The University of Texas at Austin
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Gas Density: Helium Balloon vs. Argon Balloon

Performer's Version

Safety Hazards

- Personal Protective Equipment:
  - Safety glasses/goggles

Safety Data Sheets

- Helium (AirGas)
- Argon (AirGas)

Materials

- 1 Qualatex balloon filled with helium gas (attached to a string) and labeled "He"
- 1 Qualatex balloon filled with argon gas (attached to a string) and labeled "Ar"

Procedure

1. Ensure that the helium balloon is attached to a weight/anchor to prevent it from floating away.
2. Hold one balloon in each hand, and release them simultaneously. Argon will fall, and helium will float.
3. Observe and discuss.

Pedagogy/Chemical Info

Density is a property of matter defined as a material's degree of consistency, measured by its mass per unit volume. Density is important in many ways – it's the basis for blood separation, extracting DNA from a strawberry, gold mining, and more. The density of a given object or material can also help us to predict if something will float or sink when submerged in a fluid.

Fluids aren't what many people think; in science, fluids are much broader by definition than they are in everyday, colloquial terms. In physics, a fluid is defined as a substance that is capable of altering its shape and flowing by virtue of its molecules being able to move around with respect to one another. By this definition, both gases and liquids are fluids – but solids are not due to their fixed shape! Any substance will exhibit some density – but with fluids, density opens the door to a new property known as buoyancy. Buoyancy is the upward force exhibited by a fluid in opposition to the weight of an object or substance partially or fully immersed in that fluid. In simpler terms, buoyancy is the tendency of an object or substance to float within a given fluid based on Archimedes' Principle. This principle states that an object submerged in a fluid will experience an upward buoyant force that is proportional to the weight of the displaced fluid. Broken down, this means that an object will float if it is less dense than the fluid it's submerged in.

Since gases are also considered fluids, employing this principle helps us understand gas density and why one gas floats, but another sinks. As shown in the table below, helium gas has a density of 0.1785 kg/m^3 – which is less than the density of air. Alternatively, argon has a density of 1.784 kg/m^3 – which is more than the density of air. These comparisons alone hint to the fact that a balloon full of helium, because it is *less* dense than the fluid (air) it is submerged in, will float – and that a balloon full of argon, because it is *more* dense than the fluid (air) it is submerged in, will sink.

There's a convenient ratio we can use to draw this conclusion, too; relative density, otherwise known as specific gravity, is the ratio of the density of a given object/substance to the density of the fluid it's submerged in. In this case, the fluid is air – meaning that the density of both gases *relative* to the density of air can be easily calculated. If the specific gravity of a given substance is less than 1, it will float; if the specific gravity of a substance is greater than 1, it will sink. It's important, however, to remember that adding other materials or substances to the equation can alter the results you'd expect to see. If you encase helium gas in a sturdy balloon that's anchored down with string and some heavy object, there's additional downward force due to the weight of these other objects being added to the equation, and it may not float as dramatically as expected. Make sure to take this into consideration when discussing gas density!

Chemical Name of Gas	Molecular Formula	Molecular Weight *(g/mol)*	Density, ϱ *(kg/m³)*	Specific Gravity (SG) $\varrho_{gas}/\varrho_{air}$
Air	N/A	N/A	1.225	1.000
Helium	He	4.0026	0.1785	0.1457
Argon	Ar	39.948	1.784	1.456