Module 6: Drawing and Interpreting Lewis Structures

Lewis Symbols and Structures

Fundamentals of Chemistry Open Course

Learning Objectives | Module 6

1. Infer the number of valence electrons in a neutral atom from the position of its element on the periodic table.
2. Draw Lewis symbols for atoms with the appropriate number of electrons.
3. Infer the most likely skeletal structure of a simple molecule from the molecular formula.
4. Distinguish between bonding and nonbonding electrons in Lewis structures.
5. Define and apply the octet rule when drawing Lewis structures.
6. Draw Lewis structures for simple molecules containing only single bonds and formally neutral atoms.
7. Draw Lewis structures for simple molecules containing multiple bonds.
8. Deduce the formal charge of an atom in a Lewis structure.

Lewis Symbols for Neutral Atoms

- A **Lewis symbol** is a representation of an atom that includes the element symbol and dots to represent valence electrons.
    - The element symbol represents the nucleus and the core electrons.
    - Each dot around the element symbol corresponds to one valence electron.

- Recall that the number of valence electrons in a neutral atom can be inferred from group number.

- The first four dots are drawn on the four sides of the element symbol and any additional dots are used to form electron pairs. A Lewis symbol never includes more than eight valence electrons.

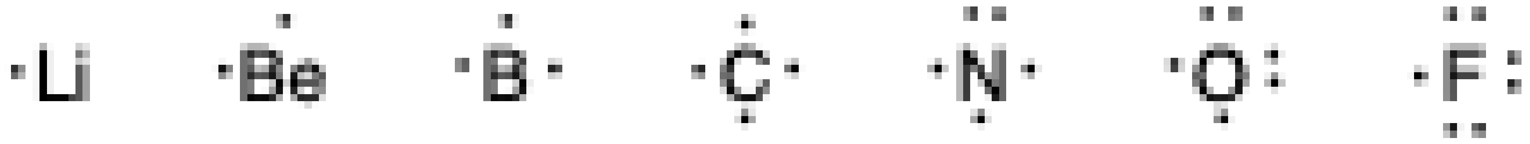


Figure. Lewis symbols for atoms of the first seven elements in period 2.

Lewis Symbols for Monatomic Ions

- Lewis symbols are sometimes used to represent monatomic ions. Electrons are added to (anions) or removed from (cations) the Lewis symbol to achieve the indicated charge.

- Note that the stable monatomic ions either have 8 valence electrons (N^{3-}, O^{2-}, F^{-}) or none (Li^{+}, Be^{2+})!

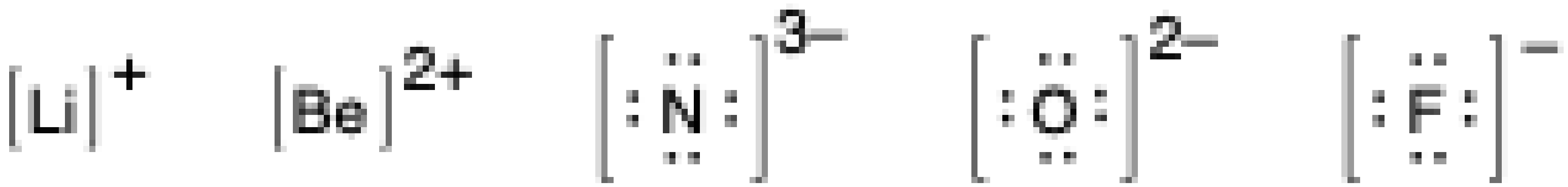
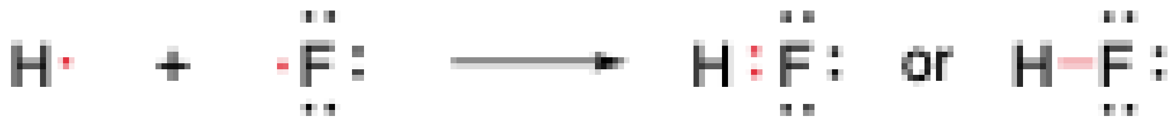


Figure. Lewis symbols for monatomic ions in period 2.

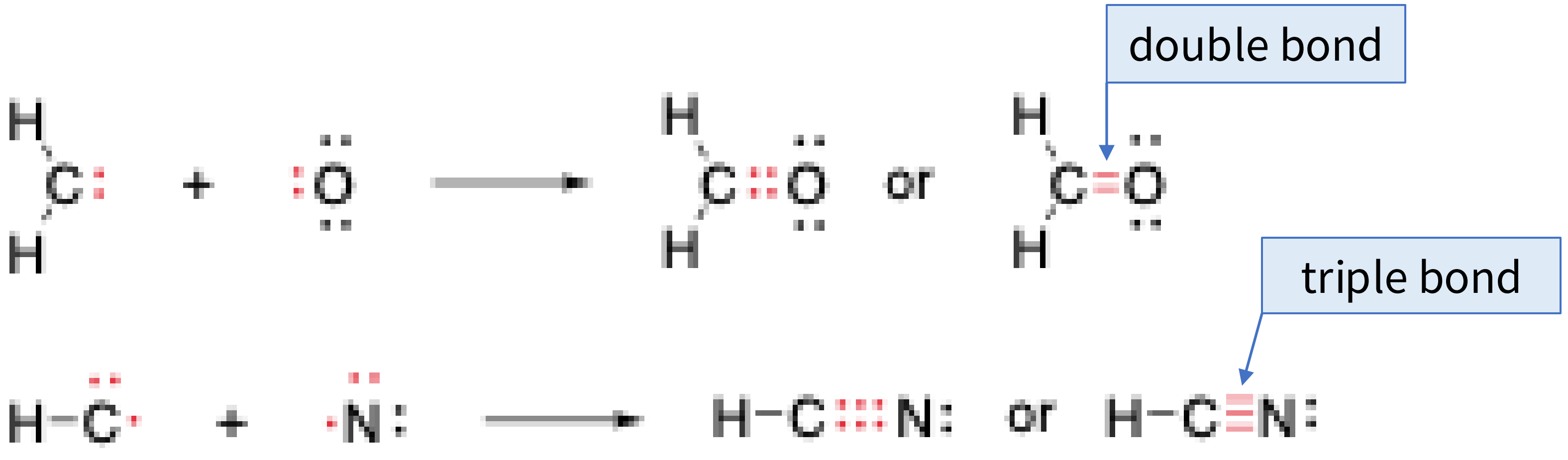
- Nonmetal atoms form **covalent bonds** by sharing one or more pairs of electrons. Let's examine the possibilities for bonding before jumping into predicting how atoms will bond in a molecule.

- We represent covalent bonds using pairs of dots or a line between bonded atoms.



- Electrons engaged in bonding (represented as lines) are *very* different from electrons that are not engaged in bonding. The latter are called **nonbonding electrons**, **lone pairs**, or **nonbonding lone pairs**.

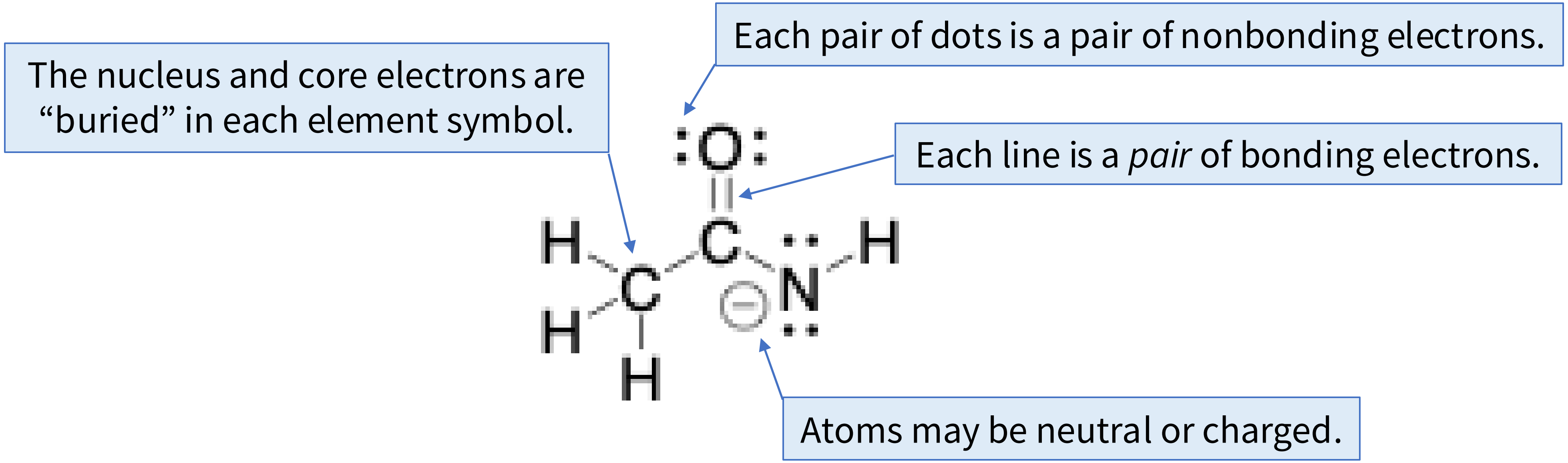
- Atoms can share one, two, or three pairs of electrons. Two pairs are shared in a **double bond** and three in a **triple bond**.



- **Lewis structures** depict the distribution of atoms and electrons in molecules, showing how bonding electrons link atoms together and the number of nonbonding valence electrons on each atom.

- In general, a molecular formula alone is not sufficient information to determine a Lewis structure. Atoms can be connected in different ways.

- However, simple molecular formulas *can* point to a single Lewis structure. Alternatively, with information about how atoms are connected, we can infer the best Lewis structure for a molecule.



The Octet Rule: A Tendency in Lewis Structures

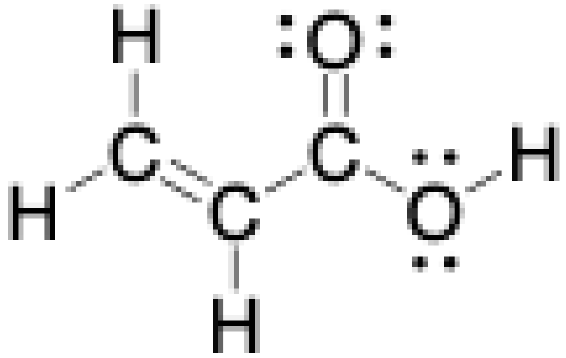
- **Total electron count (TEC):** the total number of bonding and nonbonding electrons associated with an atom, counting each bonding pair of electrons as 2.

- The **octet rule:** atoms in Lewis structures display a *tendency* to have a total electron count of 8 (an “octet”) in accurate Lewis structures.

- We use the octet rule as a guideline when drawing structures—it tells us when to create multiple bonds (or not!).

- The most important general exception to the rule is hydrogen, which has a maximum TEC of 2.

Example. In the Lewis structure of acrylic acid, all carbons and oxygens bear an octet of electrons.



Drawing Lewis Structures

Drawing a Lewis structure given a molecular formula…

1. Determine the total number of valence electrons. For cations, subtract one electron for each positive charge. For anions, add one electron for each negative charge.

2. Draw a **skeletal structure** of the molecule or ion, arranging the atoms around a central atom. Connect each atom to the central atom with a single bond (one electron pair).

3. Distribute the remaining electrons as lone pairs on the peripheral atoms (except hydrogen), completing an octet around each atom.

4. Place all remaining electrons on the central atom.

5. Rearrange the electrons of the outer atoms to make multiple bonds with the central atom to create octets wherever possible.

6. Assign formal charges, making sure no atom has charge greater than ±1 and the sum of all charges equals the total charge of the molecule or ion (next lesson).

Drawing Lewis Structures Containing Multiple Bonds

Example. Draw a Lewis structure for diimide, HNNH.

Lingering Questions

- Why does the octet rule generally hold? What is special about a total electron count of 8?

- We have seen that hydrogen “violates” the octet rule by bearing only two electrons in Lewis structures. What other common exceptions to the octet rule are observed?

- In the structures we have examined so far, the vast majority of the atoms have been neutral. However, ions must contain at least one charged atom. How do we determine the charge of an atom in a Lewis structure?