

3.3: Helium - The First Noble Gas

The second element in the periodic table is helium, He, atomic number 2. All helium atoms have 2 protons in their nuclei and 2 electrons. There are two isotopes of helium of which ${}^4\text{He}$ that contains 2 neutrons in the nucleus is by far the predominant one, with much smaller numbers of the lighter isotope, ${}^3\text{He}$ which has 2 protons and 1 neutron in its nucleus and a mass number of 3.

Helium is a *noble gas* meaning that it exists only as atoms of the elements that are never bonded to other atoms. Figure 3.3 is a representation of the helium atom showing its 2 electrons. The Lewis symbol of helium is simply He with 2 dots. This shows a very important characteristic of atoms. As electrons are added to atoms with increasing atomic number, they are added at various levels known as **electron shells**. The one electron in hydrogen, H, goes into the first electron shell, the one with the lowest possible energy. The second electron added to make the helium atom also goes into the first electron shell. This lowest electron shell can contain a maximum of only 2 electrons, so helium has a **filled electron shell**. Atoms with filled electron shells have no tendency to lose, gain, or share electrons and, therefore, do not become involved with other atoms through chemical bonding. Such atoms exist alone in the gas phase and the elements of which they consist are called noble gases. Helium is the first of the noble gases.

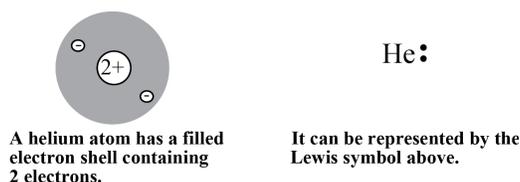


Figure 3.3. Two representations of the helium atom having a filled electron shell.

Helium gas has a very low density of only 0.164 g/L at 25°C and 1 atm pressure. Elemental helium is the second least dense substance next to hydrogen gas. It is this low density characteristic that makes helium so useful in balloons, including weather balloons, which can stay aloft for days, reaching very high altitudes.

Helium is pumped from the ground with some sources of natural gas, some of which contain up to 10% helium by volume. Helium was first observed in the sun by the specific wavelengths of light emitted by hot helium atoms. Underground sources of helium were discovered by drillers searching for natural gas in southwestern Kansas who tried to ignite gas from a new well and were disappointed to find that it would not burn, since it was virtually pure helium!

Chemically unreactive, helium has no chemical uses, except to provide a chemically inert atmosphere. A nontoxic, odorless, tasteless, colorless gas, helium is used because of its unique physical properties. Applications in weather balloons and airships were mentioned previously. Because of its low solubility in blood, helium is mixed with oxygen for breathing by deep-sea divers and persons with some respiratory ailments. Use of helium by divers avoids the very painful condition called “the bends” caused by bubbles of nitrogen forming from nitrogen gas dissolved in blood.

The greatest use of helium is as the super-cold liquid, which boils at a temperature of only 4.2 K above absolute zero (-269°C), especially in the growing science of **cryogenics**, which deals with very low temperatures. Some metals are superconductors at such temperatures so that helium is used to cool electromagnets enabling relatively small magnets to develop very powerful magnetic fields. Such magnets are components of the very useful chemical tool known as nuclear magnetic resonance (NMR). The same kind of instrument modified for clinical applications and called MRI is used as a medical diagnostic tool for scanning sections of the body for evidence of tumors and other maladies.

Hydrogen Wants to be Like Helium

Examination of the Lewis symbol of helium (right, Figure 3.3) and the Lewis formula of elemental hydrogen, H₂, (Figure 3.1) shows that each of the two hydrogen atoms in the H₂ molecule can lay claim to 2 electrons and thereby come to resemble the helium atom. Recall that helium is a noble gas that is very content with its 2 electrons. Each of the H atoms in H₂ is satisfied with 2 electrons, though they are shared. This indicates a basic rule of chemical bonding that atoms of an element tend to acquire the same electron configuration as that of the nearest noble gas. In this case, hydrogen, which comes just before helium in the periodic table, gains the noble gas configuration of helium by sharing electrons.

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