

Helium (He) - Student Datasheet

Atomic number 2 - Noble gas - Group 18 - Period 1 - s-block

Helium is element 2, a closed-shell noble gas with the lowest normal boiling point of any element. Its signature science is cryogenic: liquid helium becomes superfluid below the lambda transition, while solid helium requires pressure rather than simple cooling at 1 atm.

Quick reference

Atomic number	2
Relative atomic mass	4.002602
Electron configuration	1s ²
State at 20 C	Colorless monatomic gas at 20 deg C
Density	0.000164 g/cm ³ - gas reference
Melting point	No freezing at 1 atm - solid requires pressure
Boiling point	4.222 K
Common oxidation state	0 in ordinary chemistry
Electronegativity	Not assigned on the usual Pauling scale

Structure & orbitals

At ordinary conditions helium is a monatomic gas. At 1 atm it does not freeze on cooling; solid helium requires elevated pressure, so the ordinary-pressure viewer does not invent a solid crystal.

The 1s orbital is spherical and has no directional x/y/z variants. The probability cloud is an isolated-atom model; superfluidity is a collective quantum property of many helium atoms, not an orbital shape.

Temperature / phase context

In the ordinary-pressure cryogenic teaching path, helium-4 is gaseous above about 4.222 K, liquid He I below the boiling point, and becomes superfluid He II below about 2.17 K. It does not form an ordinary solid at 1 atm; solid helium requires elevated pressure.

Five things to remember

- Atomic number 2 means every helium nucleus contains 2 protons.
- Neutral helium has the closed-shell configuration 1s².
- Helium boils at about 4.222 K at standard pressure.
- Below about 2.17 K, liquid helium-4 enters the superfluid He II state.
- Helium does not freeze at 1 atm merely by cooling; solid helium requires elevated pressure.

Helium: Real World & Signature Science

Helium's famous balloons are only one part of the story. The deeper physics lies near 4 K, where quantum behavior becomes macroscopic in liquid helium.

Why this element matters

Cryogenics Liquid helium cools superconducting magnets and experiments to temperatures only a few kelvin above absolute zero.	MRI & research magnets Helium is used to cool some superconducting magnet systems, though engineering designs continue to reduce helium consumption.
Leak detection Helium's small atoms and chemical inertness make it useful as a tracer gas in leak detection.	Space & pressurization Helium is used in selected aerospace and industrial systems where an inert, low-density gas is valuable.
Finite terrestrial resource Most commercial helium is separated from particular natural-gas streams; atmospheric helium is too dilute for conventional bulk recovery.	

From helium-bearing gas to cryogenic use: a high-level path

1. Commercial helium is commonly recovered from natural-gas streams that contain unusually high helium concentrations.
2. Gas processing separates major components before cryogenic purification concentrates helium; detailed plant-operation guidance is outside this page.
3. Purified helium is distributed for cryogenics, leak detection, controlled atmospheres and specialized industrial/scientific uses.
4. In high-value systems, recovery and reliquefaction can reduce losses of this finite terrestrial resource.

Where on Earth?

Spectral discovery - Solar eclipse + laboratory confirmation

Helium was first recognized through a solar spectral line and later isolated from terrestrial minerals

Helium supply - Selected production context

Commercial helium is recovered from helium-rich natural gas in a limited number of regions; these are supply examples, not a map of all helium

Helium use cycle - Conceptual

Helium is separated, purified, used and sometimes captured/recycled in high-value cryogenic and industrial systems

History

1868 - During a solar eclipse, spectroscopy revealed an unknown yellow line associated with the Sun; Norman Lockyer proposed a new solar element and named it helium.

1895 - William Ramsay isolated terrestrial helium from a uranium-bearing mineral, confirming helium on Earth.

1908 - Heike Kamerlingh Onnes liquefied helium, opening the door to ultralow-temperature physics.

1930s - The superfluid behavior of helium II became a landmark example of macroscopic quantum physics.

Uses

Cryogenic cooling Helium enables temperatures low enough for superconducting magnets and condensed-matter experiments.	Leak detection Helium tracer methods can reveal very small leaks in vacuum and pressure systems.
Shielding / inert atmospheres Helium can provide inert gas environments for selected manufacturing processes.	Aerospace Low density and inertness support pressurization and purge roles in specialized aerospace systems.

Helium: Isotopes, Questions & Evidence

Isotopes

^4He - Stable - overwhelmingly dominant natural helium

Teaching nucleus contains 2 protons and 2 neutrons; the ^4He nucleus is also an alpha particle.

^3He - Stable - trace natural isotope

Important in low-temperature physics, neutron detection and specialized research.

Helium isotope mixture - Two stable isotopes

The abundance of ^3He is tiny compared with ^4He , but its quantum properties are profoundly different.

Common questions

What is helium's atomic number?

2.

What is helium's symbol?

He.

Is helium a noble gas?

Yes. Its 1s shell is full, giving helium a closed-shell electronic structure.

What is helium used for?

Major uses include cryogenic cooling, leak detection, inert atmospheres and specialized aerospace/scientific applications.

Can helium freeze at 1 atmosphere?

No. Helium remains liquid down to very low temperature at 1 atm; forming solid helium requires added pressure.

What is superfluid helium?

Below the lambda transition near 2.17 K, liquid helium-4 enters He II, a quantum fluid with extraordinary flow and heat-transport behavior.

Quick self-check

1. What is helium's atomic number? Answer: 2
2. What is helium's ground-state electron configuration? Answer: $1s^2$
3. What happens to helium-4 below about 2.17 K? Answer: It enters the superfluid He II state
4. Can helium freeze at 1 atm by cooling alone? Answer: No
5. What is ordinary gaseous helium made of? Answer: Single He atoms

Evidence & provenance

Atomic and boiling-point values are measured/evaluated. The He I/He II transition is a measured condensed-matter phenomenon. The page explicitly preserves the fact that helium does not have a normal 1-atm freezing point.

Core sources

Royal Society of Chemistry - Helium	https://periodic-table.rsc.org/element/2/helium
NIST - Cryogenic helium references	https://www.nist.gov/
USGS - Mineral Commodity Summaries 2026	https://pubs.usgs.gov/publication/mcs2026