Learning Organic Chemistry

Memorizing the structure, properties, and reactivities of each molecule will severely limit your abilities

Organic chemistry is rational and systematic

Goal:

Learn tools to dissect and analyze organic chemistry that is unfamiliar

Pay attention to detail!

Study Tips

1. **Read** the suggested readings before coming to class and record the main ideas.
2. After each lecture, **summarize** the major ideas and concepts in your notes within 24 hours of class.
3. **Annotate** these summaries from your study of the textbook
4. Work the **problems** independently
5. **Master the material from each lecture before going to the next one.**
6. Spend a few minutes each day on **review** to prevent becoming overwhelmed on the night before an exam.

You cannot [redacted]

for an Organic [redacted]

Syllabus

Organic chemistry
Structure and reactivity
Resonance
Acidity and basicity of organic compounds
Alkanes
Stereochemistry
Overview of organic reactions
Alkenes
Alkynes
Alkyl halides
Benzene and aromatic compounds
Alcohols and phenols
Carbonyl compounds
Synthesis using the chemistry of 5.12

Background Review

1. Atomic Structure
2. Atomic Orbitals
3. Electron Configuration
4. Ionic/Covalent Bonding
5. Lewis Structures
6. Formal Charges
7. Valence Bond Theory
8. VSEPR Theory
9. Hybridization
10. MO Theory

Go the the 5.12 Web Page and work through:

- **Background Handout (PowerPoint and .pdf)**
- **Background Knowledge Quiz**

[redacted]

Lecture 1: Outline

- Organic Chemistry
- Relationship of Structure, Energy, and Reactivity
- Structure
  - Atoms
  - Bonding
    - How/Why Atoms Bond Together
    - Bonding Patterns
  - Representing molecules (putting the atoms together)
    - Lewis and Kekul□ Structures
    - Line-angle Formula
    - 3-D
    - Orbital Drawings
  - Functional Groups
  - Resonance

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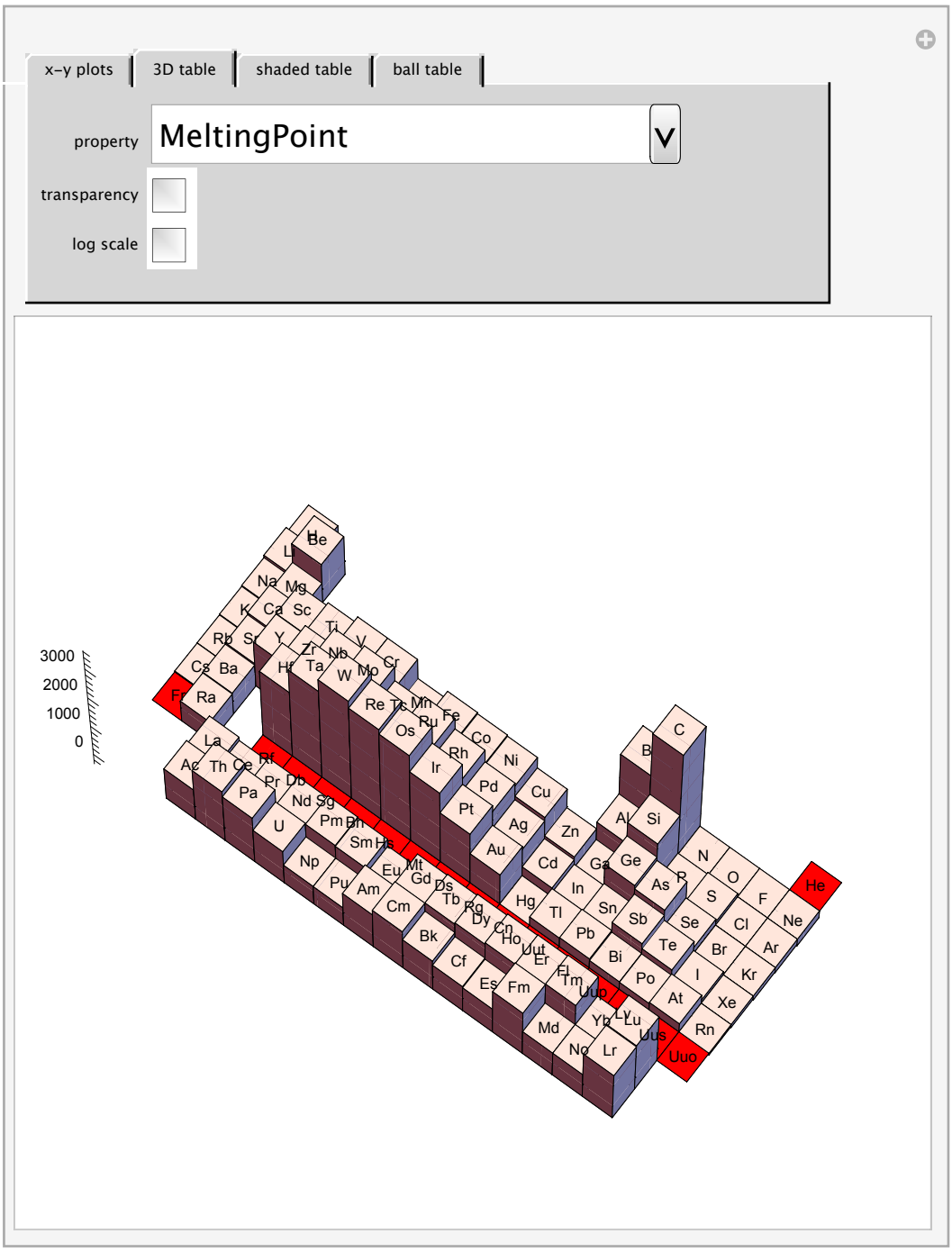
x-y plots
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Tb
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Cm
Dy
Cn
Bk
Ho
Uut
Cf
Er
Fl
Es
Tm
Fm
Uup
Yb
Lv
Md
Lu
Uus
No
Lr
Uuo

Organic Chemistry

What: The study of carbon-containing compounds

Why: Pervasive in nature

Chemical foundation of biology

Improve standard of living (medicines, plastics, pesticides . . .)

How: Examine structure and analyze how it governs reactivity

What: Carbon-Containing Compounds

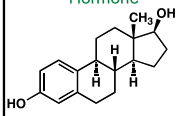
Middle of second row Li Be B C N O F

[redacted]

➢ Can neither accept or give up electrons easily

[redacted]

Hormone



Estradiol

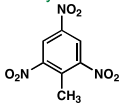
Amino acid

Alanine

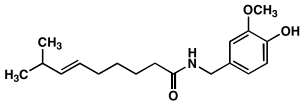
DNA base

Adenine

Dynamite

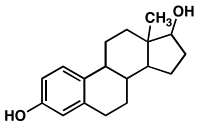


TNT

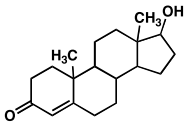


Capsaicin (peppers)

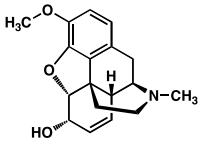
Subtleties in Structure



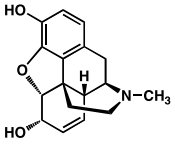
estradiol



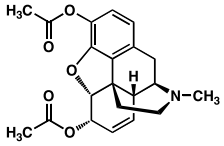
testosterone



codeine

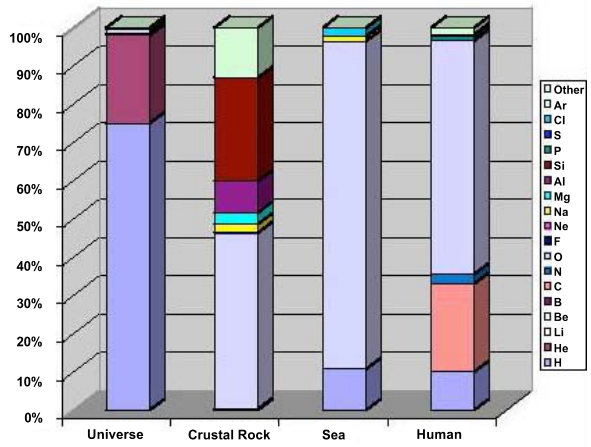


morphine



heroin

Why: Life is Based on Organic Compounds



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How: Structure and Reactivity

Structure - what atoms are present & how they are bonded together

Reactivity - potential of structure to undergo chemical change

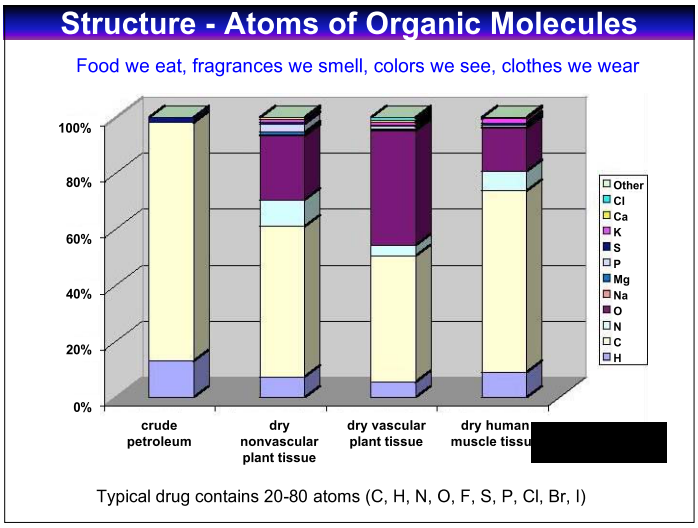
If likely - **reactive** (**unstable**)!
If unlikely - **unreactive** (**stable**)!

Potential Energy:
- function of position or configuration of components
- if low, compound more stable, change less likely
- if high, compound less stable, change more likely

Structure

Foundation of organic chemistry

1. What atoms (besides carbon) are important?
2. How are these atoms bonded together?



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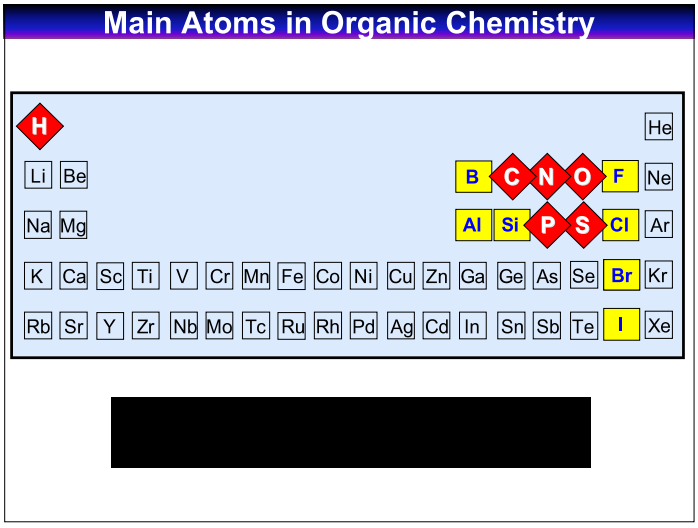

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Electron Configuration of Main Atoms

Element	Ground State Configuration	1s	2s	2p			3s	3p		
H	$1s^1$	↑								
He	$1s^2$	↑↓								
Li	$1s^2 2s^1$	↑↓	↑							
Be	$1s^2 2s^2$	↑↓	↑↓							
B	$1s^2 2s^2 2p^1$	↑↓	↑↓	↑						
C	$1s^2 2s^2 2p^2$	↑↓	↑↓	↑	↑					
N	$1s^2 2s^2 2p^3$	↑↓	↑↓	↑	↑	↑				
O	$1s^2 2s^2 2p^4$	↑↓	↑↓	↑↓	↑	↑				
F	$1s^2 2s^2 2p^5$	↑↓	↑↓	↑↓	↑↓	↑				
Ne	$1s^2 2s^2 2p^6$	↑↓	↑↓	↑↓	↑↓	↑↓				
Na	$1s^2 2s^2 2p^6 3s^1$	↑↓	↑↓	↑↓	↑↓	↑↓	↑			
Mg	$1s^2 2s^2 2p^6 3s^2$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓			
Al	$1s^2 2s^2 2p^6 3s^2 3p^1$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑		
Si	$1s^2 2s^2 2p^6 3s^2 3p^2$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑	
P	$1s^2 2s^2 2p^6 3s^2 3p^3$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑	↑
S	$1s^2 2s^2 2p^6 3s^2 3p^4$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑	↑
Cl	$1s^2 2s^2 2p^6 3s^2 3p^5$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑
Ar	$1s^2 2s^2 2p^6 3s^2 3p^6$	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓	↑↓

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Electron Configuration and Valence Electrons

Electron redistribution (change in configuration) is the origin of chemical change

WHY? Attain lower **ENERGY**

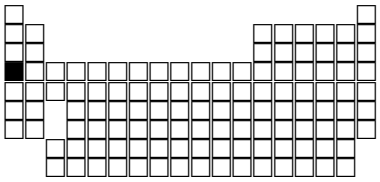
(achieved when outer shell is filled - 8 electrons)

Process of chemical bonding:

How do atoms maintain 8 electrons as well as participate in chemical bonding?

Atomic number

19
Potassium



1s●●
2s●● 2p●●●●●●
3s●● 3p●●●●●●
4s●○

Configuration: [Ar]$4s^1$
Valence: **1**
Block: **s**
Group: **1**
Period: **4**

Bonding Possibilities of Main Organic Atoms

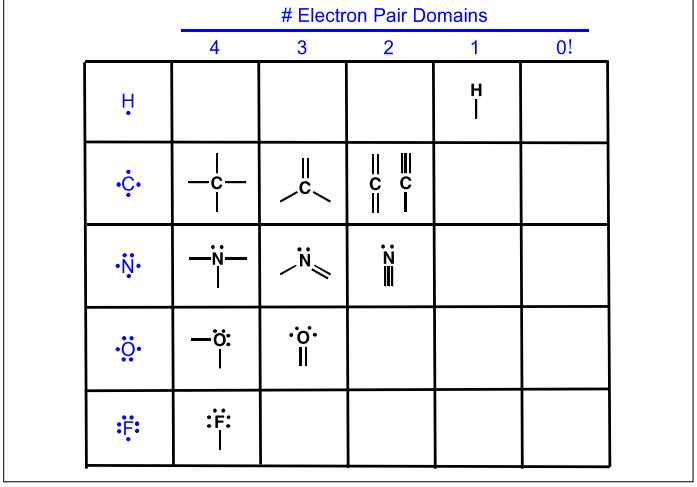
Each atom has a limited number of possibilities to satisfy octet:

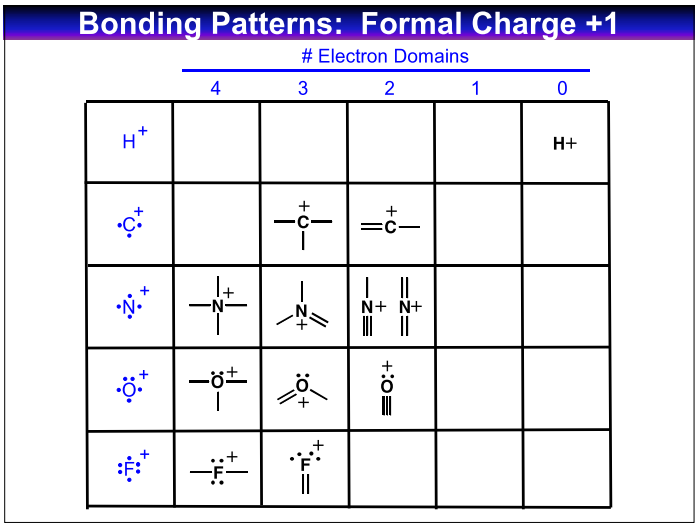
1. Nonbonding (electron pair localized on one atom)
2. Bonding (electron pair shared between two atoms)
   a. Single bond (1 shared pair)
   b. Double bond (2 shared pairs)
   c. Triple bond (3 shared pairs)

(H is exception to octet rule - has 1 electron)

Electron Pair Domain - region of high valence shell electron density (bonding or nonbonding)

Bonding Patterns: Formal Charge 0





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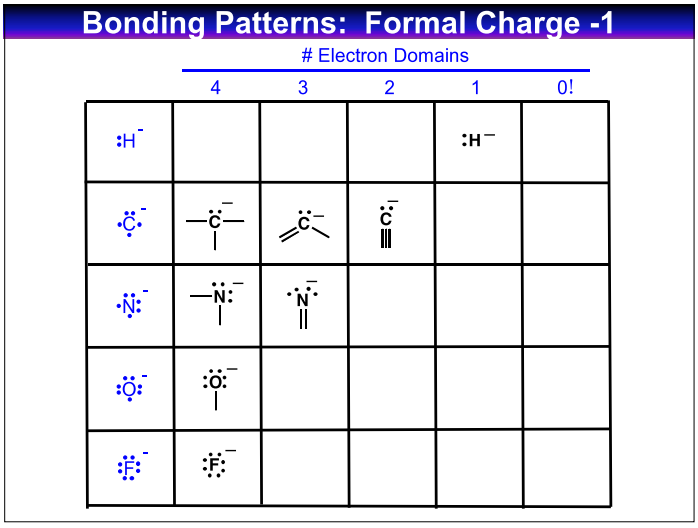

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Boron

Electron configuration

Neutral, but electron deficient

Octet, but charged

can tolerate an incomplete octet better than any other atom in the second row

EN = 2, least suited of all second row elements to carry a negative charge

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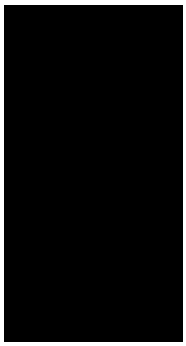
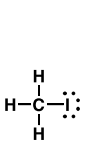
Organic Structures: Summary (so far)

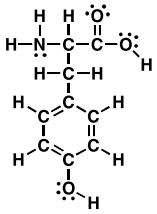
- ✓ Organic Chemistry
- ✓ Relationship of Structure, Energy, and Reactivity
- ❑ Structure
  - ✓ Atoms
  - ✓ Bonding
    - ✓ How/Why Atoms Bond Together
    - ✓ Bonding Patterns
  - ❑ Representing molecules
    - ✓ Lewis and Kekule Structures
    - o Line-angle Formula
    - o 3-D
    - o Orbital Drawings
  - ❑ Functional Groups
  - ❑ Resonance



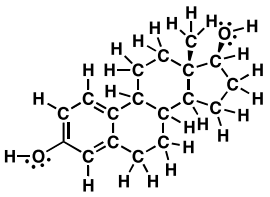
Representing Molecules: Line-Angle Formula



Iodomethane

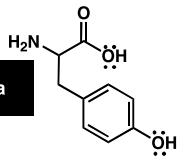


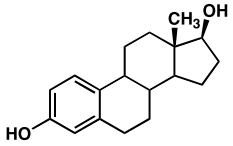
Tyrosine



Estradiol

Line-Angle Formula

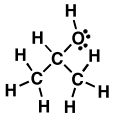


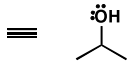


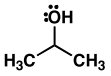
Rules of Drawing Line-Angle Formulas

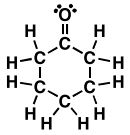
[redacted]

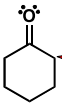
(any atom that is not carbon)











HO C CH3

Incorrect!

(Why?)

Don t forget about the implied hydrogen atoms!

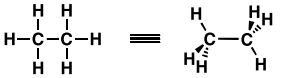
Always show all lone pairs!
(helps with electron bookkeeping)

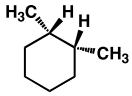
Representing Molecules: 3-D

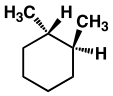
Lewis/Kekul□ and Line-Angle structures don t tell the whole story!
Molecules are not flat - use dashes and wedges to show 3-D image

Governed by VSEPR

Line - in plane of paper
Dash - going into the paper
Wedge - coming out of the paper







Same atoms, different spatial arrangement

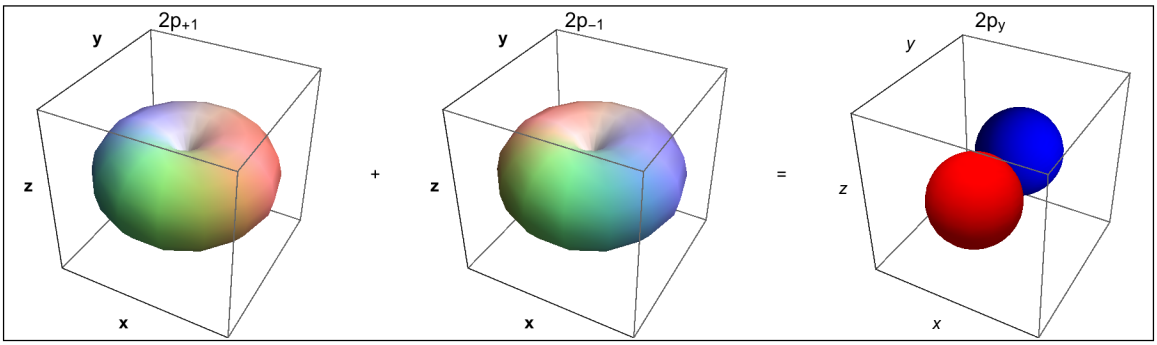
Representing Molecules: Orbital Drawings I

Atomic Orbitals

absolute value of m_l, $|m_l|$: 0 1

sign of linear combination: + −

Color key:
real & positive imaginary & positive
real & negative imaginary & negative
linear combination: $\frac{i}{\sqrt{5}}(2p_{+1}+2p_{-1})=2p_y$



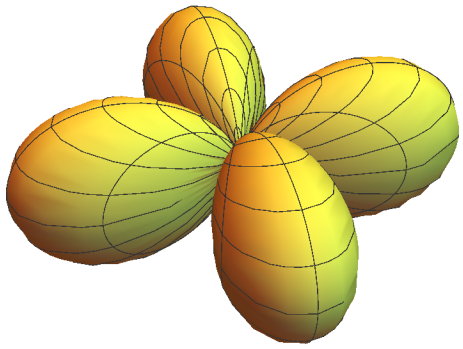
orbital $3d_{xy}$

type of view ◉ w/o phases ○ with phases

show axes and labels ☐

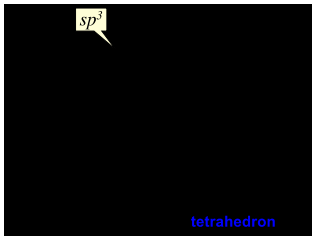
characteristics

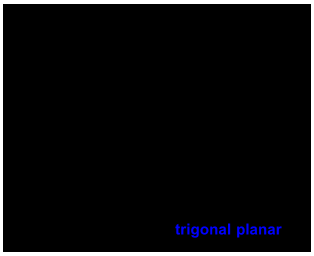
orbital designation	3d
$\lvert m \rvert$	2
number of	nodes: 2
polynomial form	$x\,y$



Representing Molecules: Orbital Drawings II!

Hybrid Orbitals



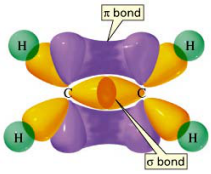


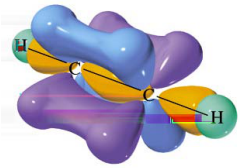
Representing Molecules: Orbital Drawings III

Ethylene

Acetylene

H–C≡C–H





Functional Groups

The atoms of organic molecules exist in common combinations

Each combination:

- unique chemical properties and reactivity
- behaves similarly in every organic molecule

10 million organic compounds exist!

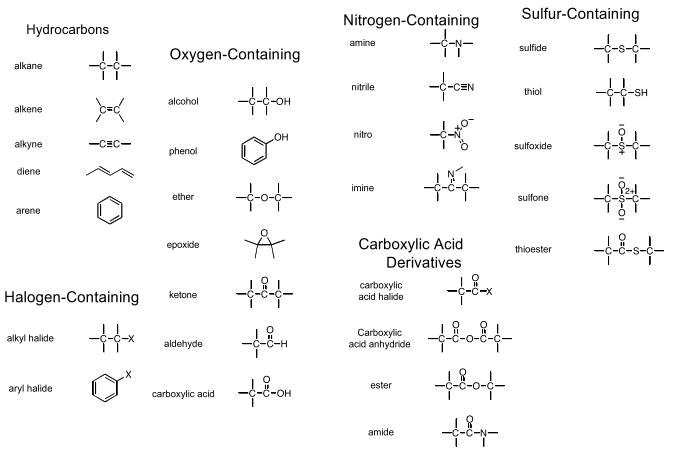
Predict how any one of those compounds reacts by analyzing its

functional groups

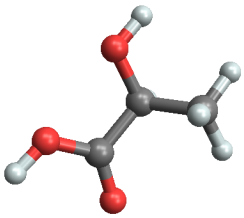
Functional Group - group of atoms with characteristic chemical behavior no matter what molecule it s in

[redacted]

Functional Groups to Learn

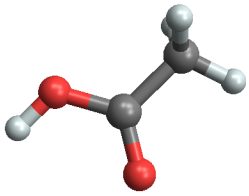


compound class acids



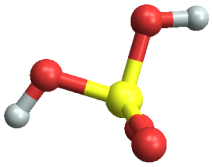
L−(+)−lactic acid

Lactic acid is commonly used for fluid resuscitation after blood loss, or an injury from a burn.



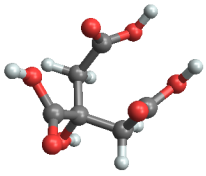
acetic acid

Acetic acid is commonly found in vinegar.



sulfuric acid

Sulfuric acid is commonly found in car batteries.



citric acid

Citric acid is an organic acid, found in citrus fruit.

Background Review

1. Atomic Structure
2. Atomic Orbitals
3. Electron Configuration
4. Ionic/Covalent Bonding
5. Lewis Structures
6. Formal Charges
7. Valence Bond Theory
8. VSEPR Theory
9. Hybridization
10. MO Theory

Go the the 5.12 Web Page and work through:

- **Background Handout (PowerPoint and .pdf)**
- **Background Knowledge Quiz**

[redacted]

Lecture 1: Outline

- Organic Chemistry
- Relationship of Structure, Energy, and Reactivity
- Structure
  - Atoms
  - Bonding
    - How/Why Atoms Bond Together
    - Bonding Patterns
  - Representing molecules (putting the atoms together)
    - Lewis and Kekul□ Structures
    - Line-angle Formula
    - 3-D
    - Orbital Drawings
  - Functional Groups
  - Resonance

[redacted]