16.3: The Air We Breathe

Learning Objectives

- Understand the composition of the air.
- Know the relative reactivities of the major components of air.

A Sea of Gas

We live and breathe in the **atmosphere**, a sea of gas consisting primarily of elemental O_2 and N_2. The fundamental properties of gases determine the properties of the atmosphere. Recall that gases consist of molecules or atoms (in the case of noble gases) with large amounts of space between them. The gas molecules are in constant, rapid motion which causes gases to exert pressure. The motion of gas molecules becomes more rapid with increasing temperature. The relationships among the the volume, temperature, and pressure of a gas can be calculated by the gas laws discussed in Chapter 9.

Whereas seawater in the ocean has a well-defined volume and a distinct surface, the same cannot be said for the mass of gases comprising the atmosphere. Although most of the atmosphere is within a few kilometers of Earth's surface, there is no distinct point at higher altitude where the atmosphere ends. Instead, air becomes progressively thinner with increasing altitude. This is noticeable to humans who have traveled to higher altitudes on mountains where the thinner air makes breathing more difficult. Indeed, climbers who scale the highest mountain peaks commonly carry oxygen to aid breathing.

Atmospheric Composition

What is air? At our level, it is a mixture of gases of uniform composition. On a dry basis, air is 78.1% (by volume) nitrogen, 21.0% oxygen, 0.9% argon, and 0.04% carbon dioxide. Normally, air is 1–3% water vapor by volume. Trace gases at levels below 0.002% in air include ammonia, carbon monoxide, helium, hydrogen, krypton, methane, neon, nitrogen dioxide, nitrous oxide (dinitrogen monoxide), ozone, sulfur dioxide, and xenon.

By a wide margin, oxygen and nitrogen are the most abundant gases in the atmosphere. Because of the extremely high stability and low reactivity of the N_2 molecule, the chemistry of atmospheric elemental nitrogen is singularly unexciting, although nitrogen molecules are the most common species that absorb excess energy from atmospheric chemical reactions to help stabilize those reactions. Elemental nitrogen is an important commercial gas extracted from the atmosphere by nitrogen-fixing bacteria and in the industrial synthesis of ammonia. Oxides of nitrogen actively participate in atmospheric chemical reactions.

Oxygen is a reactive species in the atmosphere. It will produce oxidation products from oxidizable gases in the atmosphere such as sulfur dioxide gas, SO_2, and pollutant hydrocarbons. Molecular O_2 does not react with these substances directly but only indirectly through the action of reactive intermediates, especially **hydroxyl radical**, HO•. A crucially important atmospheric chemical phenomenon involving oxygen is the formation of stratospheric ozone, O_3. Oxygen in the atmosphere is consumed in the burning of hydrocarbons and other carbon-containing fuels. It is also consumed when oxidizable minerals undergo chemical weathering, such as in the formation of Fe_2O_3, commonly known as rust.

$$4\,\mathrm{FeO} + \mathrm{O_2} \rightarrow 2\,\mathrm{Fe_2O_3}$$

Contributions & Attributions

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