Organic Chemistry

Chapter 1

Bonding and Isomerism

Ionic Compounds

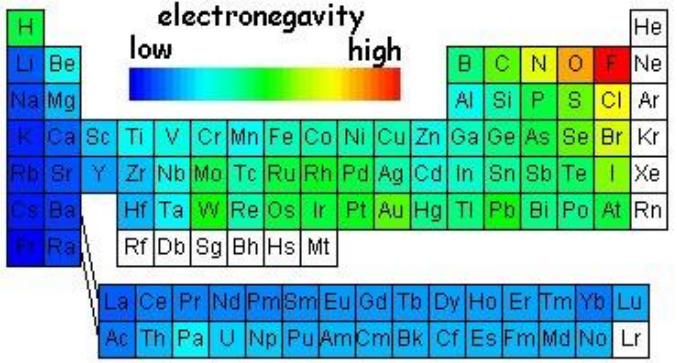
- **Ionic Compounds:** e– are transferred; Cation (+) & anion (–).
  - Opposite charge creates bond.
  - Occurs when compound is made of a metal & a nonmetal.

- Electron dot structures for:

As Ar Rb Ga O

- Electron movement when Rb combines with O:
  Rb + Rb + O →

Electronegativity



- Electropositive atoms: give up electrons and form cations (metals).
  - Francium (Fr) is the most electropositive
- Electronegative atoms: gain electrons and form anions (nonmetals).
  - Fluorine (F) is the most electronegative

- Li vs. Be? Most electropos:___ Most electroneg:____
- Li or Na? Most electropos:___ Most electroneg:____.

Covalent Bonds: Nonpolar

- **Covalent Bonds: sharing** of electrons;**similar** electronegativities
  - Between two non-metals and/or hydrogen

- **Non-polar: Identical** atoms; **similar** electronegativities
  - Exp: $\mathbf{H_2}$

    - Shared pairs represented by **: or -**

Covalent Bonds: Polar

- **Polar:** **Unequal** sharing; **large differences** in electronegativity (pg 15)
  - Exp: HCl

    - NOTE: H is not in same "row" or "family" as the other non-metals;it will ALWAYS be **lower in electronegativity** & be the atom that **becomes partially positive (+)**

      - Exps:

        C – N H – O C –Si

      - Which of the above molecules is the **most** polar (largest difference in polarity)?

      - NOTE:
        - Electroneg of H =
        - Electroneg of C =

    - C – H bond only slightly polar: we'll consider **nonpolar**

Organic Chemistry

- **Organic Chemistry:** Study of **covalent** compounds of **carbon.**
- **Valence:** The number of covalent bonds an atom can form, usually equal to the number of **electrons needed to fill the shell.**
  - Valence of: C H N O F

Practice Problems:

- C can form 4 bonds.
  - CH_4
  - CCl_4

Organic Chemistry

Practice Problems:

- C can form 4 bonds.
  - CO_2
  - HCN
  - C_2H_6

Organic Chemistry

Practice Problems:

- C can form 4 bonds.
  - C_2H_4
  - C_2H_2
  - C_3H_6
  - Problem 1.17 p17: C_4H_8 with 1 double bond

Organic Chemistry

Practice Problems:

- C can form 4 bonds.
  - Problem 1.17 p17: C_4H_8 with 1 double bond

Formulas 5 Types

1. Molecular: Tells # of each atom type, but NOT arrangement. (Order of elements in formula: C, H, then by alphabet/atomic number (CHNOPS)).

2. Structural: Shows arrangement of each atom, with a line for each bond

- 3. Abbreviated (Condensed) Structural: Shows ALL atoms on each carbon, but w/o bonds unless it's a double bond or more than one type of atom coming off a middle C

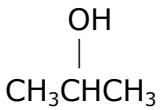
Formulas 5 Types

4. Line Segment: Lines represent carbon framework

- Carbon at each point & at each end
- H not shown, UNLESS the H is attached to something other than Carbon.

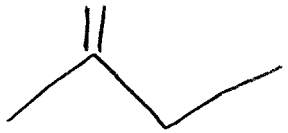
- 5. Skeletal: Only C & bonds between C shown, and atoms other than H.

Examples



1. **Molecular:**
2. **Structural:**
3. **Abbreviated Structural:**
4. **Line Segment:**
5. **Skeletal:**

Examples



1. **Molecular:**
2. **Structural:**

3. **Abbreviated Structural:**

4. **Line:**

**NOTE: MUST _____ (Can't put the CH_2 attached to the double bond in parentheses)

5. **Skeletal:**

Examples

- $CH_3CCl_2CH_3$

- $(CH_3)_2\ C\ (CH_2CH_3)_2$

Drawing Rings

- You MUST show the ring in ALL formula types.
- Abbreviated formula: For the RING PORTION ONLY, line structure may be used, but anything COMING OFF THE RING must be abbreviated.

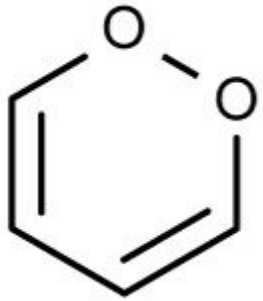
Example Ring Drawings:

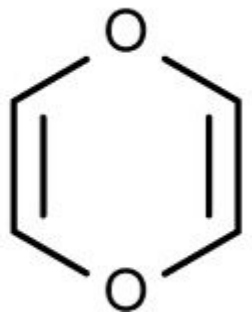
- Original / typical Abbreviated formula:
- Alternate Abbreviated formula allowed for RINGS ONLY. : For the RING PORTION ONLY, line structure may be used, but anything COMING OFF THE RING must be abbreviated.
- Structural: For a structural formula you must still show:
  - ALL bonds
  - ALL carbons
  - You CANNOT do a “line” for the ring

Isomers

- Same molecular formula but different arrangements of atoms

- **Structural Isomers:** Differ in the order in which the atoms are bonded.
  - ***Must*** meet valence requirements
  - Different chemical properties
    - Melting Point
    - Boiling Point
  - C_5H_{12} Has 3 isomers



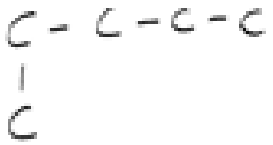


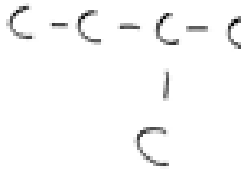
Isomer Example

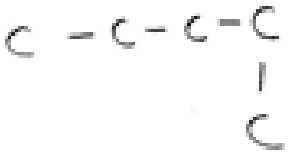
C_5H_{12} Has 3 isomers

Isomers

The following are NOT different isomers of C_5H_{12}, why?







Isomer Examples

- Draw the isomers for:
- $C_3H_6Br_2$ (There are 4 isomers)

Isomer Examples

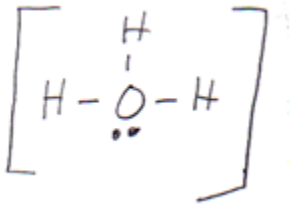
- Draw the isomers for:
- C_4H_8 (There are 5 isomers)

- C_2H_6O (2 isomers)

Formal Charge

- Some atoms within covalent compounds carry a formal charge.
- Areas with formal charges affect chemical reactions.
- Atom "owns" all of its unshared electrons AND 1 electron in each covalent bond.
- Simple determination: Count the #e- electrons each atom "owns" and subtract from the #e- in a normal atom of that element

Formal Charge Example

Example: Hydronium H_3O^+ or 

- Hydrogen in Hydronium ion
  - Usual # **valence** e- in H – #e- "owned" above = Formal charge

_____ – _____ = _____

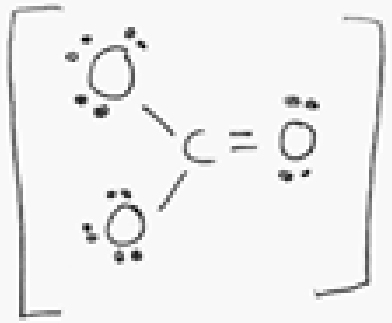
- Oxygen in hydronium ion:
  - Usual # **valence** e- in O – #e- "owned" above = Formal charge

_____ – _____ = _____

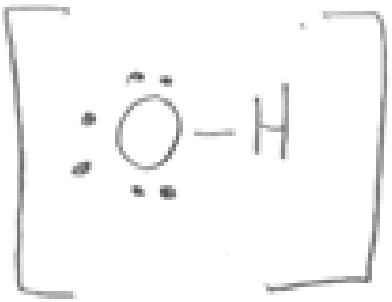
- Add the formal charge, if not 0, to the compound

Formal Charge Examples

Carbonate



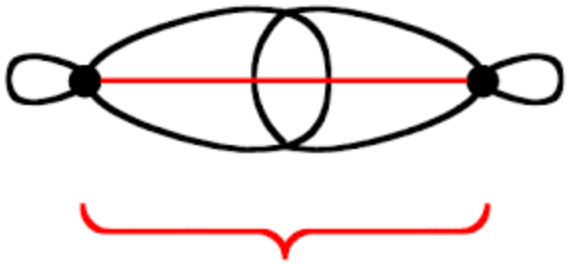
Hydroxide



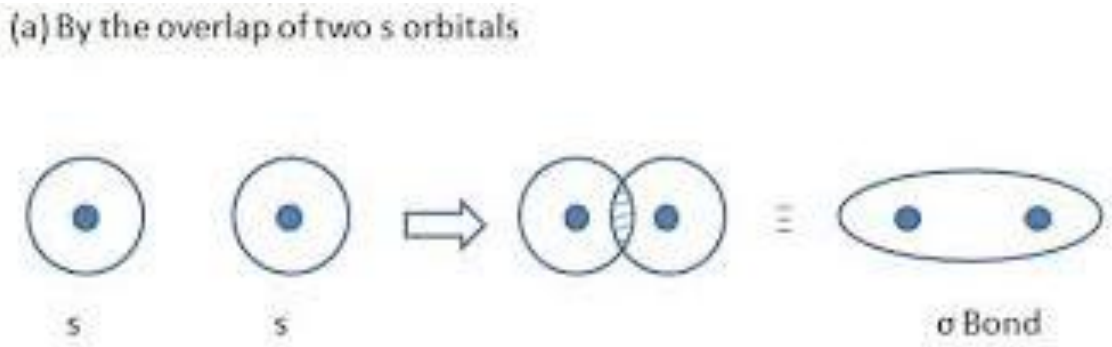
Arrows

Curved	Movement of electron pairs
Curved half-head (fishhook)	Movement of single electrons
Straight	Point from reactants to products, ONE WAY reaction
Double-headed straight (Arrow on both ends)	Resonance structures (Same substance, but electrons, not atoms, in different order)

Bonding and Orbitals

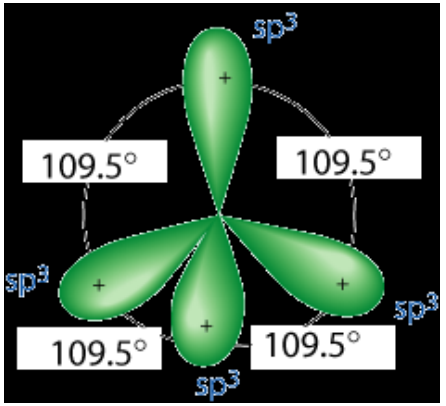


- Sigma (σ) bond: Formed by **ends overlapping** of 2 orbitals on adjacent atoms.
-
  - Between *s – s, s – p, or p – p*
  - (Can be between **any** type of orbitals)



Bonding and Orbitals

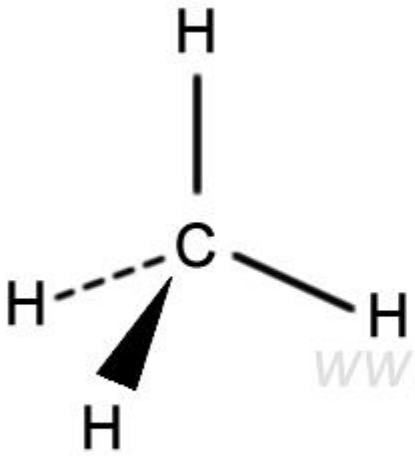
- sp^3 hybrid orbitals: Orbitals that are 1 part *s* & 3 parts p
  - Point towards the corners of a tetrahedron.
  - Orbitals are 109.5 degrees apart
  - All four sp3 orbitals are equal in energy.



Bonding and Orbitals

Tetrahedral Carbon Bonding of CH_4

- 4 sigma bonds between a s orbital of H & an sp^3 hybrid of C
- Bond ∠ each H – C – H = 109.5^0
- Tetrahedron: Plane of 2 corners & C is perpendicular to the plane of other 2 corners & C
- 3-D representation
  - Line: In plane of paper
  - Dashed wedge: behind
  - Solid wedge: forward towards you



Sketched 3-D Structural Formula of Methane

"Ball and Stick" Model of 3-D Structure of Methane

Classification

Ways to classify:

1. **Shape** of C skeleton
   - A. Acyclic. No Rings
     Exp:

   - B. **Carbocyclic**. Contains a ring of CARBON atoms.
     - Other atom types can be attached to the ring, but NOT in the ring itself.
       Exp:

   - C. **Heterocyclic**. RING contains ≥ 1 atom that is NOT Carbon
     Exp:

Classification: Ways to Classify

2. Functional groups attached or within C skeleton

- Type of carbon-to-carbon bond
  - **Alkane.** All single Carbon to Carbon bond.
    - Name ends with –ane
  - **Alkene.** 1 or more Carbon to Carbon double bonds.
    - Name ends with –ene
  - **Alkyne.** 1 or more Carbon to Carbon triple bonds.
    - Name ends with –yne

Classification: Ways to Classify

- **Arene.** Alternating Single AND Double bonds between Carbon in a 6 Carbon ring.

- If a multiple bond is present ANYWHERE in the molecule, it is **no longer** considered an alkane!!!!
  - Exp: If the chain is 10 carbons long with one double bond, the entire molecule is considered to be an alkene.

Classification

Ways to classify:

2. Functional groups attached or within C skeleton

- **Alcohol**

- **Ketone**
  - Double bond to oxygen in middle of carbon chain

- **Carboxylic Acid**
  - Always terminal, at end of chain or end of branch. Can be written multiple ways.

- **Amine**

Prior Knowledge #1

- 1. How would you explain to someone what an organic compound is?
- 2. Name 3 organic compounds.
- 3. Look around the room. What items are made primarily of organic compounds?

Prior Knowledge #2

1. How do you determine the subscripts for ionic compounds?

2. **PREDICT** the formula for an ionic compound made of Beryllium (Be) and Iodine (I):

3. Electronegativity:
   a. What is it?

   b. Which element has the highest electronegativity?

Prior Knowledge #3

1. Are the following ionic or covalent?

   SF_6 FH_4 SrF_2 CH_4 MnO_2 CuS

2. Which of the above are Organic?

3. What are the formulas for the following ionic compounds?

   a. Potassium Sulfate

   b. Iron(III) Oxide

   c. Calcium Phosphate

Prior Knowledge #4

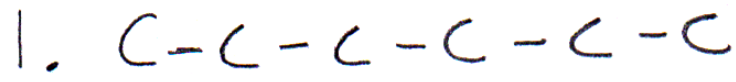
1. Determine what, if anything, is wrong with the following electron arrangement for carbon dioxide:

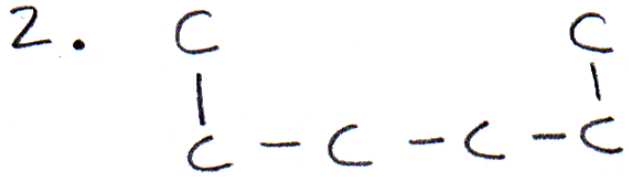
Prior Knowledge #5

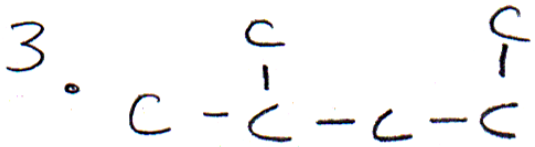
1. Using dashes for bonds, draw a structure for C_3H_4 that has the proper valence of 1 for each H & 4 for each C.

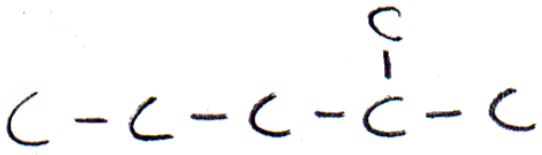
Prior Knowledge #6

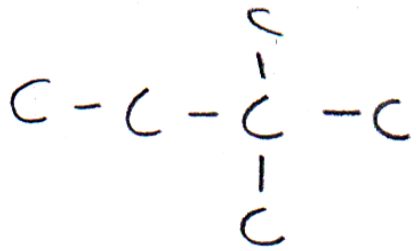
- Which of the following are:
- The same?
- Isomers?

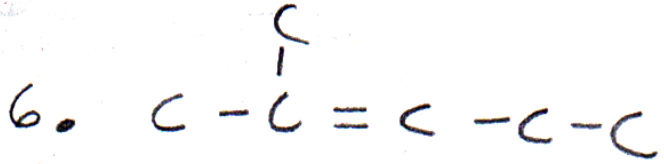
1. 

2. 

3. 

4. 

5. 

6. 

Prior Knowledge #7

Draw $CH_2BrCH_2OCH_3$ in the following formula types:

- Molecular
- Structural
- Skeletal
- Line

Chapter 1: QUIZ

- Points: 30
- All problems like HW, no MC
- Topics Covered:
  - Most electronegative? Electropositive?
  - Electron dot & valence for element
  - Decide Polarity of bonds
  - Draw polarity with arrows
  - Identify ionic vs. covalent compounds based upon polarity
  - Be able to draw the 5 formula types
  - Know which formula is which-will specify which I want for the questions
  - Isomers – draw given number, or identify