Partial Pressure

Are the astronauts on the International Space Station (ISS) safe if the oxygen level is at 20%? Answer: It depends.

Percentage is a ratio of how much stuff you have compared to the whole. Our air is about 20% oxygen. That means that of every 100 molecules of air, 20 are oxygen. Now, imagine there are 100 molecules of air on the ISS and 20 of the molecules are oxygen. There is 20% oxygen, but are the astronauts safe?

Let's do a quick calculation on the **amount** of oxygen taken in in a normal breath.

An average human breath is about 500ml of air. If 20% is oxygen, that gives:

$$500\ ml\ x\ 0.20 = \mathbf{100\ ml\ oxygen}$$

Air has a density of 1.43 gram/liter. So the mass of oxygen is:

$$100\ ml\ x\ 1.43\ \frac{gram}{liter}\ x\ \frac{liter}{1000\ ml} = \mathbf{0.143\ grams\ oxygen}$$

And finally, let's calculate the number of molecules of oxygen using its molar mass of 16 and Avogadro's number:

$$\frac{0.143\ g}{\frac{16\ g}{mole}}\ x\ 6.022\ x10^{23}\ \frac{molecules}{mole} = \mathbf{5.38\ x10^{21}\ molecules\ oxygen}$$

That is a lot of oxygen. Referring back to our problem on the ISS, we had 20 molecules of oxygen available to our astronauts. Are they ok? No. There isn't even close to enough oxygen for even a single breath. So percentage is the wrong thing to look at when determining safe oxygen levels. In fact, anytime a person is placed in a closed volume (high flying aircraft, ISS, submarine, etc.) we have to be careful that we don't rely on oxygen percentage for safety. We need something measures the **amount** of oxygen on the air. Luckily, we have that. It is called partial pressure.

Partial Pressure is defined as the pressure that would be exerted by one of the gases in a mixture if it occupied the same volume on its own. In other words, if we took our 20% oxygen, removed all the other gasses, and allowed the oxygen to fill

the whole volume, the pressure that resulted would be the partial pressure of oxygen.

This value is more significant for us because the pressure that results is a function of the **amount** of oxygen in the volume.

The minimum safe partial pressure of oxygen in breathing air is generally considered as **16 kPa** (kiloPascals) which is **0.16 bar** or **2.32 psi** or **120 Torr**. When levels in an enclosed environment start seeing oxygen levels get down to this value, it is important to start adding oxygen to the environment. This can be done by producing it (through the electrolysis of water) or bleeding it from storage tanks.

Dalton's Law states that the total pressure of a mixture of gasses is equal to the sum of the partial pressures of the individual gasses.

There are many other factors that affect the atmospheres of closed environments (getting rid of CO_2, sampling for toxic gasses, removing potentially flammable or explosive gases, etc.). But maintaining safe oxygen amounts are vital to supporting life, allowing for activity and concentration, and preventing toxic conditions.

Measuring and controlling the partial pressure of oxygen will allow you to more safely control the amount of oxygen in the air than if you just used pure percentage readings.

