Chemical Structures

Lecture 9

Part I.

Electron Dot Diagrams & Covalent Bonding

Valence and Covalent Bonding

- In order to look at covalent bonding, you need to look at valence electrons.
- The electron dot diagrams allow this, but to use them we construct 2 parts to the atom:

  1-the **kernel =** the nucleus plus the inner, non-valence electrons

  2-the **valence electrons**.

Carbon as an example

- Carbon has an atomic number of 6.
- We represent the kernel: its nucleus and the first 2 electrons (which fill 1s) by using the symbol for carbon **C**
- The 4 remaining electrons at principal energy level 2 ($2s^2\ 2p^2$) are the valence electrons. We will represent these around the kernel as a series of dots.
- They must be placed in a special manner.

Indicate the Filled Orbitals.

- Valence electrons are found to only occupy s and p orbitals; s has one orbital (2 electrons max.) and p has 3 orbitals (6 electrons max.)
- A total of 4 orbitals exist as valence space.
- If **X** represents an element's symbol, the electrons of the sublevels are placed so:

s

p_z **X** p_x

p_y

What is not there matters too

- If an orbital is empty leave that position blank.
- If an orbital has 1 electron place a dot to represent the electron at that position.
- Carbon's valence using the electron dot diagram:

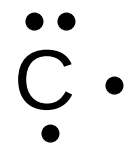
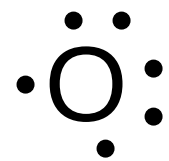


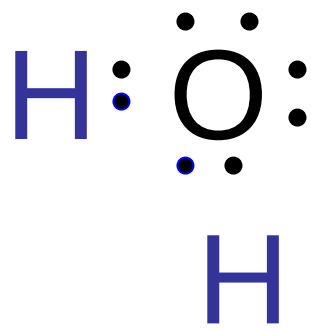
Figure these out

- <u>Oxygen</u>
  - What is the atomic #?
  - Draw the electron configuration.
  - What is its valence energy level?
  - What is its valence electron #?
  - Draw the electron dot diagram.

- <u>Oxygen</u>
  - Atomic # = 8
    - Electrons # = 8
  - Configuration is
    - $1s^2 2s^2 2p^4$
  - Valence energy level is 2.
  - Valence electron # is 6
  - Electron dot diagram
  - 

Now you can begin bonding:

- if oxygen has 2 empty orbitals
- 2 hydrogen atoms could share their 1 electron with this oxygen atom to create water:



The octet rule

- This rule states that there is a tendency for atoms in molecules to have 8 electrons in their valence shells, if they have sp sublevels. (hydrogen has only s-fills with 2)
- Many molecules have atoms which follow this rule, some do not.
- In this course we will look at those which do.

The periodic table

- The period that an element is found within will determine the valence and bonding capacity.
- Until now what we have reviewed refers primarily to the first two periods of the table.
- Where the d sublevels surface, exceptions do as well. (this begins in the 3rd period)

Rules to Bonding: Make a Molecule

1. Calculate the total valence electron number, of all atoms in the molecule. (the group A number of each atom = the valence *sp* electrons)
2. Draw out the skeleton of the molecule, start with atoms that form the most bonds, draw the electron dot diagrams.
3. Rearrange atoms to distribute electrons around the atoms surrounding the central atom, to fill the valence shell if needed.
4. Distribute the remaining electrons around the central atom(s) if a shortage exists, there are double bonds.

Skeletal Structure of a Molecule

- Most small molecules have one or more central atoms surrounded by more electronegative atoms.
  - electronegative atoms have a greater valence electron # than the central atoms. They belong to groups 6 and 7A (O, Cl, F..)
- Atoms with very low electro-negativity and low valence number also are found surrounding the central atoms.
  - These elements are in groups 1 and 2A (H, Na, Mg)

Exceptions

- Compared to what we have talked about thus far items in the 4^{th} period & beyond, have atoms with d and f sublevels being filled that produce pseudo-noble-gas-cores when full.
- We recognize the B group as being the same as their valence number.

Part II.

Chemical Structures & Drawing Molecules

Molecular Formulas

- The molecular formula tells you how many atoms are in a molecule of a compound.

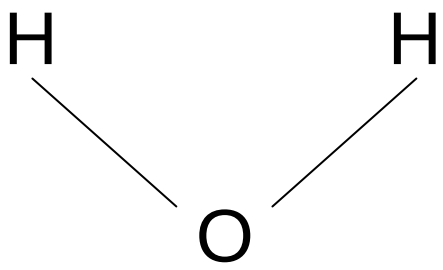
For example :

The molecular formula for water is H_2O

Which tells you that one molecule of water has 2 hydrogen atoms and 1 oxygen atom.

Structural Formula

On the other hand the structural formula is the diagram of how all of the atoms are bonded to one another in space.



This is the structural formula of a water molecule. It shows the bonds that link the atoms that are found in one molecule of water. The dots (from the last lecture) disappear and dashes represent 2 shared electrons, 1 covalent bond.

We are basically going to look at organic compounds

- Organic refers to molecules with a carbon based backbone
  - (one or more carbon atoms at the center of multiple bonds forming a molecule
  - Typically CHNOPS are the elements found in living things and seen in the molecule structures we will put together
  - Hydrocarbons are primarily made of hydrogen and carbon
  - Hydrogen atoms only form 1 bond, so they terminate a molecule

What you need

- To draw structural formulas you use the symbols of the elements to identify each atom in the molecule.
- You need to know the valence of each atom.
- The valence is represented using the electron dot diagrams.
- From there you can determine the bonds formed. So draw some common electron dot diagrams to have on hand:

Draw electron dot diagrams of the following atoms

H	N	S
He	P	Na
Li	C	O
F	Mg	Cl

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When there are not enough electrons to create single bonds 2 can be shared, this is called a double bond

A name ending in

- -ane indicates a carbon carbon single bond
- -ene indicates a carbon carbon double bond
- -yne indicates a carbon carbon triple bond
- -ol indicates an alcohol group (OH)

Create the following molecules: start with the electron dot diagrams and draw the final molecule with only the bonds showing

O_2 oxygen gas

H_2O_2 hydrogen peroxide

CO_2 carbon dioxide

CH_4 Methane

C_2H_6O Ethanol

N_2 Nitrogen gas

C_2H_4 Ethene

C_2H_6 Ethane

$C_2H_5NO_2$ Glycine (an amino acid)

C_3H_8 Propane

C_6H_6 Benzene

Which molecules do these 3-D models represent?

These are called ball and stick models, balls are atoms & sticks are bonds.

Black is carbon (1 atom)

Light blue/white is hydrogen

Red is oxygen