Covalent Bonding

Chemistry

Unit 6

Module 1

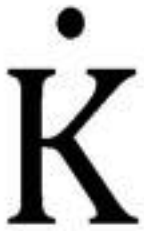
Module Concepts

- Valence electrons
- Electron Dot Diagrams for Elements
- Lewis Dot Structures for Covalent Molecules
- Shared Pairs of Electrons
- Unshared Pairs of Electrons
- Single, Double and Triple Bonds

Electron Dot Diagrams

An element's valence shell electrons, those that can participate in chemical bonding, can be represented pictorially using an *electron dot diagram.*

Examples of electron dot diagrams:

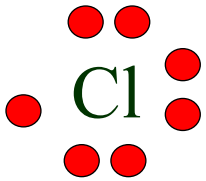


Electron Dot Diagrams – Cont'd

- The electrons are arranged such that the s orbital valence electrons are drawn as dots positioned directly *above* the element symbol, and the p orbital valence electrons are drawn as dots positioned around the three remaining sides.
- Remember the order for filling in electrons:
  - 2 in the s orbital, positioned on *top* of the element symbol *(Fill this first before starting to fill p orbitals – Aufbau Principle)*
  - 1 in each p orbital, positioned on the remaining sides, before adding a second *(Hund's Rule)*

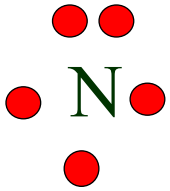
Examples - Electron Dot Diagrams for Elements

Chlorine – $[Ne]3s^2 3p^5$, 7 v.e.

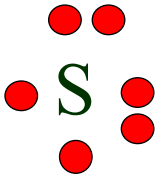


Sodium - $[Ne]3s^1$ 1 v.e.

Nitrogen - $[He]2s^2 2p^3$, 5 v.e.



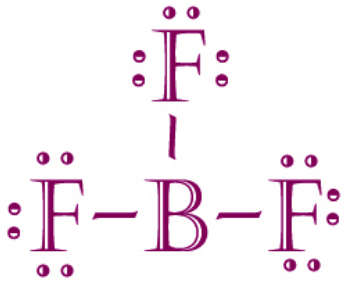
Sulfur - $[Ne]3s^2 3p^4$, 6 v.e.



Lewis Dot Diagrams for Covalent Molecules

We can also represent covalent molecules pictorially with electron dot diagrams. *Diagrams for covalent molecules are called Lewis Dot Diagrams*.

Examples of Lewis Dot Diagrams for Covalent Molecules:



- It is important to remember that main block elements seek to follow the *octet rule* with the exception of hydrogen and helium (who follow the duet rule); this is what determines the structure of each molecule.

- The bonds between atoms in a molecule can be single (one shared electron pair), double (two shared electron pairs), or triple (three shared electron pairs) bonds.

Rules for Drawing Lewis Dot Diagrams

Calculate the total number of electrons that should be in the structure by adding together the number of *valence* electrons for each element in the molecule.

Example: Draw the Lewis Dot structure for CH_4 (methane).

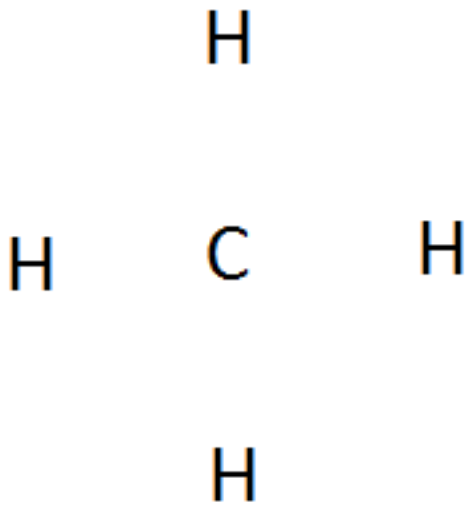
- C, in group 14, has 4 valence electrons
- Each H, in group 1, has 1 valence electron.
- Calculate the total number of valence electrons in the molecule by adding together the valence electrons for each element in the molecule.
- 4 + 4(1) = 8 valence electrons in structure for CH_4

Rules - continued

Determine which element should be the central element and draw all other elements surrounding it. The central element is usually the one present in the smaller quantity. If carbon is present, it is ALWAYS the central element. Hydrogen can NEVER be the central element because it cannot exceed the duet.

- Example: CH_4
  - Carbon is present, so it is the central element. Draw C with 4 H's surrounding it (i.e. one H on top, one on bottom, one on left, one on right).

Example: Cont'd



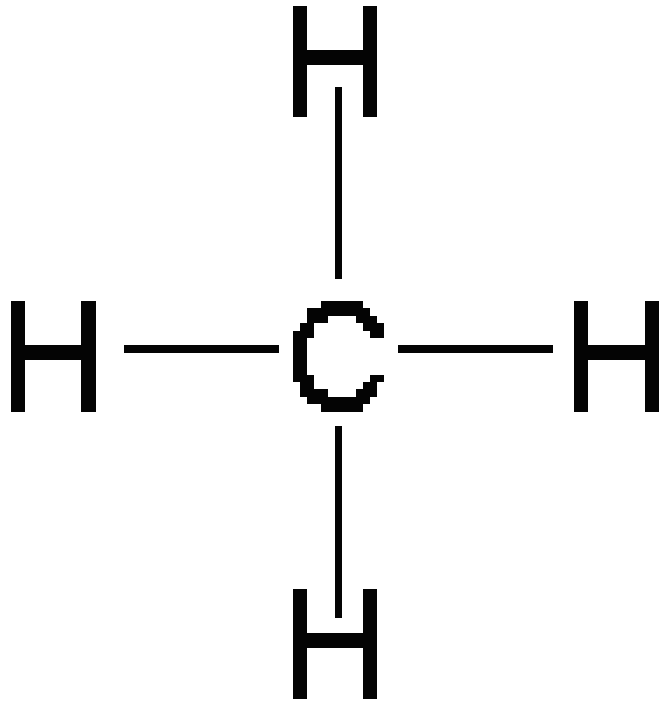
Draw in 1 single line to connect each of the terminal (outside) atoms to the central atom.

Every line counts as 1 pair of electrons (i.e. 2 electrons).

Count the number of electrons surrounding each element. Every element should be surrounded by 8 electrons. ***(Exception: H is happy with 2, B is happy with 6)***

If an atom does not have 8 electrons, add in electrons (in pairs) until every atom is surrounded by 8 electrons.

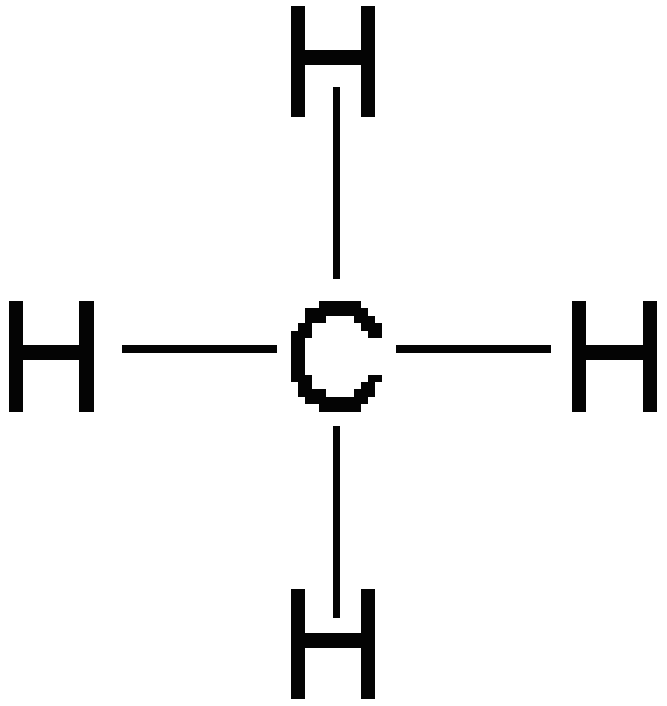
Here, a line is drawn between each H and the central C atom.



Count the total # of electrons in the structure.

Check to see if the #of electrons in the structure is the same as the # of electrons calculated in the first step. Your goal is to make sure these two #s to match. All unshared electron pairs should be left alone and should remain in the structure.

Here, we have four lines. Each line represents 2 electrons. That's a total of 8 electrons. This matches the number of electrons calculated in the first step.

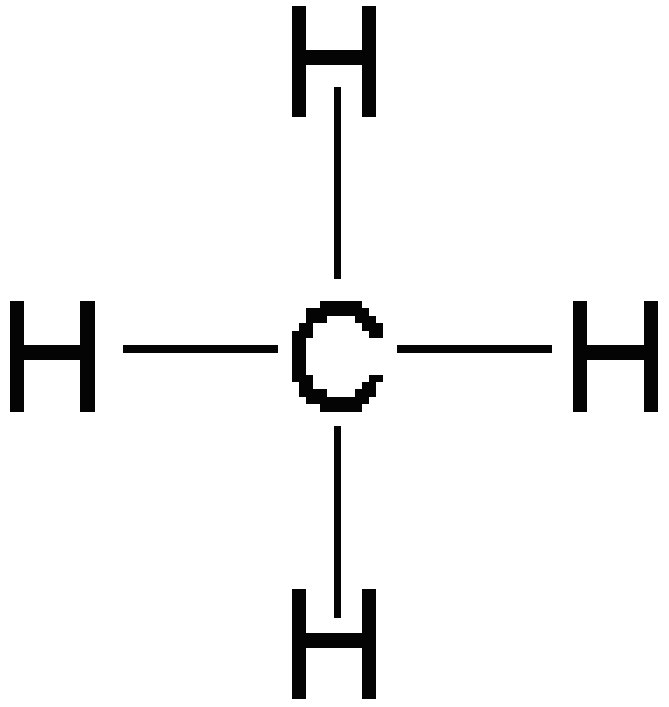


Neutral molecules should obey the *HONC* Rule of Chemistry!

H and Halogens want 1 line (bonding pair)
O and Group 16 elements want 2 lines (2 bonding pairs)
N and Group 15 elements want 3 lines (3 bonding pairs)
C and Group 14 elements want 4 lines (4 bonding pairs)

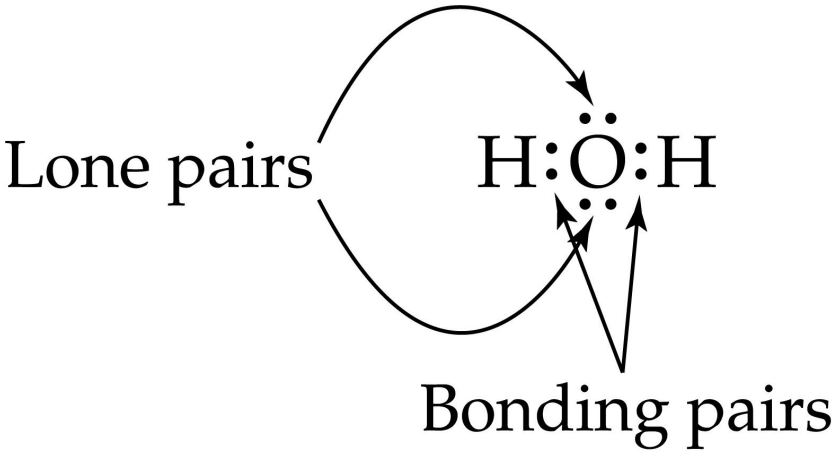
Final Lewis Dot Structure for CH_4

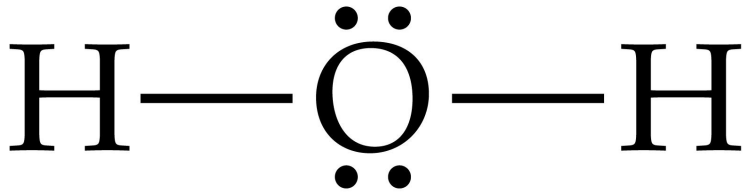
This structure shows 4 shared pairs of electrons, aka 4 single bonds. Each H has 1 bond, the C has 4 bonds, so it obeys the HONC rule of chemistry!



Your Turn! Draw the Lewis Dot Structure for water, H_2O

Covalent Bonding





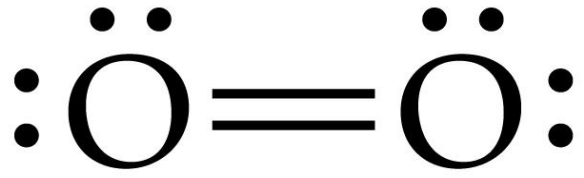
With water, there are two types of electron pairs:

- 2 Bonding (shared) pairs
  - Connect the hydrogen atoms with the oxygen atom in covalent bonds.
- 2 Lone (unshared) pairs
  - Do not interact with the hydrogen atoms, sit atop oxygen to satisfy the octet rule.

We represent bonding pairs with straight lines between the bonding atoms.

Now let's draw the Lewis Dot Structure for oxygen, O_2.

1. Find how many electrons should be in the structure. (2x6=12)
2. Only 2 atoms, no central element. Just draw 2 Oxygen atoms side by side.
3. Connect the 2 atoms with 2 lines to obey the *HONC* rule of chemistry.
4. Draw in dots in pairs until each Oxygen atom is surrounded by 8 electrons.

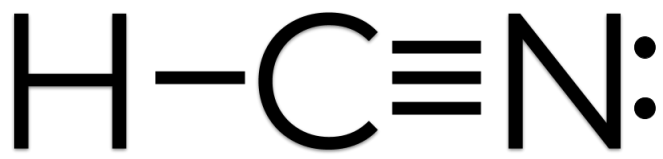


This structure for O_2 satisfies the octet rule and maintains the same number of electrons as that calculated by adding together the number of valence electrons for each element (6+6=12). The double bond represents two shared pairs of electrons (four total electrons). Notice each oxygen also carries 2 unshared pairs of electrons for a total of 4 unshared pairs in the molecule (8 total electrons). 4 shared + 8 unshared = 12

Now let's draw the Lewis Dot Structure for HCN.

1. Find how many electrons should be in the structure. (1+4+5=10)
2. Carbon is present, so it should be the central element. Draw an H on one side of the C and a N on the other side of the C.
3. Connect the atoms with lines to obey the *HONC* rule of chemistry. (1 line between C and H, 3 lines between C and N)
4. Draw in dots in pairs until each every atom is surrounded by 8 electrons, except H.

Lewis Structure for HCN



This structure for HCN satisfies the octet rule and maintains the same number of electrons as that calculated by adding together the number of valence electrons for each element (1+4+5=10). The single bond represents one shared pair of electrons (2), the triple bond represents three shared pairs of electrons (6) and the N carries an unshared pair in the molecule (2 electrons). 2+6+2 = 10 total electrons