4.4: Coordinate Covalent Bonds

Learning Objectives

- Describe the difference between a covalent bond and a coordinate covalent bond.
- Identify molecules that form coordinate covalent bonds.

Remember when you were younger, and were told to share your favorite toy with your brother, sister, or friend? You probably didn't want to share, but did anyway. It likely turned out that you had more fun playing with the toy together than if you had kept it to yourself. Atoms often share electrons with other atoms that have nothing to contribute to the situation forming a **coordinate covalent bond**; the end result is a new structure.

Coordinate Covalent Bonds

Each of the covalent bonds that we have looked at so far has involved each of the atoms that are bonding contributing one of the electrons to the shared pair. There is an alternate type of covalent bond in which one of the atoms provides *both* of the electrons in a shared pair. Carbon monoxide, CO, is a toxic gas that is released as a byproduct during the burning of fossil fuels. The bonding between the C atom and the O atom can be thought of in the following procession:

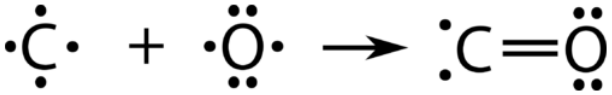


Figure 4.4.2: Formation of a CO double bond (incorrect structure). (Credit: Joy Sheng; Source: CK-12 Foundation; License: CC BY-NC 3.0(opens in new window))

At this point, a double bond has formed between the two atoms, with each atom providing one of the electrons to each bond. The oxygen atom now has a stable octet of electrons, but the carbon atom only has six electrons and is unstable. This situation is resolved if the oxygen atom contributes one of its lone pairs in order to make a third bond with the carbon atom.

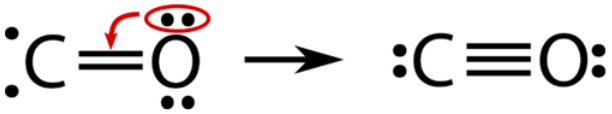
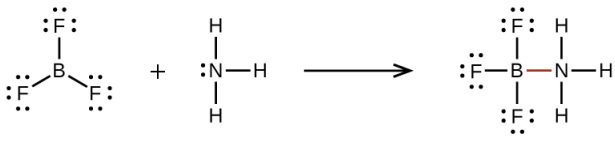


Figure 4.4.3: Correct CO structure. (Credit: Joy Sheng; Source: CK-12 Foundation; License: CC BY-NC 3.0(opens in new window))

The carbon monoxide molecule is correctly represented by a triple covalent bond between the carbon and oxygen atoms. One of the bonds formed is a coordinate covalent bond, a covalent bond in which one of the atoms contributes both of the electrons in the shared pair. Once formed, a coordinate covalent bond is the same as any other covalent bond. It is not as if the two conventional bonds in the CO molecule are stronger or different in any other way than the coordinate covalent bond.

Electron-deficient molecules, like $\mathrm{BF_3}$, are very reactive and will often combine with other molecules forming coordinate covalent bonds. The central boron atom in $\mathrm{BF_3}$ does not have eight electrons, and is therefore very reactive. It can readily combine with a molecule containing a central atom with a lone pair of electrons. For example, $\mathrm{NH_3}$ reacts with $\mathrm{BF_3}$ because the lone pair on nitrogen can be shared with the boron atom:



Summary

- Coordinate covalent bonds can form when one atom provides a lone pair of electrons to the bond.
- Coordinate covalent bonds are as strong as other covalent bonds.

Review

1. Where does the third covalent bond in the CO molecule come from?
2. Why is the incorrect structure for CO above wrong?

3. Are coordinate covalent bonds stronger or weaker than regular covalent bonds?
