Solubility and Pressure

The Effect of Pressure on Solubility

For solids and liquids, known as condensed phases, the pressure dependence of solubility is typically weak and is usually neglected in practice. However, the solubility of gases shows significant variability based on pressure. Typically, a gas will increase in solubility with an increase in pressure. This effect can be mathematically described using an equation called Henry's law.

Henry's Law

When a gas is dissolved in a liquid, pressure has an important effect on the solubility. William Henry, an English chemist, showed that the solubility of a gas increased with increasing pressure. He discovered the following relationship:

$$C = k * P_{gas}$$

In this equation, C is the concentration of the gas in solution, which is a measure of its solubility, k is a proportionality constant that has been experimentally determined, and P_{gas} is the partial pressure of the gas above the solution. The proportionality constant needs to be experimentally determined because the increase in solubility will depend on which kind of gas is being dissolved.

Applications of Gas Solubility

In order for deep-sea divers to breathe underwater, they must inhale highly compressed air in deep water, resulting in more nitrogen dissolving in their blood, tissues, and joints. If a diver returns to the surface too rapidly, the nitrogen gas diffuses out of the blood too quickly, causing pain and possibly death. This condition is known as "the bends."

To prevent the bends, a diver must return to the surface slowly, so that the gases will adjust to the partial decrease in pressure and diffuse more slowly. A diver can also breathe a mixture of compressed helium and oxygen gas, since helium is only one-fifth as soluble in blood as nitrogen.

Underwater, our bodies are similar to a soda bottle under pressure. Imagine dropping the bottle and trying to open it. In order to prevent the soda from fizzing out, you open the cap slowly to let the pressure decrease. On land, we breathe about 78 percent nitrogen and 21 percent oxygen, but our bodies use mostly the oxygen. When we're underwater, however, the high pressure of water surrounding our bodies causes nitrogen to build up in our blood and tissues. Like in the case of the bottle of soda, if we move around or come up from the water too quickly, the nitrogen will be released from our bodies too quickly, creating bubbles in our blood and causing "the bends."

Solubility and pressure are very relevant to scuba divers, who are susceptible to "the bends." As divers swim deeper, the pressure increases the amount of nitrogen dissolved in their blood. Unless they ascend slowly, the nitrogen can diffuse out of their blood too quickly, causing pain and even death.

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