Chem 103, Section F0F
Unit VI - Compounds Part II: Covalent Compounds
Lecture 15

- The formation of covalent bonds
- Naming binary covalent and organic compounds
- The covalent bonding model

Lecture 15 - Covalent Bonding

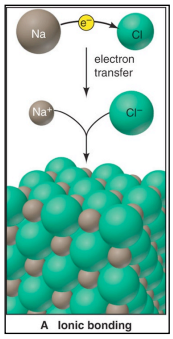
Reading in Silberberg

- Chapter 2, Section 7 (pp. 62-64)
  - *The Formation of Covalent Compounds*
- Chapter 2, Section 8 (pp. 70-72)
  - *Compounds, Formulas and Names*
- Chapter 9, Section 3
  - *The Covalent Bonding Model*

Lecture 15 - Introduction

So far we have focused primarily on ionic compounds

- Which combine metals with non metals
- Are held together by the electrostatic attractions of cations with anions



A Ionic bonding

Lecture 15 - Introduction

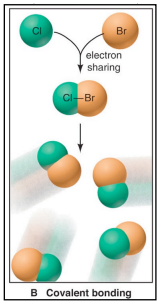
Today we will start looking in more detail at compounds that are held together by covalent bonds.

- We have encountered some examples already
  - Water
  - Acids
  - Polyatomic ions

Lecture 15 - The Formation of the Covalent Bond

Covalent compounds form when elements share electrons,

- This usually occurs between nonmetals.

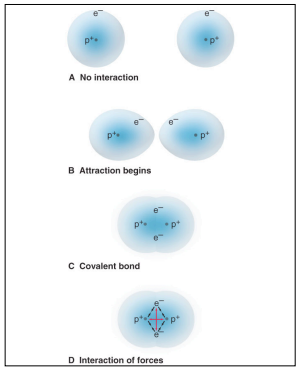


B Covalent bonding

Lecture 15 - The Formation of the Covalent Bond

Example: H_2

- The covalent bond that forms between two hydrogen atoms leads to the formation a diatomic molecule of H_2.



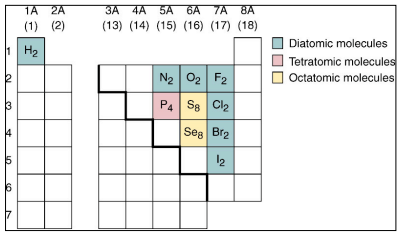
Lecture 15 - The Formation of the Covalent Bond

There are several other nonmetal elements that also form diatomic molecules:

- F_2, Cl_2, Br_2, I_2, O_2 and N_2

And others that form polyatomic molecules

- P_4, S_8 and Se_8

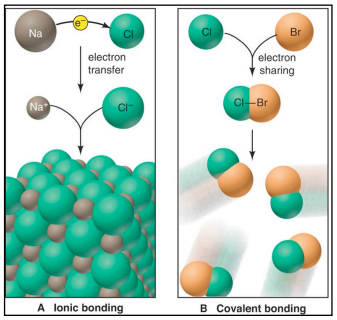


Lecture 15 - The Formation of the Covalent Bond

Covalent compounds can also form between atoms of different elements:

Lecture 15 - The Formation of the Covalent Bond

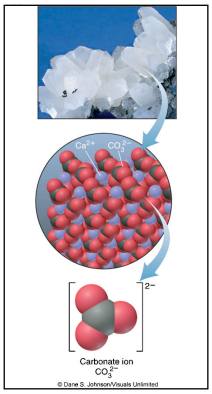
Unlike ionic compounds, covalent compounds are made up of individual molecules.



Lecture 15 - The Formation of the Covalent Bond

Polyatomic ions are both covalent and ionic:

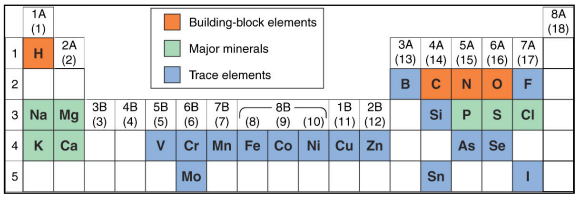
- For example:
  Calcium Carbonate ($CaCO_3$)



Lecture 15 - The Formation of the Covalent Bond

The elements of life

- About 25% of the elements are found in living organisms,
- However 99% of the compounds found in living organisms are made of C, H, O & N:



Lecture 15 - Naming Binary Covalent and Organic Compounds

- The name of the element with the lower group number goes first and the one with the higher group number goes second.
  - CO (carbon monoxide)
- If the two elements are in the same family, the one with the higher period number goes first
  - BrCl3 (bromine trichloride)
- The sufix *-ide* is appended to the second element
- A Greek prefix is used to indicate the number of atoms of each

Lecture 15 - Naming Binary Covalent Compounds

Table 2.6 Numerical Prefixes for Hydrates and Binary Covalent Compounds

Number	Prefix
1	mono-
2	di-
3	tri-
4	tetra-
5	penta-
6	hexa-
7	hepta-
8	octa-
9	nona-
10	deca-

Lecture 15 - Naming Binary Covalent Compounds

We will focus first on the hydrocarbons that have only carbon-carbon single bonds.

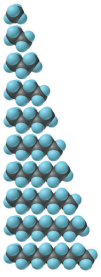
- This group of molecules is called alkanes.
- Alkanes can be *straight-chained* or *branched-chained*
- The names for alkanes all end with the ending *-ane*.

Lecture 15 - Naming Binary Covalent Compounds

For straight chain alkanes, a prefix is used to indicate the number of carbons in the chain:

Table 2.7 The First 10 Straight-Chain Alkanes

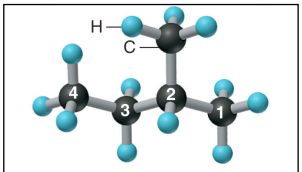
Name (Formula)	Model
Methane (CH_4)	
Ethane (C_2H_6)	
Propane (C_3H_8)	
Butane (C_4H_{10})	
Pentane (C_5H_{12})	
Hexane (C_6H_{14})	
Heptane (C_7H_{16})	
Octane (C_8H_{18})	
Nonane (C_9H_{20})	
Decane ($C_{10}H_{22}$)	



Lecture 15 - Naming Binary Covalent Compounds

The branched-chained hydrocarbons, longest chain of carbons forms the root name.

- The branches have names that end in *-yl* instead of *-ane*.

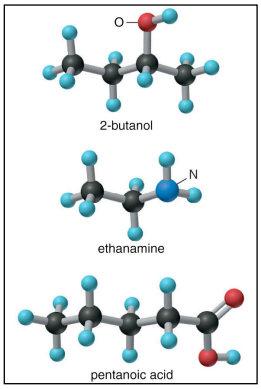


Ball-and-stick model of 2-methylbutane

Lecture 15 - Naming Binary Covalent Compounds

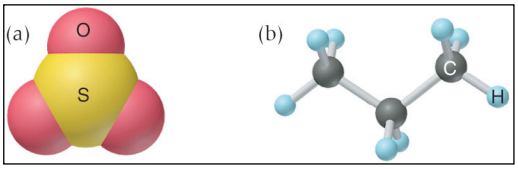
Going beyond alkanes, other organic molecules have groups of atoms containing elements other than carbon and hydrogen.

- These are called **functional groups**.
- Examples
  - Alcohols -OH
  - Amines -NH_2
  - Carboxylic acids -COOH



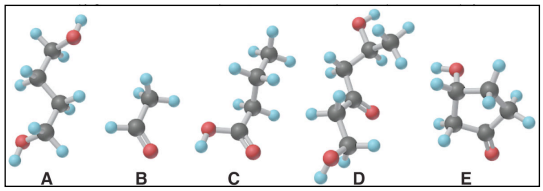
Lecture 15 - Question 1

Give the formula, name and molecular mass of the following molecules:



Lecture 15 - Question 1

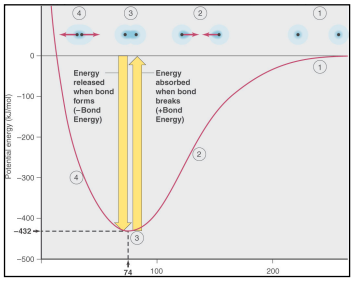
Which of the following models represent compounds having the same empirical formula?



Lecture 15 - The Covalent Bond Model

Covalent bonds form when the nuclei of one atom is attracted to the electrons of another.

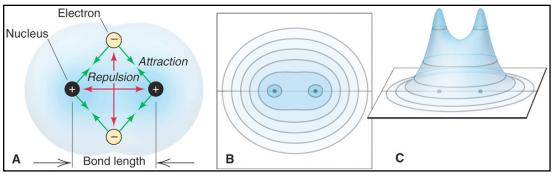
- And the attraction is mutual.



Lecture 15 - The Covalent Bond Model

Covalent bonding leads to a greater electron density between the atoms

- In a covalent bond, electrons from two atoms are shared.
- There are rules to how covalent bonds form.



Lecture 15 - The Covalent Bond Model

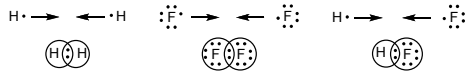
Like ionic bonding, covalent bonds form as a way of giving each atom 8 valence electrons (except hydrogen, which only wants 2 valence electrons).

- Instead of accomplishing this by one atom giving its electrons to the other, as occurs in ionic bonding
- The two atoms involved in a covalent bond "share" electrons pairs,
  - Each atom counts those electrons as part of its valence shell.

Lecture 15 - The Covalent Bond Model

Lewis dot structures are useful for showing this:

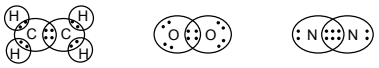
	1A(1)	2A(2)	3A(13)	4A(14)	5A(15)	6A(16)	7A(17)	8A(18)
	ns^1	ns^2	ns^2np^1	ns^2np^2	ns^2np^3	ns^2np^4	ns^2np^5	ns^2np^6
Period 2	Li	Be	B	C	N	O	F	Ne
Period 3	Na	Mg	Al	Si	P	S	Cl	Ar



Lecture 15 - The Covalent Bond Model

If sharing just one pair of electrons is insufficient to meet the needs of each atom participating in a covalent bond, then additional pairs of electrons can be shared.

- The leads to the formation of double and triple bonds.



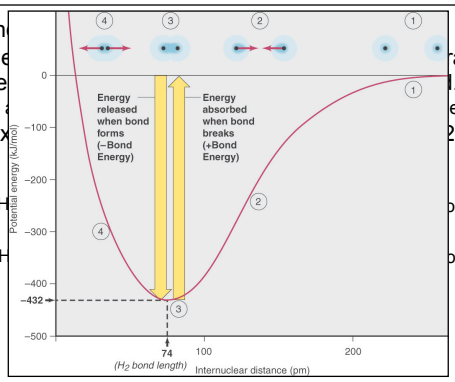
- The number of electron pairs shared in a covalent bond give the bond order of the bond
  - Single bond has bond order of 1
  - Double bond has a bond order of 2
  - Triple bond has a bond order of 3

Lecture 15 - The Covalent Bond Model

The bon
- It is he raction betwe l.
  - It is a ed.
- For ex 2 kJ/mol

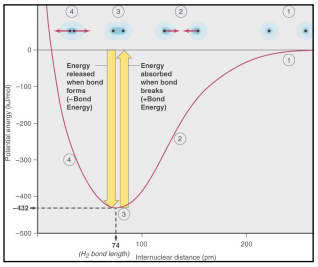
H ol

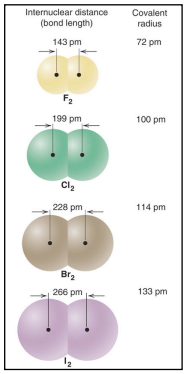
H ol



Lecture 15 - The Covalent Bond Model

The bond length is the distance between the nuclei of the the two atoms participating in a covalent bond.





Lecture 15 - The Covalent Bond Model

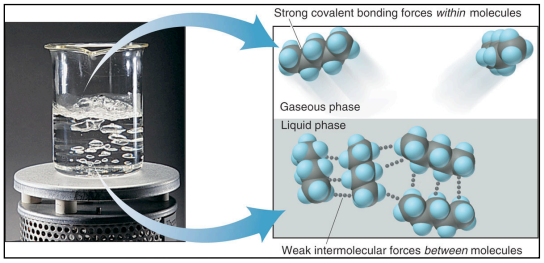
As the bond order *increases*, the bond length *decreases*

Table 9.3 The Relation of Bond Order, Bond Length, and Bond Energy

Bond	Bond Order	Average Bond Length (pm)	Average Bond Energy (kJ/mol)
C—O	1	143	358
C═O	2	123	745
C≡O	3	113	1070
C—C	1	154	347
C═C	2	134	614
C≡C	3	121	839
N—N	1	146	160
N═N	2	122	418
N≡N	3	110	945

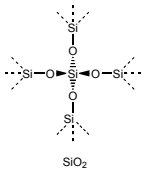
Lecture 15 - The Covalent Bond Model

The physical properties of covalent substances
- Generally have low melting points and boiling points compared to ionic compounds.

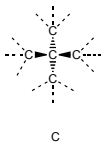


Lecture 15 - The Covalent Bond Model

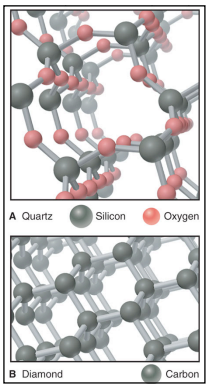
The few compound, however, form covalent networks of covalent bonds and have extremely high melting points.
- Quartz
- Diamonds



SiO_2



C



Unit VI - Up Next

Lecture 16 - Covalent Bonding con'd
- Bond energies and chemical change
- Electronegativity and bond polarity

The End