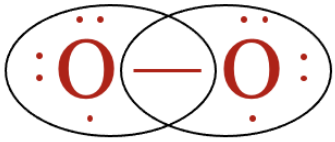
11.5: Multiple Covalent Bonds

Learning Objectives

- Illustrate covalent bond formation with Lewis electron dot diagrams for simple molecules with multiple bonds.

Some molecules are unable to satisfy the octet rule by making single covalent bonds between atoms. Consider the a molecule of oxygen, O_2. Each oxygen atom has 6 valence electrons and needs two more electrons to complete its valence shell:

If the two oxygen atoms were to form a single bond with each other, they each have access to only seven valence electrons:



Recalling that a dash represents a covalent bond, or two electrons, each oxygen atom is still one electron short of satisfying the octet rule. Since there are only 12 valence electrons with which to work,

$$2 \text{ O atoms} \times 6 \text{ valence } e^- \text{ per atom} = 12 \text{ valence } e^- \text{ in the molecule}$$

each oxygen atom must achieve the octet rule by forming a double covalent bond, also called a **double bond**. A double bond is formed when two pairs of valence electrons are shared between the same two atoms. Since each dash represents a pair of electrons, we can see that the Lewis structure contains a total of 12 valence electrons and that each oxygen atom as access to eight valence electrons.

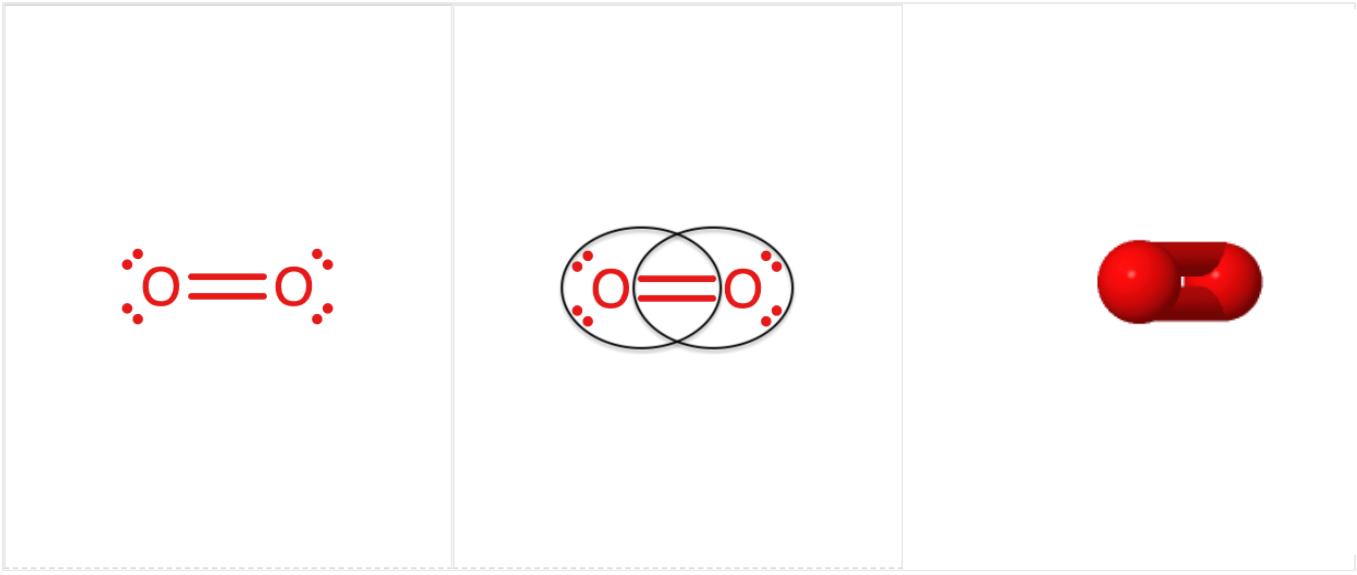


Figure 11.5.1 (from left to right): The Lewis structure of O_2. Each oxygen atom has access to 8 valence electrons by forming a double bond with the other oxygen atom. The three-dimensional rendering of an O_2 molecule.

Finally, let's consider a molecule of nitrogen, N_2. Each nitrogen atom has 5 valence electrons and needs three more electrons to complete its valence shell:

As one might suspect, since there are only 10 valence electrons with which to work,

$$2 \text{ N atoms} \times 5 \text{ valence } e^- \text{ per atom} = 10 \text{ valence } e^- \text{ in the molecule}$$

each nitrogen atom must achieve the octet rule by forming a triple covalent bond, or simply, a **triple bond**. A triple bond is formed when three pairs of valence electrons are shared between the same two atoms. Since each dash represents a pair of electrons, we can see that the Lewis structure contains a total of 10 valence electrons and that each nitrogen atom as access to eight valence electrons.

Figure 11.5.2 (from left to right): The Lewis structure of N_2. Each nitrogen atom has access to 8 valence electrons by forming a triple bond with the other nitrogen atom. The three-dimensional rendering of an N_2 molecule.

Summary

- Double bonds or triple bonds between atoms may be necessary to attain octets in some molecules.