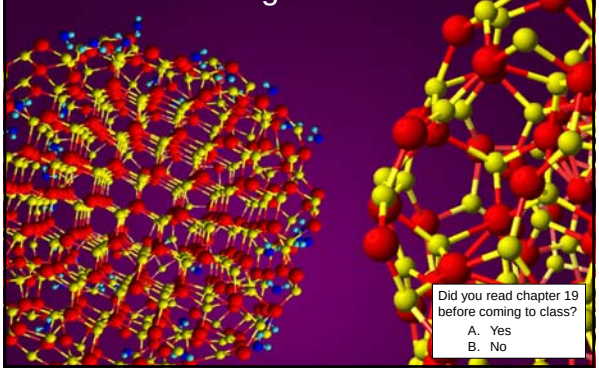
Chapter 19: Atoms, Molecules, and Extended-Bonding Substances



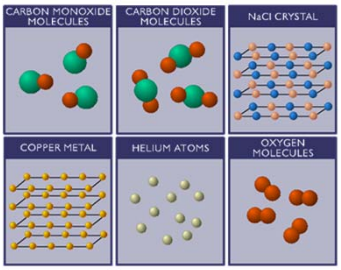
Did you read chapter 19 before coming to class?

A. Yes
B. No

Elements vs Compounds

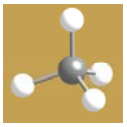
- Elements: only one kind of atom
- Compounds: two or more kinds of atoms

- Which are elements?
- Which are compounds?

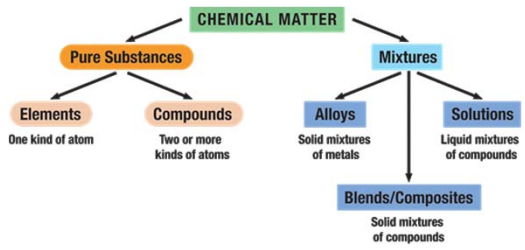


Chemical Bonds

- The constituent atoms in molecules are held together by "bonds". A bond is usually a pair of electrons.
  - Strong Bonds: Metallic, Ionic, Covalent
  - Weak Bonds: van der Waals, Hydrogen
- The quantum model explains them all
- In our visual models we often use sticks to represent bonds, and balls to represent atoms



Chemical matter is classified into a number of types



How does bonding work?

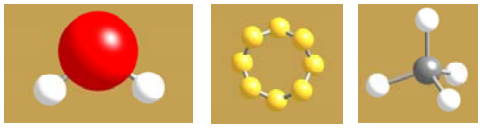
- Atoms give up, obtain, or share electrons and in the process combine to form the substances around us.
- Bonding involves only the electrons in the outermost, unfilled orbitals: *the valence electrons.* All other inner electrons don't matter as far as bonding is concerned.
- All bonding involves atoms sharing or exchanging electrons in a "stable" way.

Stability means:

- To fall to a lower energy state and thus be more tightly bound.
- To completely fill an orbital set.

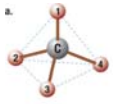
Writing chemical formulas for molecular matter

- Identify atoms in a molecule
- Give the number of each atom type
- Examples
  - H_2O
  - S_8
  - CH_4



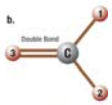
Molecules have shapes

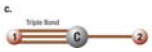
- How many ways can you arrange Carbon and Hydrogen?
- Guess the shape of Benzene
  - C_6H_6



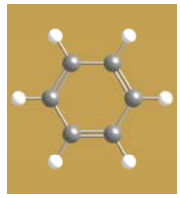
Tetrahedral

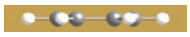
Planar





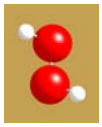
Linear



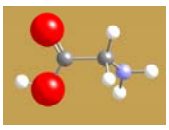


Friedrich August Kekulé discovered benzene's structure

Write down the chemical formula for these two molecules



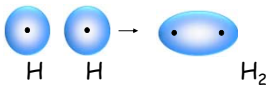
Hydrogen peroxide
Bleach and disinfectant

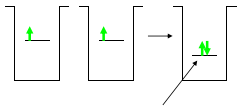


Glycine
One of the 23 essential Amino acids

The shape of a molecule is determined by molecular orbitals

- When H_2 was formed from H, energy was released as heat.
- So in H_2 each electron needs more energy than before to escape.
- H has a different discrete spectrum than H_2. This allows astronomers to tell the temperature of hydrogen gas.





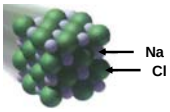
The electrons sit lower in the energy well than before

Chemical Formulas for Network/Extended Matter

1. Identify kinds of atoms
2. Give the *relative* number of each atom type

Atoms of metallic Mg

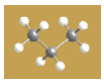
Sodium chloride
NaCl



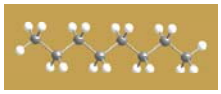
Quartz
SiO_2

Molecules belong to families -- Hydrocarbons

Methane -- CH_4



Propane -- $CH_3CH_2CH_3$ (or C_3H_8)



Octane -- $CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$ (or C_8H_{18})

What elements are present?

Formulas?

All react to form CO_2 and H_2O

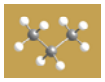
methane, propane, octane belong to hydrocarbon family
all three are used as fuels

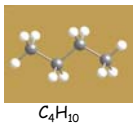
What formula represents this family of molecules?

A. $(CH_2)_n$
B. C_nH_{2n+2}
C. C_nH_{n+2}
D. $C_{2n}H_n$

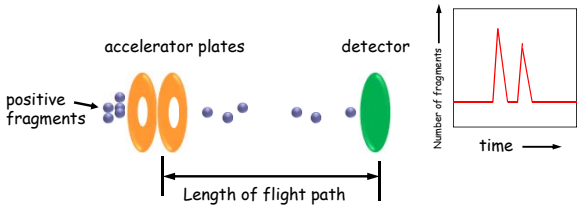
where n is an integer starting with 1


CH_4


C_3H_8


C_4H_{10}

Deducing molecular formulae and structures: Time-of-Flight Mass Spectrometer

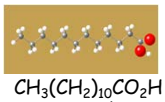


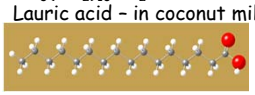
kinetic energy = $\frac{1}{2}$(mass)(speed)^2

If all fragments are given the same kinetic energy, which ones get to the detector first?

Another molecular family – Organic acids


CH_3CO_2H -- Acetic acid (gives vinegar its taste)


$CH_3(CH_2)_{10}CO_2H$
Lauric acid – in coconut milk

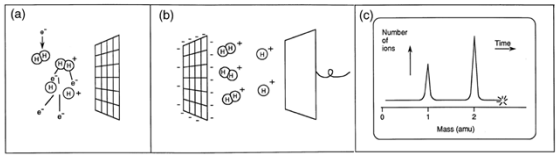

$CH_3(CH_2)_{14}CO_2H$ -- Palmitic acid (palm oils, and animals)

What groups of atoms are common to all three molecules?

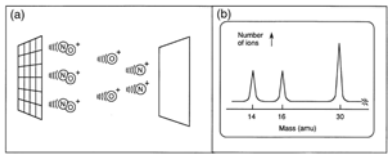
CH_3—
CH_2—
—CO_2H (carboxyl)

family of organic acids - all three are in foods we eat

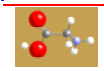
Deducing molecular structure with a mass spectrometer

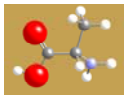


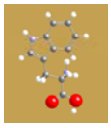
Nitric oxide



Amino Acids, the building blocks for protiens


$NH_2CH_2CO_2H$


$NH_2CHCH_3CO_2H$


$NH_2C_{10}H_9NHCO_2H$

What elements are present?

Formulas?

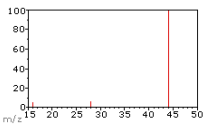
What groups of atoms are common to all three molecules?

NH_2— (amine)
—CO_2H (Carboxyl)

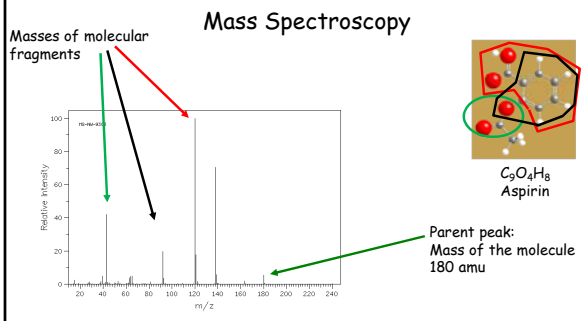
family of amino acids – acid group + amino group -- also in foods we eat

What molecule does this mass spectrum represent?

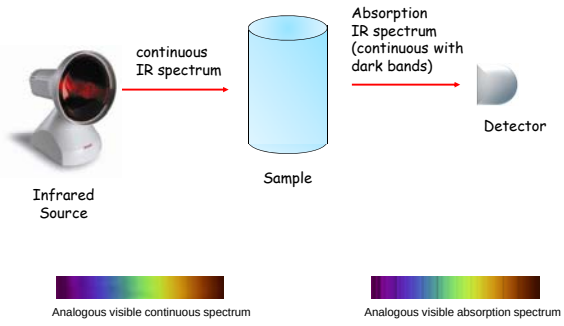
a) *CO*
b) H_20
c) *NO*
d) CO_2



Deducing molecular structure with a mass spectrometer

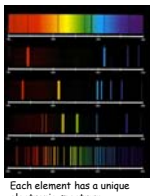


A simplified view of infrared (vibrational) spectroscopy

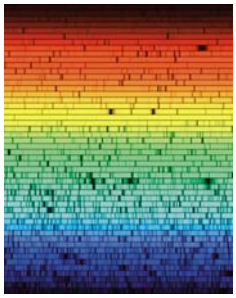


Electronic Spectroscopy

Solutions of transition and non-transition metals. Transition metals are often colored because of their electronic transitions.

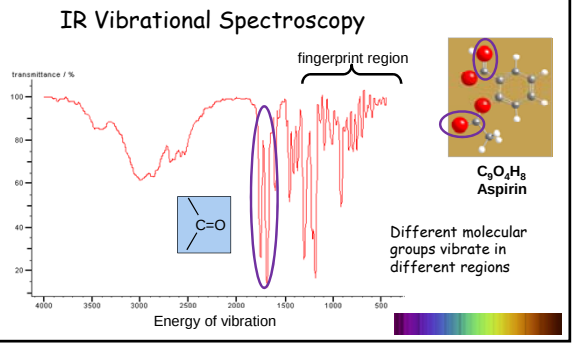


Each element has a unique electronic spectrum



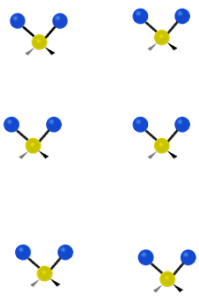
Visible absorption spectrum of the giant star Arcturus

IR spectroscopy can be used to deduce chemical formulas and structures



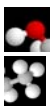
Motion within a molecules

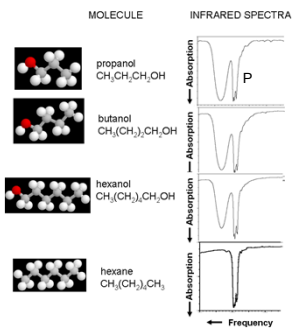
- Bonds are not rigid
  - lengths change
  - Bond angles bend – angle opens and closes
- The various types of stretches and bends occur with different energies and frequencies
- Energy depends on how stiff the bond is and the atomic masses that are moving.
- Most frequencies are in the infrared frequency range



A portion of the IR spectrum for each molecule is shown. Formulate a hypothesis about what portion of the molecule gives rise to the sharp set of peaks labeled P?

A. OH group
B. Hydrocarbon part





How do we deduce chemical formulas and structures?

Crystallography