Guide to gases - Helium

After hydrogen (H_2), helium (He) is the lightest gas (0.169 kg/m^3 versus 0.085 kg/m^3) and thus is much lighter than air (1.29 kg/m^3). The result is that helium will rise in air and when contained (e.g. in a balloon) will exert a considerable upwards force. Archimedes figured out this principle and we now use it in helium-inflated balloons.

Another very important property is its inertness; it practically does not react chemically with any other chemical. The third and final key property is the size: a helium atom (the smallest atom there is approx 0.07 Å = 0.000 000 000 7 mm) is so small that it easily diffuses through materials and is thus very suitable when checking for leaks. Helium is practically odourless and colourless.

Helium is a gas that forms only a tiny percentage of normal atmospheric air. The average composition of air is:

Nitrogen	78.09%
Oxygen	20.94%
Argon	0.93%
CO2	0.033%
Neon	0.0018%
Helium	0.0005%

Clearly, air is not a good source for the production of helium gas. Fortunately, there are possibilities to extract it from natural gas. Some wells produce gas with up to 2% helium and one well is known to produce up to 7% helium. Production is then done by cooling and fractional distillation. World production is about 169 Mill cubic metres of gas per annum.

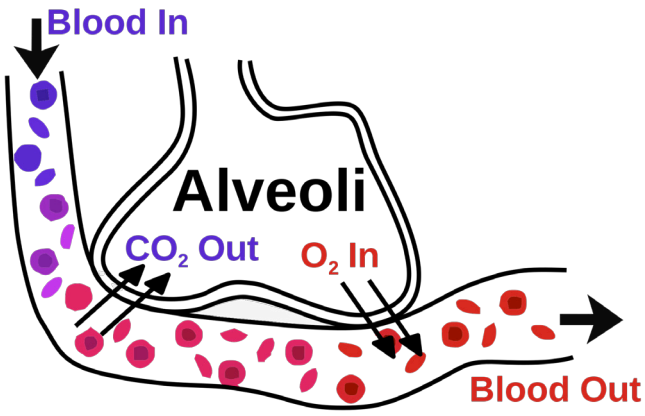
Supply to customers takes place in two distinctive forms: high pressure cylinders or cryogenic liquid (-269 ºC = 4.2 K). Which method the end-user will choose depends on the application helium is needed for. Important hereby is the purity of the helium. Typical applications:

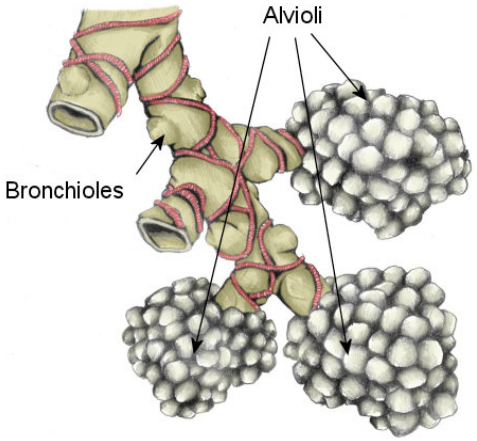
- Diving, in particular, diving to great depths (100-150 m). Mixtures of helium and oxygen in different concentrations are used (up to 4% Oxygen). Inertness and particle size are the main drivers in this application. The purity of the helium used is a medium grade.
- Production of microprocessors and related material. The most important property is the inertness of helium. Here normally the highest purities are used.
- Shielding gas during welding. Inertness but also its effect on heat transfer and ionisation of the arc are the main reasons for choosing medium purity helium.
- Scientific instruments such as gas chromatographs use high purity helium as an inert carrier gas.
- And finally, in balloons to ensure that they rise (lighter than air). The Hindenburg (famous German Zeppelin) was filled with hydrogen which is extremely flammable. The Germans were aware of this but due to export restrictions prior to World War II, they had very limited access to helium. If helium had been used, the Hindenburg disaster most probably would have ended quite differently.

The balloons we use during parties and festivities are just smaller versions of the Zeppelins. They would work perfectly well with hydrogen, but the flammability remains a problem. Helium-filled balloons, because of its inert properties, do not have this problem; they are inherently safe. However, the standard latex balloons do not hold the helium very well; within several hours large amounts of helium will have diffused through the latex. Balloons made of plastic foil with metalized inner coatings can withstand the diffusion much better.

This all does not mean that there are **NO** health risks when helium is being used. At parties it is quite common to inhale and than to speak. The pitch of the voice changes to a higher level (Donald Duck voice) because the speed of sound in helium differs considerably (= much higher) compared to normal air.

Is it then safe to do this?
Two main risks occur: first of all by inhaling helium. The blood transports carbon di-oxide to the lungs where it is exchanged for oxygen from the air. When the lungs are filled with helium it limits the possibility of absorbing oxygen into the blood because there is less oxygen in the lungs and additionally it actually lowers the oxygen contents in the bloodstream even more because oxygen from the blood moves into the lungs. The result is that the user loses consciousness very quickly without any warning. We need oxygen to function, thus repeated use of helium in a short period leads to oxygen deficiency.





Most people will understand this problem, but there is a greater risk and this happens in particular when people inhale helium straight from the cylinder (even when a regulator is mounted). Regulators reduce the cylinder pressure (typical 200 bar = 2900 psi) to lower values (2 bar = 29 psi and up). When people place their mouths directly on the outlet of the regulators, the lungs are extremely quickly filled with helium under too high pressure for the lungs to handle. The pressure in the lungs will rise quickly to levels that the fine lung tissue can not handle. All standard regulators used during the filling of balloons are not able to handle such low pressure

differences and will supply much more gas. The lungs are made up of alveoli and are not designed to handle this high pressure. Values of 0.1 bar = 1.5 psi is given as the maximum pressure in the lungs. Higher pressures can lead to bursting of the alveoli which leads to internal bleeding in the lungs and almost immediate death.

To summarize, helium is a widely used gas with very special and interesting properties. Be always aware and careful when using helium; do not underestimate the risks. And finally do not inhale helium to change the pitch of your voice. Before you know it, a visit to the hospital will be your next “port” of call.

Wilhelmsen Ships Service supplies balloon grade helium, widely used onboard cruise ships for inflating standard size balloons. One 40 litre cylinder filled with 200 bar helium will inflate approx. 375 balloons.

For more information on this subject, please read the publications of the European gas industry: EIGA position paper: http://www.eiga.eu/fileadmin/docs_pubs/PP-24-Dec2008.pdf

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