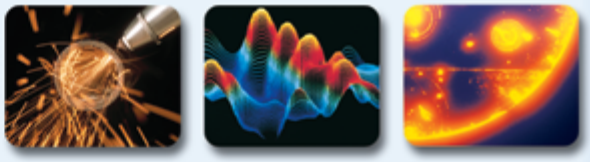
Chemistry in Action



The Gas Laws and Scuba Diving

An understanding of Dalton's law and Henry's law is essential to safe scuba diving. Dalton's law states that the total pressure of a gas mixture is equal to the sum of the partial pressures of the component gases. Henry's law predicts that the solubility of a gas in a liquid is a direct function of the partial pressure of that gas.

For every 33 ft of sea water that a diver descends, he or she feels one additional atmosphere of pressure because of the increasing weight of water overhead. Most divers use compressed air tanks to breathe underwater. The air in these tanks, which contains approximately 78% nitrogen and 21% oxygen, is the same as the air that we breathe. Once the compressed air enters the diver's lungs, it is subjected to the pressure caused by the water. The increase in the air pressure leads to an increase in the partial pressures of the nitrogen and oxygen in air, as predicted by Dalton's law. Henry's law predicts that this increase in partial pressures will increase the solubility of nitrogen and oxygen in the diver's bloodstream.

The increase in the partial pressure of oxygen is not problematic under typical diving conditions because a diver's body can metabolize the extra oxygen that is present in the bloodstream. The body does not metabolize nitrogen, however, so it can accumulate in a diver's body during a dive. The extra nitrogen can affect the nerve cells of the diver, causing *nitrogen narcosis.* Divers suffering from nitrogen narcosis become disoriented and experience symptoms similar to intoxication. This impairment of a diver's judgment can be very dangerous. To decrease the probability of contracting nitrogen narcosis, divers can use gas mixtures that contain less nitrogen than compressed air does.

Dissolved nitrogen can also be harmful if a diver ascends too quickly. As Henry's law predicts, nitrogen becomes less soluble in the blood as the pressure decreases. This decrease in solubility causes nitrogen to leave the diver's tissues and blood. Normally, the excess nitrogen is discharged through the lungs. However, if the diver comes up too rapidly, the nitrogen will form bubbles in the tissues and veins. This condition is known as *decompression sickness,* or "the bends." If the bubbles block blood flow, a wide range of effects, including severe joint pain, may occur. For this reason, divers are very careful to ascend slowly after diving.

At extreme depths, even the increased pressure of oxygen becomes a problem for scuba divers. Although oxygen is necessary for life, extended exposure to large concentrations of oxygen can result in *oxygen toxicity.* This condition can cause damage to the lungs and nervous system. Divers can avoid oxygen toxicity by breathing gas mixtures that contain more helium and less oxygen than compressed air does.

◀ *In order to dive safely, scuba divers must be aware of some of the basic gas laws.*

Questions

1. Why is the concentration of helium increased in some gas mixtures that divers breathe in order to reduce the partial pressure of oxygen?
2. Although carbon monoxide, CO, is normally present in trace quantities in air, compressed air scuba tanks that are filled improperly can contain elevated levels of CO. Why is this particularly dangerous for divers?