2.8

Atoms, Molecules, and the Atmosphere

Slowly breathe in a lungful of air. As you do, think about the billions of molecules that you are inhaling. Air is mostly nitrogen and oxygen, but you are breathing in a mixture that contains other gases as well. In this section, you will learn about some of the gases found in air (**Figure 1**).

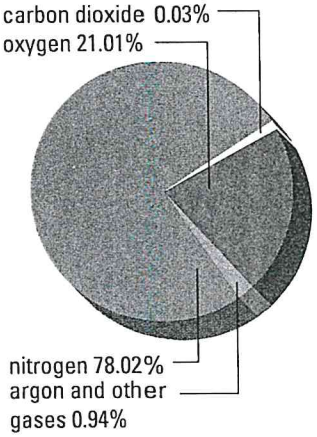


Figure 1
Gases in Earth's atmosphere

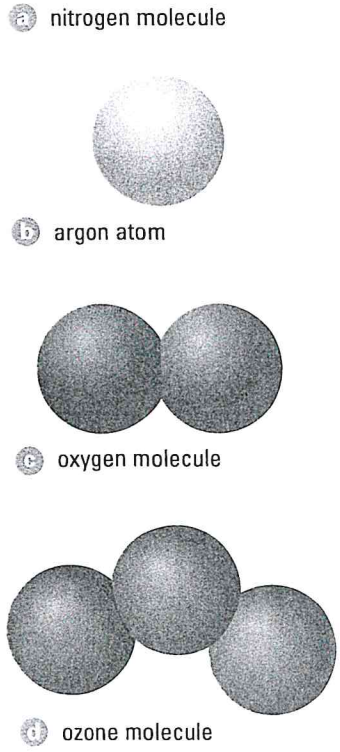
Nitrogen (N_2)

Two atoms of the element nitrogen combine to form a molecule of the gas nitrogen (**Figure 2a**). Nitrogen makes up approximately 80% of the atmosphere. It is not very reactive, which means we can breathe it safely without causing chemical changes in our lungs. However, under certain conditions, such as in a car engine, nitrogen gas reacts with oxygen to produce nitrogen dioxide (NO_2), a very toxic red-brown gas. Nitrogen dioxide in low concentrations causes the yellow haze of air pollution you may have seen in some cities.

Argon (Ar)

Argon atoms do not combine with other atoms to form molecules. As a result, argon gas is composed of single atoms of argon (**Figure 2b**). Almost all of the argon in the atmosphere has leaked out from inside the Earth. This gas is completely harmless and quite useful, especially for filling electric light bulbs and fluorescent tubes.

Figure 2



Oxygen (O_2 and O_3)

Atoms of the element oxygen can combine to form two different molecules. The more common of these contains two atoms of oxygen. This is the form that makes up about 21% of the air you breathe and is what we commonly call oxygen gas (**Figure 2c**). Almost all organisms need oxygen to survive, as it is used in cellular respiration.

The less common oxygen molecule, called ozone (O_3), contains three atoms of oxygen (**Figure 2d**). Ozone is formed naturally in the upper layers of the atmosphere. It is very important to life on Earth because it absorbs most of the ultraviolet radiation from the Sun. If all of this radiation reached the surface of Earth, it would harm all living things exposed to it.

Unfortunately, air pollutants such as chlorofluorocarbons (CFCs) have been destroying the ozone layer at an alarming rate. Worldwide measures to stop this pollution have begun, but it will be years before the risk to the ozone layer is past. Because of damage to the ozone layer, more ultraviolet light is now reaching Earth's surface. Ultraviolet light damages skin. As a result, scientists now encourage people to protect their skin with clothing or sunscreen when they go out in the sunshine.

While the layer of ozone several kilometres up in the upper atmosphere is necessary for life, ozone at ground level is hazardous to living things. It can damage plants and causes respiratory problems in people and other animals because it reacts with lung tissue. It is produced when certain gases, produced mainly by vehicles, react with each other and with the more common O_2 molecule.

Carbon Dioxide (CO_2) and Carbon Monoxide (CO)

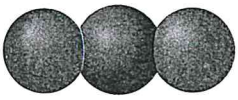
Did You Know ?

A sign of carbon monoxide poisoning is that the skin turns redder than normal.

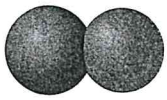
Two atmospheric gases contain only atoms of carbon and oxygen (**Figure 3**). One, carbon dioxide, is necessary for life on Earth. The other, carbon monoxide, is extremely poisonous to vertebrate animals.

When fossil fuels burn, the two main products are carbon dioxide and water. However, if there is a shortage of oxygen during combustion, carbon monoxide is also produced. How can the supply of oxygen be limited? If you burn propane indoors, for instance in a gas barbecue or heater, you might use up most of the oxygen from the air in the room. The same might happen if you run an automobile engine in a closed garage.

Figure 3



(a) carbon dioxide molecule



(b) carbon monoxide molecule

The carbon monoxide molecule (CO) is similar to the oxygen molecule (O_2). This similarity makes carbon monoxide poisonous. When carbon monoxide molecules enter the lungs, the body's red blood cells treat CO molecules as if they were O_2 molecules. Instead of oxygen, the cells carry CO through the body. The cells of the body are starved of the oxygen they need. Death can result.

In order to prevent accidental fatalities due to CO poisoning, many municipalities are passing bylaws that require CO detectors in every home.

Try This What Is Air?

Is air an element or a mixture of several substances? Moisten a piece of steel wool. Drop it into an empty jar and then invert the jar over a pan of water. Mark the liquid level in the jar. Leave the jar for 24 h. Mark the liquid level again. What has happened to the air in the jar? Test the jar for oxygen using a glowing splint. What do your observations suggest?

Understanding Concepts

1. Identify (as elements or compounds) each of the following molecules:
   - **(a)** carbon dioxide
   - **(b)** carbon monoxide
   - **(c)** oxygen
   - **(d)** ozone
   - **(e)** nitrogen
2. Carbon dioxide and carbon monoxide contain only carbon and oxygen. Which of these molecules is dangerous to breathe? Why is it dangerous?
3. **(a)** How is ozone formed at ground level?
   (b) What effect does this ozone have on living things?
4. If humans and all other animals are constantly producing carbon dioxide, and it is a fairly stable gas, why does it make up only a tiny percentage of Earth's atmosphere?

Exploring

5. People with some diseases, such as emphysema, are given air with an increased percentage of oxygen. Find out what proportion of oxygen is in this air. What safety precautions would you advise for people near the patient? Create an information brochure.
6. Visit an automotive service centre.
   - **(a)** What device is used to prevent any buildup of carbon monoxide inside the garage?
   - **(b)** How is fresh air brought into the garage?
   - **(c)** How would fresh air reduce the amount of carbon monoxide produced by cars?

Reflecting

7. Would you make any changes to the list of substances that you produced at the beginning of the chapter?