



Charles's Law: Balloons in Liquid Nitrogen

Performer's Version

Safety Hazards

- Personal Protective Equipment:
 - Cryogen gloves
 - Safety glasses/goggles
 - Chemical & flame retardant lab coat
- Physical Hazards
 - Contains refrigerated gas; may cause frostbite or cryogenic burns
 - Gas under pressure; may cause injury
- Chemical Hazards
 - May displace oxygen and cause rapid asphyxiation

Materials

- 1 black insulated bucket with lid
- 4 L dewar filled with liquid nitrogen
- 1 balloon or balloon animal (preferably filled with oxygen)

Safety Data Sheets

- [Nitrogen, refrigerated liquid \(Airgas\)](#)

Procedure

1. Wearing cryogenic gloves, carefully pour liquid nitrogen into the black insulated bucket until $\frac{3}{4}$ full.
2. While still wearing the gloves, gently submerge balloon/balloon animal into the liquid nitrogen. It will begin to collapse quickly.
 - a. *Note: You do not need to push the balloon down! If you push too hard, you may cause the liquid nitrogen to splash out of the bucket and risk contact with the skin.*
3. As soon as the balloon has fully collapsed/shrank, remove it from the insulated bucket and set down on the table.
4. Allow the balloon to warm up to room temperature and re-inflate!

Pedagogy & Supplemental Information

Charles's Law, described by Jacques Charles in an unpublished work from the 1780s, describes the relationship between the volume and temperature of gasses. According to Charles's Law, the volume and temperature of a gas behaving ideally are directly proportional to one another.

An important stipulation for Charles's Law to hold true is that the pressure of the gas and the number of gaseous moles must remain constant. If these conditions are not met, the relationship between volume and temperature cannot be isolated.

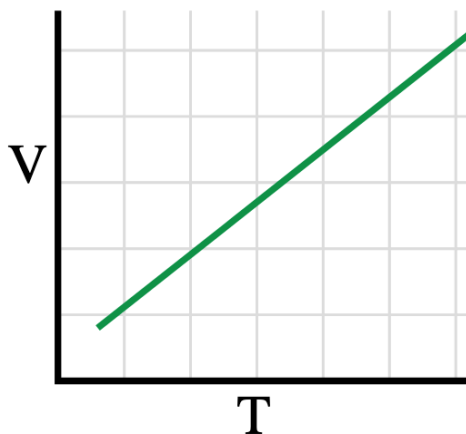
Mathematically, Charles' Law is:

$$\frac{V}{T} = k \text{ or } V = kT, \text{ in which } k \text{ is a constant}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

It is important to remember that the standard SI unit for volume is in liters (L), and Kelvin (K) for absolute temperature.

Graphically, Charles' Law can be plotted for an ideal gas with a linear function:





VOLUNTEERS ALLOWED

Volunteers can lower the balloon/balloon animal into the nitrogen while wearing proper personal protective equipment (PPE). Volunteers must be closely supervised.