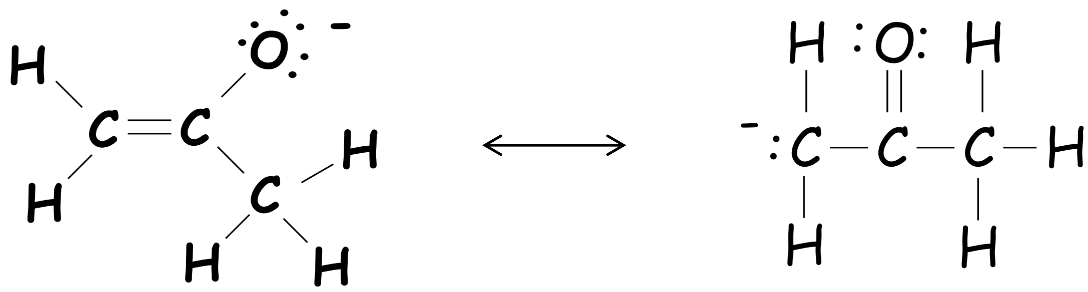
Resonance Structures

- Two valid Lewis structures can be drawn for the ion, $CH_2COCH_3^-$

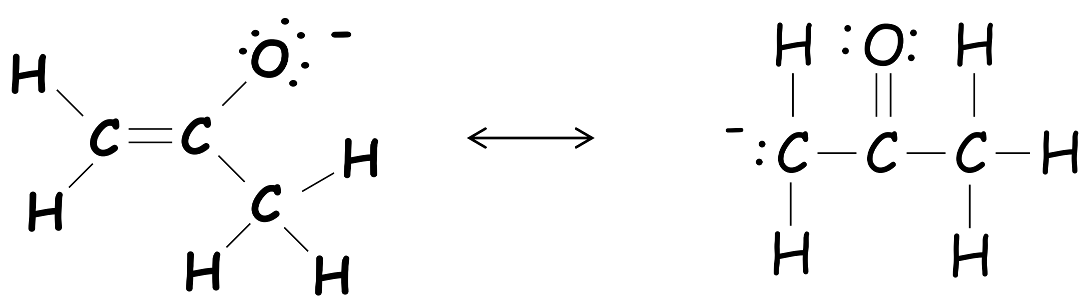


resonance structures

- Resonance structures:
  - Lewis structures that differ only in the placement of electrons.

Resonance Structures

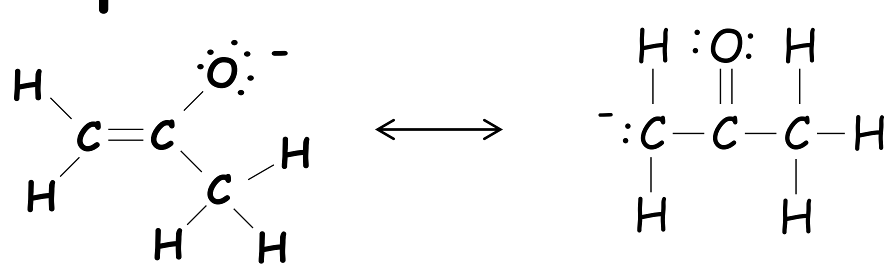
- $CH_2COCH_3^-$ exists as a resonance hybrid
  - a substance that requires 2 or more resonance structures to adequately represent it
  - properties of the substance are a blend of all possible resonance structures



Resonance Structures

- The negative charge on $CH_2COCH_3^-$ is delocalized over both the carbon and oxygen.
  - spread out over two or more atoms by resonance

- Charge delocalization makes $CH_2COCH_3^-$ more stable.
  - It is resonance stabilized because the charge can be spread out over 2 or more atoms.



Drawing Resonance Structures

- **Rules for drawing resonance structures:**
  - All resonance structures must be valid Lewis structures
  - Only electrons can be moved around
    - nuclei cannot be moved
  - Resonance stabilization is most important when it helps delocalize a charge over two or more atoms

Are these resonance structures?

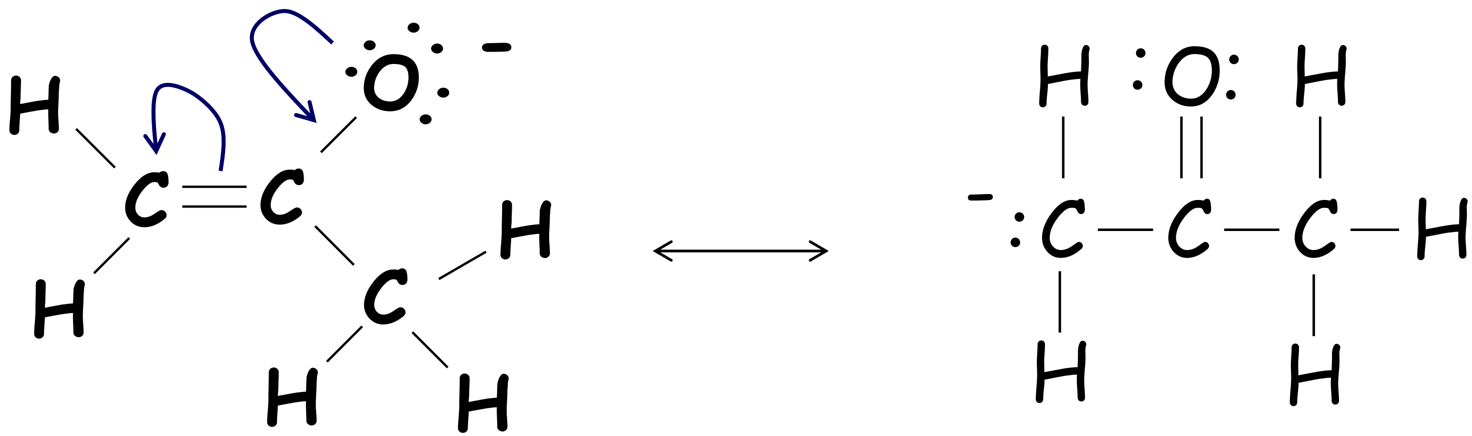
Resonance Structures

- To convert from one resonance structure to another:
  - move nonbonding electrons or pi electrons towards either:
    - a positive charge
    - an adjacent pi bond
    - a more electronegative atom

- Remember, <u>the electrons</u> move.
  - The charge is delocalized (and moves to a new atom) *as a result* of the electrons moving.

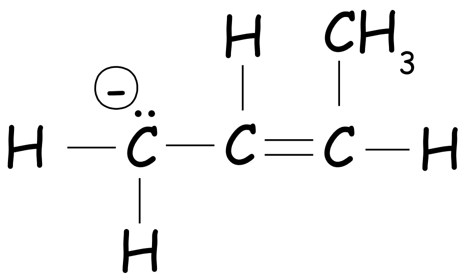
Resonance Structures

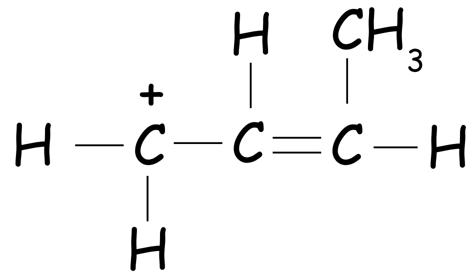
- Curved arrows are commonly used to show the <u>movement of electrons</u> when converting from one resonance structure to another.
  - Arrow begins at the electron pair that is moving.

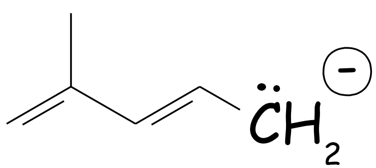


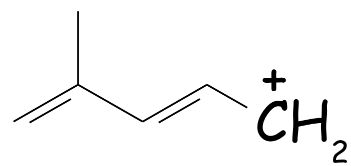
Resonance Structures

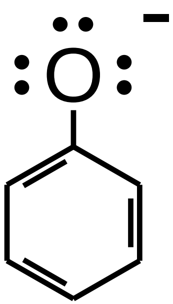
Example: **Draw all possible major resonance structures for the following.**

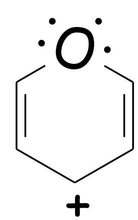












Resonance Structures

- The resonance structures for a particular substance sometimes have different energy and stability.
  - Major contributor:
    - the more stable resonance structure
      - lower energy
    - has the greatest influence on the properties and behavior of the resonance hybrid

  - Minor contributor
    - the less stable resonance structure
      - higher energy

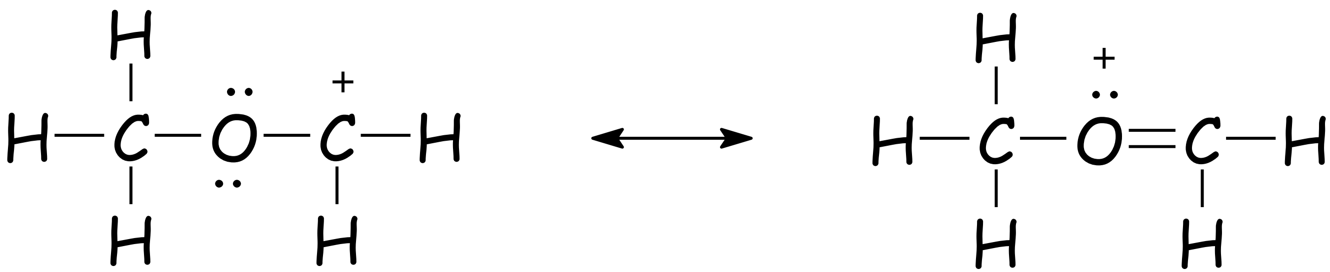
Resonance Structures

- A resonance hybrid most strongly resembles the lowest energy resonance structure (major contributor).

- Lewis structure of the major contributor is characterized by:
  - as many octets as possible
  - as many bonds as possible
  - negative charge on the most electronegative atom
  - as little charge separation as possible

Resonance Structures

Example: Consider the following two resonance structures for $CH_3OCH_2^+$. Which one is the major contributor?

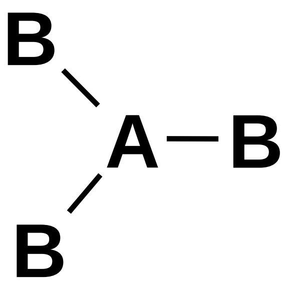


3-Dimensional Drawings

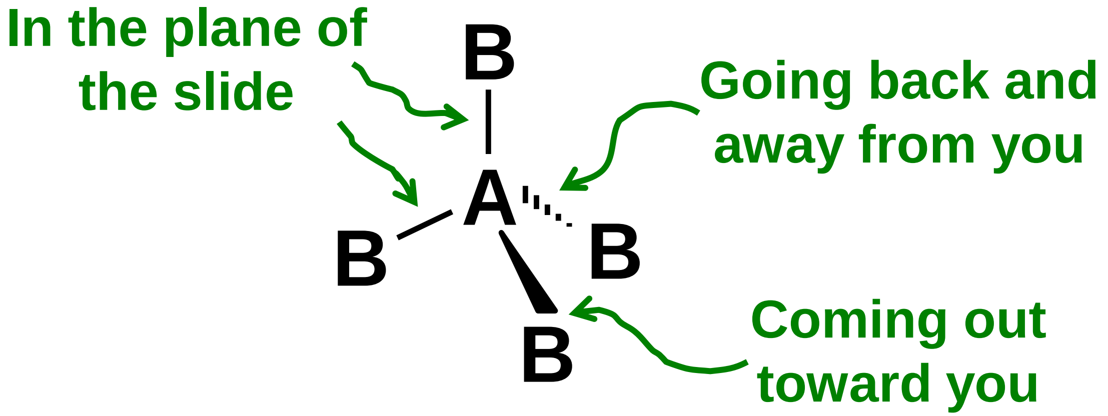
- VSEPR can be used to determine the electron domain and molecular geometries around any main group atom.
  - Draw the Lewis structure.
  - Count the number of electron domains.
  - Assign the geometry.
    - 2 e.d. =
    - 3 e.d. =
    - 4 e.d. =

3-Dimensional Drawings

- You must also be able to draw an appropriate 3-dimensional structure for organic molecules.



Trigonal planar



tetrahedral

3-Dimensional Drawings

Example: Draw a 3-dimensional drawing of acrylic acid, $H_2C{=}CHCO_2H$

3-Dimensional Drawings

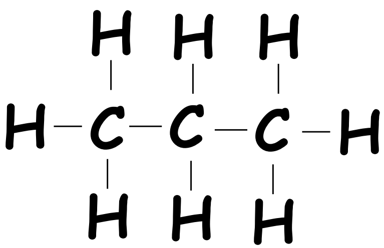
Example: Draw a 3-dimensional structure for acetone.

Condensed Structural Formulas

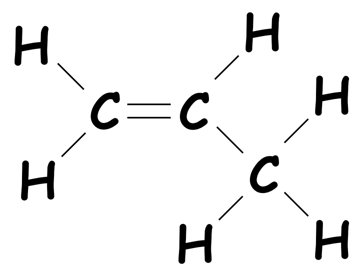
- Condensed structural formula
  - each central atom is shown with the atoms that are bonded to it
    - atoms bonded to the central atom are usually listed after the central atom
      - Put substituents in parentheses
      - two or more identical groups are shown in parentheses with a subscript to indicate quantity
  - the bonds between atoms are usually not shown
    - exception: double and triple bonds between two carbons should be shown

Condensed Structural Formulas

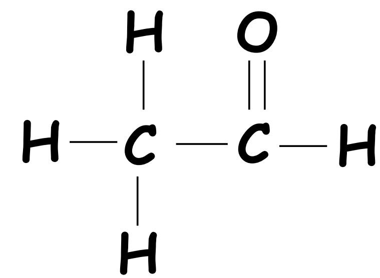
Examples:



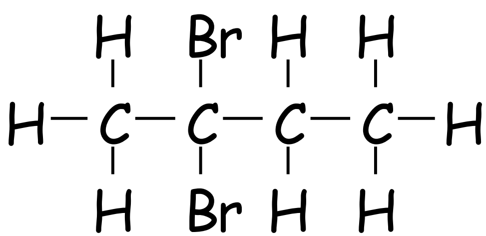
$CH_3CH_2CH_3$



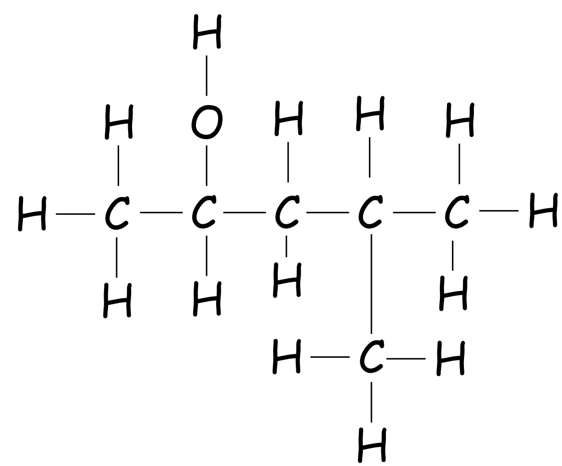
$H_2C{=}CHCH_3$



CH_3CHO



$CH_3C(Br)_2CH_2CH_3$



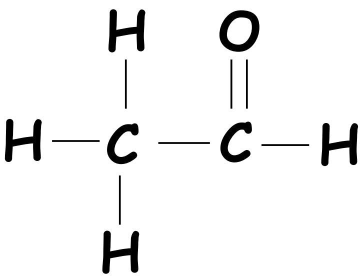
$CH_3CH(OH)CH_2CH(CH_3)_2$

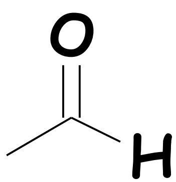
Line Angle Drawings

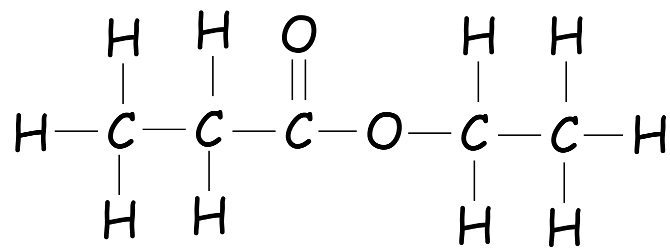
- Line-angle formula or drawing
  - bonds are represented by lines
  - carbon atoms are present:
    - where a line begins or ends (if no other atom is shown at the end of the line)
    - where two lines meet
  - Heteroatoms like N, O, S and halogen atoms are always shown.
  - Aldehyde hydrogens are always shown.
  - Other hydrogens are shown only if attached to an atom that has been drawn using its elemental symbol.

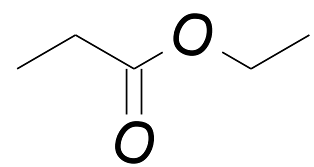
Line Angle Drawings

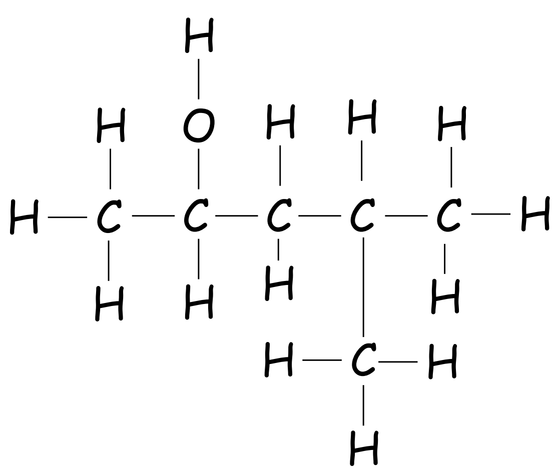
Examples:

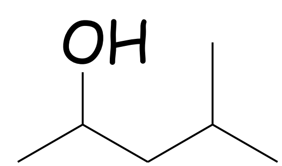








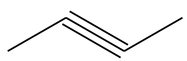




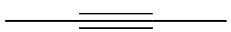
Line Angle Drawings

- Line angle drawings are intended to show 3-d structure.

- Common errors:

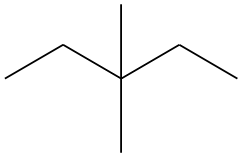


incorrect

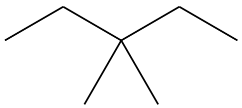


correct

Alkynes are linear, not tetrahedral or trigonal planar.



incorrect

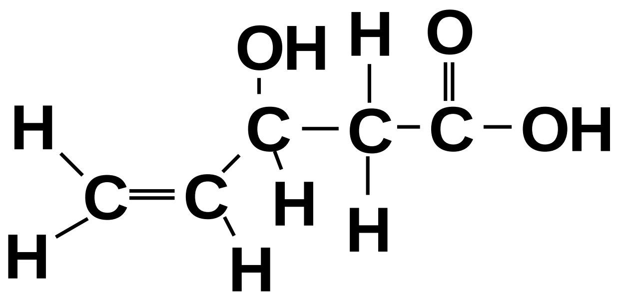


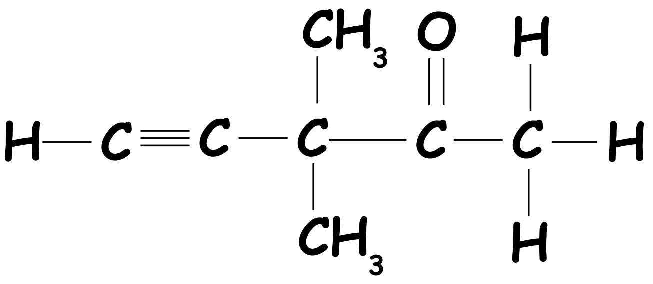
correct

Substituents on a tetrahedral C are ~109.5° apart, not 180° as this drawing shows.

Chemical Formulas

Example: Draw the condensed structural formula and the line angle drawing for:





Chemical Formulas

Example: **Draw the condensed structural formula for**