Chemistry I
Notes #1b (2nd Semester)

Covalent Bonding

Chapter 9

Updated:3/10/2011

Covalent Bonding

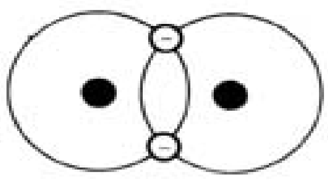
- Atoms form bonds to achieve stability
- Covalent Bond – sharing of valence e- to form bond.
- Molecule – formed when atoms bond covalently

Don't forget the octet rule

Formation of Covalent Bond

- H_2, N_2, O_2, F_2, Cl_2, Br_2, I_2, occur in nature bonded with themselves (Diatomic)

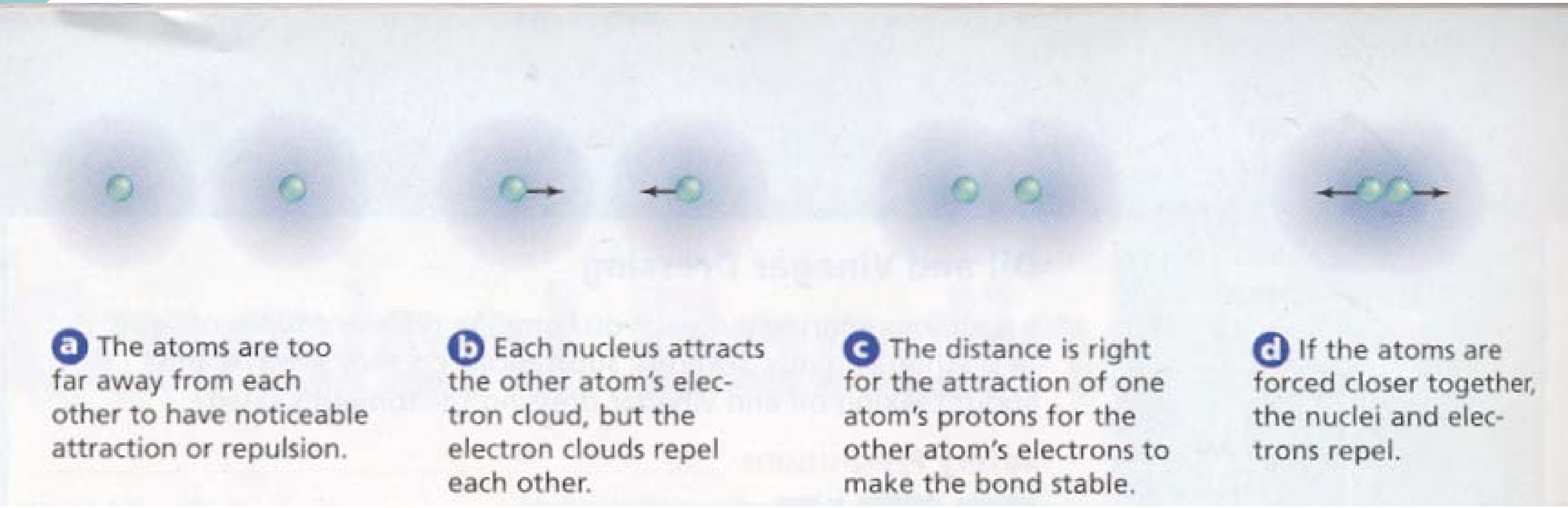
Figure 1-2
Covalent bond of two hydrogen atoms.



- F - $1s^2 2s^2 2p^5$ – 7 valence electrons. The sharing of 1e- will give both F atoms a stable noble gas configuration.

Formation of Covalent Bond

- These bonds form due to ATTRACTIVE and REPULSIVE forces



Single Covalent Bonds

- When a single pair of e- is shared
- Lewis Structure – use e- dot diagram to show how e- are arranged in molecules

  H:H or H—H

Multiple Bonds

- Double: 2 pairs e- shared
  - Ex. - O_2
- Triple: 3 pairs e- shared.
  - Ex. - N_2

Covalent Bonds

- sigma (σ) bonds –formed when valence atomic orbitals overlap or merges with another atom’s orbitals
- pi (π) bonds – formed when parallel orbitals overlap to share e-

First covalent bond is always sigma (σ), then pi (π) bonds follow.

Single bond = 1 sigma bonds

Double bond = 1 sigma and 1 pi bonds

Triple bond = 1 sigma and 2 pi bonds

Strength of Covalent Bonds

- The strength of a covalent bond is dependent on the *bond length*
- Bond length – distance between two nuclei at the position of maximum attraction.
- Bond length is determined by
  - the size of the atoms – increased size of atoms = increased bond length
  - the number of electrons shared – increased number of shared electrons = decreased bond length

Strength of Covalent Bonds

- The shorter the bond length, the stronger the bond.
- *Bond Dissociation Energy* – energy required to break a specific covalent bond.
  - Breaking bonds always requires the addition of energy, so bond dissociation energy is always positive (+)

Endothermic vs. Exothermic

- Endothermic reactions occur when the energy needed to break existing bonds is greater than the energy released to form new bonds
- Exothermic reactions occur when more energy is released forming new bonds than is required to break existing bonds.

9.2 Naming Molecules

1. First element is named using entire element name
2. Second element uses ending “ide”
3. Add appropriate prefix to indicate the number of atoms.

- Mono = 1
- Di = 2
- Tri = 3
- Tetra = 4
- Penta = 5
- Hexa = 6
- Hepta = 7
- Octa = 8

Naming Molecules

Extras...

- Do not use mono with the first element

  Ex. CO_2 = carbon **di**oxide

- Do not leave "ao" or "oo" combination in name

  Ex. N_2O_4 = **di**nitrogen **tetr**oxide

  NO = nitrogen **mon**oxide

Naming Molecules

Let’s Practice...

CCl_4 = carbon tetracholoride

As_2O_3 = diarsenic trioxide

SO_2 = sulfur dioxide

NF_3 = nitrogen trifluoride

Naming Molecules

Many molecules were named prior to the development of the modern naming system.

Formula	Common Name	Molecular Compound Name
H_2O	water	dihydrogen monoxide
NH_3	ammonia	nitrogen trihydride
N_2H_4	hydrazine	dinitrogen tetrahydride
N_2O	nitrous oxide (laughing gas)	dinitrogen monoxide
NO	nitric oxide	nitrogen monoxide

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Naming Acids

HCl

hydrogen chloride

hydrochloric acid

H_2SO_4

hydrogen sulfate

sulfuric acid

HNO_2

hydrogen nitrite

nitrous acid

Naming Acids

Binary Acids

- contain hydrogen and one other element
- use prefix “hydro-”+ name of element + change ending to “-ic”
- follow with the word acid

Ex. HF

hydrofluoric acid

Naming Acids

- follow same rules for non-binary acids that do not contain oxygen

Ex. HCN

$(CN)^-$ = cyanide

hydrocyanic acid

Naming Acids

<u>Oxyacids</u>

- contain hydrogen and an oxyanion (anions that contain oxygen – like NO_3^-)
- to name...
  - root of the oxyanion + "-ic" if the anion ends in "-ate"
  - root of the oxyanion + "-ous" if the anion ends in "-ite"
  - follow with the word acid

Ex. HNO_3

$(NO_3)^-$ = nitrate

nitric acid

Naming Acids

Let's Practice...

HI = hydroiodic acid

$HClO_3$ = chloric acid

$HClO_2$ = chlorous acid

H_2S = hydrosulfuric acid

Molecular Structures

- **Structural formula**
  - a molecular model that uses symbols and bonds to show relative positions of atoms
  - can be predicted for many molecules by drawing the Lewis structure.

Gilbert Lewis – 1875-1946
In 1916, he introduced the idea of covalent bonding

Molecular Structure

Steps to determine Lewis Structure

1. Predict (and draw) the location of atoms
   - Hydrogen is always a terminal (end) atom.
   - The first element listed is usually the central atom. All other atoms become terminal.

Molecular Structure

Steps to determine Lewis Structure

2. Find the total number of valence electrons needed to make each atom "stable."
3. Find the total number of valence electrons available.
4. Subtract "available" (step 3) from "needed" (step 2)
5. Divide by 2 (covalent bonds use 2 e-) to determine the total number of covalent bonds

Molecular Structure

Steps to determine Lewis Structure

6. Distribute covalent bonds between the atoms evenly.
7. Draw in remaining unshared electrons (remember octet rule.)
8. Count electrons to check your work.

Molecular Structure

Let’s Practice...

CH_4

SO_2

Chapter 9 Homework

page 272:
88,92,93,94,96,98,100,102,105,
106,108,111

RESONANCE

- When more than one valid structure exists for the same molecule, resonance occurs.

OCTET VIOLATORS

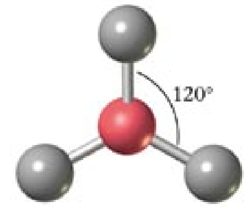
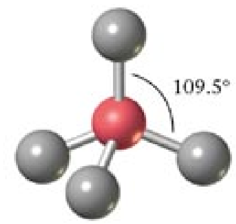
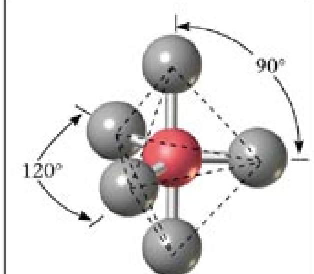
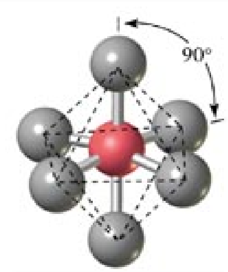
- When more or less than 8 electrons occur around a central atom in a covalent bond.
- 3 Reasons to violate octet rule:
  1. Odd number of valence electrons (NO_2)
  2. Rarely -some form with fewer than 8 e-
  3. Expanded octet – when d orbital comes into play.

MOLECULAR SHAPES

- The molecular geometry of covalent molecules is based on the **V**alence **S**hell **E**lectron **P**air **R**epulsion Theory: **VSEPR**

VSEPR

- Electron pairs arrange themselves to be as far apart as possible: this results in specific molecular shapes and **BOND ANGLES**
- **LONE PAIRS** (Unshared) of electrons occupy slightly larger amounts of space than shared pairs

Species type	Orientation of electron pairs	Predicted bond angles	Example	Ball and stick model
AX_2	Linear	180°	BeF_2	
AX_3	Triangular planar	120°	BF_3	
AX_4	Tetrahedron	109.5°	CH_4	
AX_5	Triangular bipyramid	90° 120° 180°	PF_5	
AX	Octahedron	90° 180°	SF_6	

POLARITY

- WHEN ONE END OF A MOLECULE HAS A CONCENTRATION OF NEGATIVE CHARGE AND THE OTHER END HAS A POSITIVE CHARGE THE MOLECULE IS POLAR.

POLARITY :When is it Polar?

- When there is an unequal sharing of electron pairs due to a large DIFFERENCE IN ELECTRONEGATIVITY BETWEEN TWO ATOMS IN THE BOND.

POLARITY :When is it Polar?

- WHEN THE MOLECULE IS NOT SYMMETRICAL: The molecule is not the same all the way around.

POLARITY :When is it Polar?

- When there are **unbonded** or lone pairs of electrons on one of the atoms in the bond.

POLARITY :When is it Polar?

- Electronegativity difference(Unequal sharing of electron pairs)
- Non-symmetrical molecule
- Unbonded pairs of electrons

POLARITY : IS IT POLAR?

- CCl_4
- NON POLAR BECAUSE IT IS **SYMMETRICAL**

POLARITY : IS IT POLAR?

- CH_3Cl
- POLAR: IT IS NOT SYMMETRICAL AND THE CHLORINE IS HIGHLY ELECTRONEGATIVE

POLARITY : IS IT POLAR?

- H_2O

- POLAR: IT IS NOT SYMMETRICAL AND THERE ARE 2 UNBONDED PAIRS OF ELECTRONS AROUND THE OXYGEN.

POLARITY : IS IT POLAR?

LOOK FOR:

- NON SYMMETRICAL
- UNEQUAL SHARING
- UNBONDED PAIRS OF ELECTRONS

IONIC OR COVALENT

WHEN IS A BOND IONIC OR COVALENT?

- FIND THE DIFFERENCE IN **ELECTRONEGATIVITY** BETWEEN ATOMS
- COMPARE THIS VALUE TO THE BOND POLARITY CHART

IONIC OR COVALENT

GENERAL GUIDELINES FOR BOND CHARACTER:

< .4 MEANS **NON POLAR COVALENT**

.4 < DIFF <1.8 MEANS **POLAR COVALENT**

>1.8 MEANS **IONIC**

PROPERTIES OF COVALENT COMPOUNDS

- THE **ATTRACTIVE FORCES** BETWEEN INDIVIDUAL COVALENT MOLECULES ARE GENERALLY **WEAK**
- **THIS RESULTS IN PROPERTIES THAT DIFFER FROM IONIC COMPOUNDS**

PROPERTIES OF COVALENT COMPOUNDS

GENERALLY, COVALENT COMPOUNDS HAVE:

- **LOW MELTING, BOILING POINTS**

Many are gases or liquids at room temp

- **SOLIDS ARE USUALLY SOFT**

Paraffin (wax), butter,