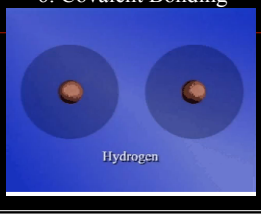
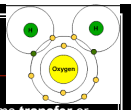
Chemical Bonding

Part 3:
Covalent Bonds,
Chemical Formulas, Structural Diagrams

6. Covalent Bonding



Bond with me



- A chemical bond forms when atoms **transfer** or **share electrons**.
- For example, in a water molecule, each hydrogen atom shares its single electron with the oxygen at the center.
- This way, all of the atoms are happy with full shells.
- Almost all elements form chemical bonds easily - which is why most matter is found in compounds.

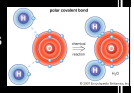
Types of bonds

- There are a couple different types of bonds.
  1. **Ionic** Bond
  2. **Covalent** Bond
  3. **Metallic** Bond
- Now, we are going to talk about covalent bonds.

7. Covalent Bonding

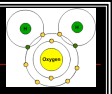
Cooperating Covalents

- What is a covalent bond?
- A bond formed by **shared electrons**.
- Also, **molecules** are groups of atoms that are held together by covalent bonds in a specific ratio & shape.



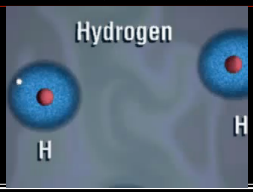
- UCSD SuperComputer Center Animation

Covalent Bonds

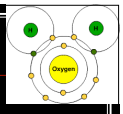


- A **covalent bond** is formed when atoms **share** electrons.
- The bonds between oxygen and hydrogen in a water molecule are covalent bonds.
- There are two covalent bonds in a water molecule, between the oxygen and each of the hydrogen atoms.
- Each bond represents one electron.
- In a covalent bond, electrons are **shared** between atoms, not transferred.

8. Special information about Hydrogen bonding

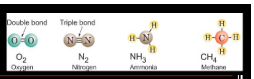


"M" is for Molecule



- A group of atoms held together by covalent bonds is called a **molecule**.
- Water is a molecule, and so is sugar.
- Other examples of molecules are
  - methane (CH_4)
  - ammonia (NH_3)
  - oxygen (O_2)
  - nitrogen (N_2).

Fancy Bonding

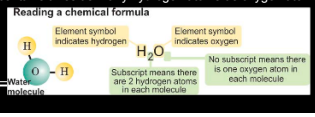


- Sometimes, atoms share more than one electron.
- Occasionally, they can share 2 or even 3 electrons.
- These are called **double** and **triple** bonds.

Single bond	Double bond	Triple bond
H–H	O=O	N≡N
H:H	·Ö::Ö·	·N:::N·

Chemical Formulas

- Molecules are represented by a **chemical formula**.
- The chemical formula tells you the **exact number** of each kind of atom in the molecule.
- For example, the chemical formula for water is H_2O.
- The **subscript** 2 indicates there are two hydrogen atoms in the molecule.
- The chemical formula also tells you that water always contains twice as many hydrogen atoms as oxygen atoms.



Chemical Formula Take 2

- Water is a simple molecule, so the formula is pretty easy.
- Let's look at a more complex molecule.
- Baking soda, or sodium bicarbonate, is $NaHCO_3$.
- That means it has:
  - 1 Sodium (Na)
  - 1 Hydrogen (H)
  - 1 Carbon (C)
  - 3 Oxygen (O)

You Try it!

- Let's see how you do it. Next to each formula, write the name and number of each element.

Chemical Formula	Elements - #
C_6H_6	
NH_3	
$Al(OH)_3$	
$CO(NH_2)_2$	

You Try it!

Chemical Formula	Elements - #
C_6H_6	Carbon - 6 Hydrogen - 6
NH_3	
$Al(OH)_3$	
$CO(NH_2)_2$	

You Try it!

Chemical Formula	Elements - #
C_6H_6	Carbon - 6 Hydrogen - 6
NH_3	Nitrogen - 1 Hydrogen - 3
$Al(OH)_3$	
$CO(NH_2)_2$	

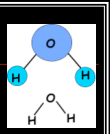
You Try it!

Chemical Formula	Elements - #
C_6H_6	Carbon - 6 Hydrogen - 6
NH_3	Nitrogen - 1 Hydrogen - 3
$Al(OH)_3$	Aluminum - 1 Oxygen - 3 Hydrogen - 3
$CO(NH_2)_2$	

You Try it!

Chemical Formula	Elements - #
C_6H_6	Carbon - 6 Hydrogen - 6
NH_3	Nitrogen - 1 Hydrogen - 3
$Al(OH)_3$	Aluminum - 1 Oxygen - 3 Hydrogen - 3
$CO(NH_2)_2$	Carbon - 1 Oxygen - 1 Nitrogen - 2 Hydrogen - 4

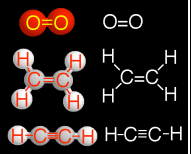
Structural Diagram



- The shape of a molecule is also important to its function and properties.
- For this reason, molecules are represented by **structural diagrams** which show the shape and arrangement of atoms.
- A single bond is represented by a bold short line.
- For example, water would look like this:

Structural Diagram - take 2

- Double and triple bonds are indicated by **double** and **triple** lines.
- Here are some examples:



Structural Diagram - take 3

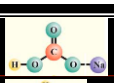
- Of course, real molecules are **3-dimensional**, not flat as shown in a structural diagram.
- For example, methane - CH_4 - has the shape of a 4-sided pyramid called a tetrahedron.

Chemical Formula	Diagram with Electrons	Flat Structural Diagram	3D Structural Diagram
CH_4			

You Try it!

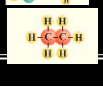
Match the structural diagram with its chemical formula.

1. C_2H_6
2. $NaHCO_3$
3. $HC_2H_3O_2$
4. C_6H_6

A 

B 

C 

D 

You Try it!

Match the structural diagram with its chemical formula.

1. C_2H_6 - D
2. $NaHCO_3$ - A
3. $HC_2H_3O_2$ - C
4. C_6H_6 - B

A 

B 

C 

D 

Lewis Dot Molecules

- We've already seen how you draw a Lewis dot structure.
- The dots represent the valence electrons of an atom.
- We can draw Lewis dot structures for molecules too.
- Each element forms bonds to reach one of the magic numbers of valence electrons: **2** or **8**.
- In dot diagrams of a happy molecule, each element symbol has either 2 or 8 dots around it.

Lewis Dot Molecule - Example

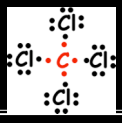
- Draw the dot diagram for carbon tetrachloride, CCl_4.
  1. List the elements in the molecule
- Carbon
- Chlorine

Lewis Dot Molecule - Example

- Draw the dot diagram for carbon tetrachloride, CCl_4.
  1. List the elements in the molecule
  2. Determine how many valence electrons each element has.
- Carbon - 4
- Chlorine - 7

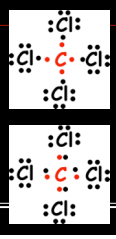
Lewis Dot Molecule - Example

- Draw the dot diagram for carbon tetrachloride, CCl_4.
  1. List the elements in the molecule
  2. Determine how many valence electrons each element has.
  3. Match the elements so that each atom has 8 (or 2 for H & He) electrons.
- Carbon - 4
- Chlorine - 7



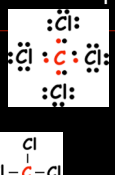
Lewis Dot Molecule - Example

- Notice that with this molecule, each atom has 8 electrons.
- The shells are all full!!!
- Each chlorine atom shares an electron with carbon.
- In return, carbon shares its electrons with chlorine.
- We can change the drawing to look like this…

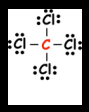


Lewis Dot Molecule - Example

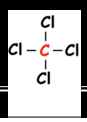
- Eventually, this drawing changes into…



- This one…



- And finally, into this one….



9. Time for a little music!

What Kinds Of Bonds Are These?

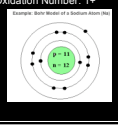
Lyrics & Music © 2005, Mark Rosengarten

You Try it!

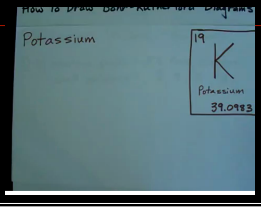
- Now, time for you to draw dot diagrams of molecules!!
- And count some atoms!
- Little Book Pg: 4 & 5

LB: Pg 4: Bohr Models

- Bohr Models show ALL the electrons, protons and neutrons in an atom.
- Start by completing the info on the side.
- Complete the info in the nucleus
- Finish by drawing ALL the electrons around the nucleus.
- Symbol: Na Atomic Number: 11
- #of Electron: 11 #of protons: 11
- Atomic Mass:23 # of Neutrons:12
- Oxidation Number: 1+



Video: How to draw a Bohr diagram



LB: Lewis Dot Structures: pg5

- Information needed:
- Example: Aluminum Atomic # 13:
- Symbol: Al
- Valence electrons: 3
- You simply put the valence electrons around the element symbol

Video: How to draw a Lewis Dot Diagram

Lewis Dot Structure for Aluminum

And finally, Counting Atoms: (found on the back of the ionic lecture)

- Name: Calcium Carbonate:
- Also known as: Limestone
- Formula: $CaCO_3$
- We have to account for each and every atom:
- Ca: Calcium
- C: Carbon
- O: Oxygen

- The Formula is : $CaCO_3$
- How many atoms do we have: Ca: 1 C: 1 O: 3 total: 5 atoms
- What is their atomic number: Ca: 20 C: 6 O:8
- Ca: Alkaline Earth Metal: metal
- C: Carbon Family: nonmetal
- O: Oxygen Family: nonmetal