = cation & anion
Held together by electronic interactions

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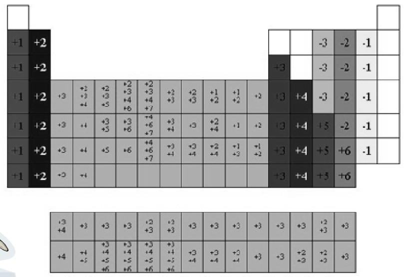
Ionic Interactions

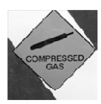


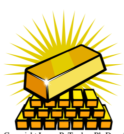
Atoms gain/lose electrons to mutually become "Noble"

Gain or Lose Electrons?

Metals ➔ lose electrons

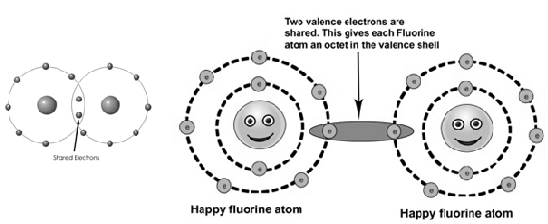
Non-Metals ➔ gain or share

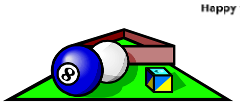




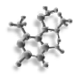
Covalent Bonding

Atoms share electrons to complete "Octet"

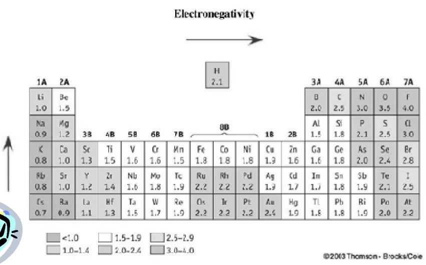




Electronegativity Differences



- Δ ≤ 0.4 ➔ non-polar covalent
- Δ > 0.4 - 1.9 ➔ polar covalent
- Δ > 1.9 ➔ ionic
- Δ = difference in electronegativity of the bonded atoms



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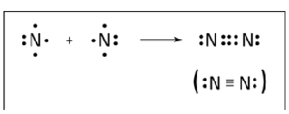
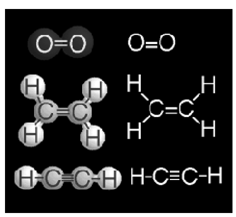
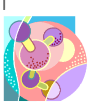
Multiple Bonding

Atoms reach octet by sharing more than one pair of electrons
Each shared pair constitutes a bond
One shared pair = single bond
Two shared pairs = double bond
Three shared pairs = triple bond







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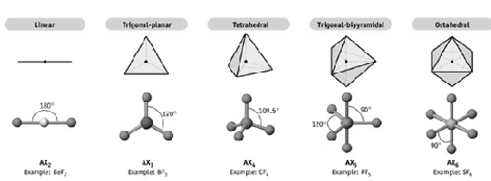
Central Atom Bonding Determines Molecular Shape

Number of electron bonding groups:

2 3 4 5 6



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Lone Pair Repulsion Finalizes Shape

Groups

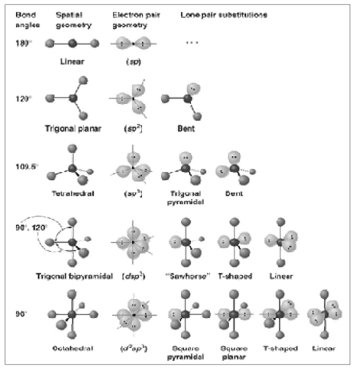
2

3

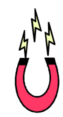
4

5

6



Maximize distance
Between electron pairs



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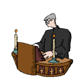
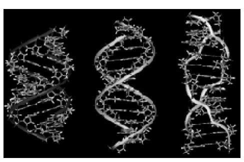
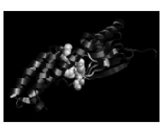
Basic Chemical Theology; Form & Function Intimately Related







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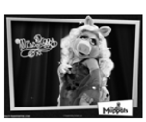
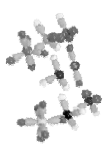
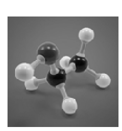


Modeling Lab



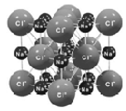


LPT

Today's Lab

Purpose

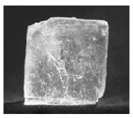
To observe models of ionic and covalent compounds
To build models of covalent compounds

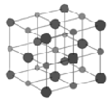


Chemical Bonding Video

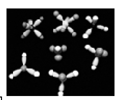
Model of an Ionic Crystal

Create a data table
Observe the model of the sodium chloride (NaCl) crystal
Describe its shape (Cubic)
Are there any independent units that are "molecules" of NaCl? (No)
What is the ratio of number of Na^+ to Cl^- ions? (1:1)





Making Models (Work in pairs)
Examine each of the different spheres.
Count & record the # holes (# bonds) in each



Element	Symbol	Color	# bonds	Element	Symbol	Color	# bonds
Hydrogen	H	white	1	Nitrogen	N	Blue	3 (4)
Chlorine	Cl	green	1	Oxygen	O	Red	2 (4)
Carbon	C	black	4				

Rules for constructing molecular models:
The color code tells you which sphere to use.
The subscripts tell you how many of the atoms to use.
All bonds (holes) must be used.
All bonds must connect to atoms at both ends.
Use short sticks for single bonds (one shared pair of electrons).
Use longer, flexible sticks for multiple bonds.

Construct each of the following models
The gases in air:
- **oxygen, O_2**
- **nitrogen, N_2**

The "greenhouse gases"
- **carbon dioxide, CO_2**
- **methane, CH_4**

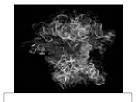
Others:
- **water, H_2O**
- **ammonia, NH_3**
- **carbon tetrachloride, CCl_4**

Compounds of carbon:
- **ethane, C_2H_6**
- **ethene (ethylene), C_2H_4**
- **ethyne (acetylene), C_2H_2**
- **propane. C_3H_8**
- **butane, C_4H_{10}**

Modeling Lab

Conclusion

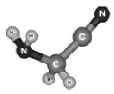
Summarize the different types of bonds studied during this experiment.
How are ionic bonds different from covalent bonds?
What types of geometries did you encounter?

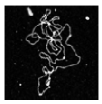


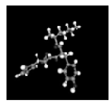
Elementary Modeling Site: (Optional)

Allows Real-time manipulation of simple molecules

http://www-personal.umich.edu/~lpt/Modeling/lab15.htm

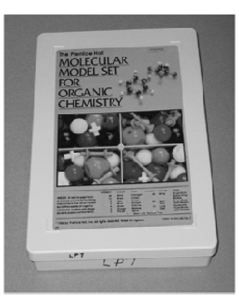


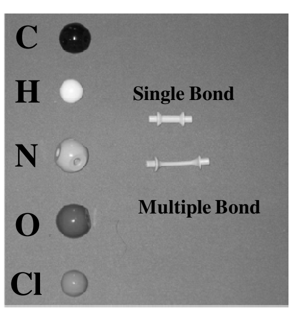




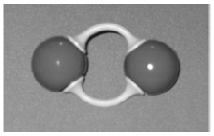
Let's Boldly Go Explore Today's Lab

Using the Prentice-Hall Molecular Modeling Set

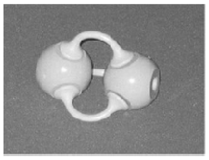




Atmospheric Gases



Oxygen: O_2
Linear, Diatomic Molecule
Oxygen - Oxygen Double Bond
(2 Electron Pairs Shared)



Nitrogen: N_2
Linear, Diatomic Molecule
Nitrogen - Nitrogen Triple Bond
(3 Electron Pairs Shared)

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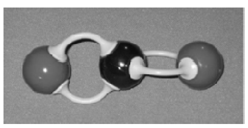
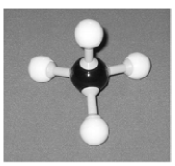
Greenhouse Gases



Carbon Dioxide: CO_2
Linear
2 Carbon - Oxygen Double Bonds
Carbon Shares 4 Electron Pairs
Polar Covalent Bonding



Methane: CH_4
Tetrahedral
4 Carbon - Hydrogen Single Bonds
Carbon Shares 4 Electron Pairs
Non-Polar Covalent Bonding

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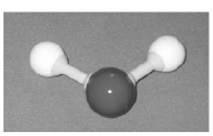
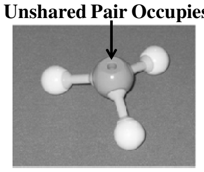
Others



Water: H_2O
2 Lone Pairs Distort Linear Geometry
2 Oxygen Hydrogen Single Bonds
2 Polar Covalent Bonds
Oxygen Shares 2 Electron Pairs

Unshared Pair Occupies this Slot



Ammonia: NH_3
3 Nitrogen Hydrogen Single Bonds
3 Non-Polar Covalent Bonds
Nitrogen Shares 3 Electron Pairs
Molecule Has Trigonal-Pyramidal Shape
Unshared Pair Creates Tetrahedral Geometry
(gives molecule a dipole moment)

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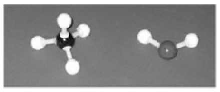
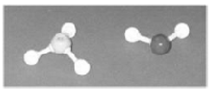
Models Explain/Predict Molecular Behavior



Methane Compared To Water

Methane is totally symmetrical and non-polar
Water is non-symmetrical and polar
They will not mix



Ammonia Compared To Water

Ammonia has a dipole moment because of 1 unshared electron pair
Water has a dipole moment because of oxygen's 2 unshared pairs of electrons
They will mix

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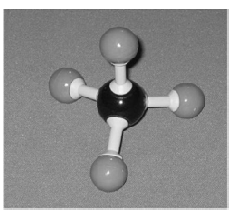
Others



Carbon Tetrachloride: CCl_4
Tetrahedral
4 Carbon - Chlorine Single Bonds
Carbon Shares 4 Electron Pairs
4 Polar Covalent Bonds

Molecule is non-polar
symmetrical
no dipole

Will not mix with water

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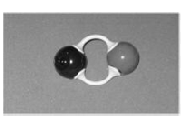
Molecule With Rendering Problem

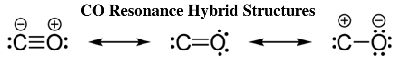


Carbon Monoxide: CO
Linear, Diatomic Molecule
Simple P - H Models Cannot Render
Oxygen: 2 Bonding Sites filled
Carbon: 2 Bonding Sites Empty

CO Molecule Explained By Quantum Mechanical Orbital Mixing (Hybridized Orbitals)

Orbital Electrons "Resonate" (Diffuse and simultaneously occupy several regions)
None of the representations below exist (can be isolated) …
provide visualization of potential mixing of multiple bonding scenarios

CO Resonance Hybrid Structures



Hybridized Orbitals & Resonance Discussed in Higher Level Classes

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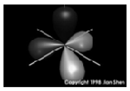
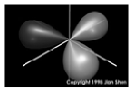
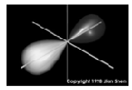
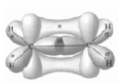
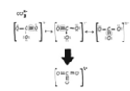
Failure Of Lewis Dot & Simple Models To Represent Bonding & Geometry of Many Molecules Led To:

Orbital Mixing

Hybrid Orbitals **Aromaticity** **Resonance Structures**





If model fails to explain data, science revises the model
These topics are beyond 101 level

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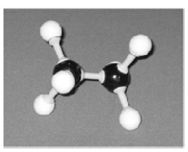
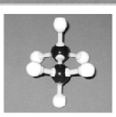
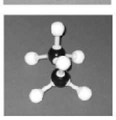
Simple Organic (Carbon-Containing) Molecules



Ethane: C_2H_6
A Hydrocarbon (contains only C and H)
Saturated (all single bonds)
Free Rotation around C - C Bond
6 Non-Polar Covalent C - H Bonds
1 Non-Polar Covalent C - C Bond



Ethane: C_2H_6
The 2 Methyl Groups (CH_3) are "staggered"



Ethane: C_2H_6
The 2 Methyl Groups (CH_3) are "eclipsed"

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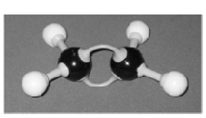
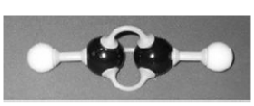
Simple Organic (Carbon-Containing) Molecules



Ethylene (Ethene): C_2H_4
A Hydrocarbon (contains only C and H)
Unsaturated (Contain non-single bond)
No Free Rotation around C - C Double Bond
4 Non-Polar Covalent C - H Bonds
1 Non-Polar Covalent C - C Double Bond
Molecule is planar



Acetylene (Ethyne) : C_2H_2
A Hydrocarbon (contains only C and H)
Unsaturated (Contain non - single bond)
No Free Rotation around C - C Triple Bond
2 Non-Polar Covalent C - H Bonds
1 Non-Polar Covalent C - C Triple Bond
Molecule is linear

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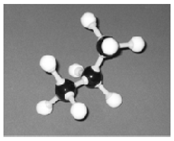
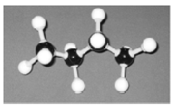
Simple Organic (Carbon-Containing) Molecules



Propane: C_3H_8
A Hydrocarbon (contains only C and H)
Saturated (all single bonds)
Free Rotation around 2 C - C Bonds
8 Non-Polar Covalent C - H Bonds
2 Non-Polar Covalent C - C Bond



Butane: C_4H_{10}
A Hydrocarbon (contains only C and H)
Saturated (all single bonds)
Free Rotation around 3 C - C Bonds
10 Non-Polar Covalent C - H Bonds
3 Non-Polar Covalent C - C Bond

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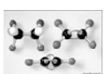
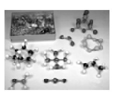
Lab 15 Questions

Do the covalent molecules exist as independent units? Explain.

Yes, because they are not ionic matrix compounds.

List the advantages / disadvantages of using ball-and-stick models.

Visualize shape	**Difficult for large molecules**
Evaluate Bonding	**May not accurately represent "resonance"**
Compare different molecules	**Cost**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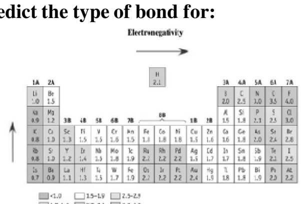
Based on electronegativity, predict the type of bond for:

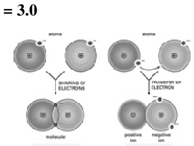
Na-Cl
Na = 0.9 Δ = 2.1 Ionic
Cl = 3.0

C-Cl
C = 2.5 Δ = 0.5 Polar Covalent
Cl = 3.0

S-O
S = 2.5 Δ = 1.0 Polar Covalent
O = 3.5

N-N Δ = 0.0 Non-Polar Covalent
N = 3.0





$\Delta \leq 0.4$ ➔ non-polar covalent
$\Delta < 0.4 - 1.9$ ➔ polar covalent
$\Delta > 1.9$ ➔ ionic

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Which bond is least polar? Which bond is most polar?

H—O H—S H—P H—C

$\Delta \leq 0.4$ ➔ non-polar covalent
$\Delta < 0.4 - 1.9$ ➔ polar covalent
$\Delta > 1.9$ ➔ ionic

H = 2.1	H = 2.1	H = 2.1	H = 2.1
O = 3.5	S = 2.5	P = 2.1	C = 2.5
Δ➔ 1.4	Δ ➔ 0.4	Δ ➔ 0.0	Δ = 0.4

H-P < H-C < H-S < H-O



H-P least polar
H-O most polar

Most Polar of all

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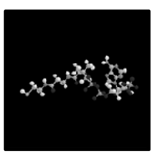
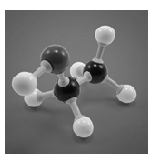
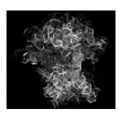
Chemistry is a 3D Process
Molecular Models Facilitate Understanding of Chemical Properties and Reactions



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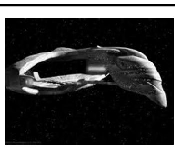
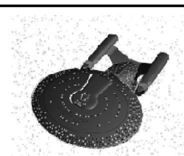
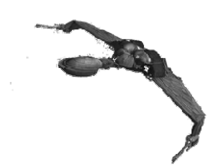



Last Thoughts

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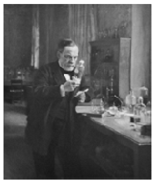
Louis Pasteur



Mid-1800's

Promoted germ theory of disease
Developed Pasteurization process
Debunked spontaneous generation of life
Developed cure for anthrax & rabies
Discovered stereoisomers using polarized light

Chance Favors the Prepared Mind

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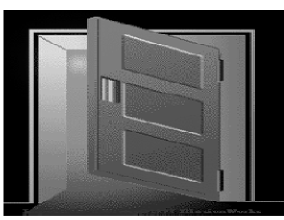
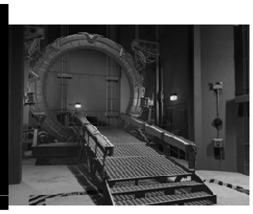
The more
Acquired knowledge
The Greater Your Skill Set
The More Doors Will Open For You





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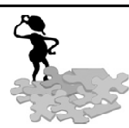
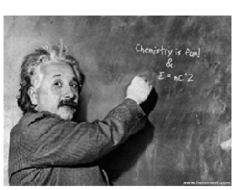


Hopefully

Problems Solving
What is the nature of the problem? (Needed)
What do I know (Given)?
How do I get from Known to Needed?



Will stay with you
long after
memories of this class
have faded

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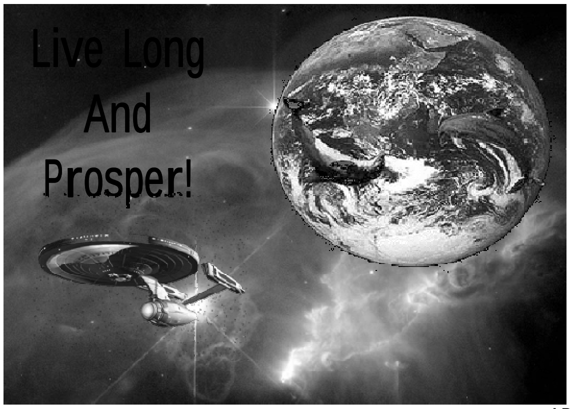

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