

# All About Elements: Neon

# Boreal's All About Elements Series

## Building Real-World Connections to the Building Blocks of Chemistry

**PERIODIC TABLE OF THE ELEMENTS**

**KEY**  
 35 — Atomic Number  
 Br — Symbol  
 79.90 — Atomic Weight

**Boreal Science**  
 Boreal Science is a leading provider of hands-on chemistry materials for classrooms and science labs. Visit [boreal.com](http://boreal.com) for more information.

The periodic table of elements is an essential part of any chemistry classroom or science lab, but have you ever stopped to wonder about all of the amazing ways each element is used to create the world around us? Each of the trillions of substances in our universe can be tied back to just these 118 simple, yet powerful elements.

In our *All About Elements* series, we've brought together the most fascinating facts and figures about your favorite elements so students can explore their properties and uses in the real world and you can create chemistry connections in your classroom and beyond.

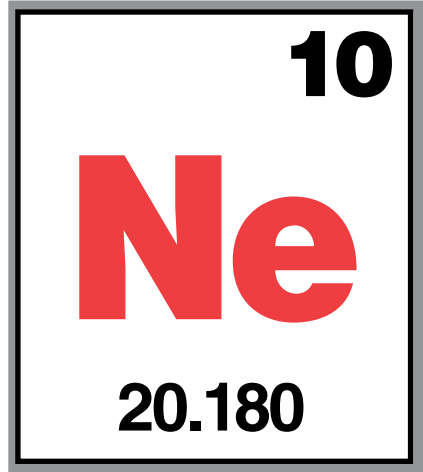
**Look for a new featured element each month, plus limited-time savings on select hands-on materials to incorporate these element in your lessons.**

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## Fun Facts About... NEON

1. Although it is relatively rare on our planet, (0.0018 percent of Earth's atmosphere), neon is the fifth most abundant element in the universe.
2. Neon has no stable compounds
3. Which city in the US has the most neon lights?  
Las Vegas. That said, neon lighting is on the decline, being replaced by LED lighting.
4. Neon lights are used in aircraft because they can operate at very low temperatures.
5. In 1913 Neon was the first element discovered to consist of more than one stable isotope.



## All About Neon:

Neon (Ne) is the second of the noble gases. Just like all noble gases, it is very non-reactive; it doesn't form compounds with anything.

Neon is non-reactive because its electron shells are full. Atomic Neon has two electron shells, the first containing two electrons and the second eight electrons. ( $1s^2, 2s^2, 2p^6$ ) This total of ten electrons gives neon the atomic number 10.



## Properties of Neon

Neon was the first element discovered to consist of more than one stable isotope. Neon-20 and Neon-22 were identified by mass spectrometry in 1913. The third stable isotope, neon-21 was detected later. Five radioactive isotopes of neon have also been identified. The Table below shows the relative abundance of the three stable isotopes. The weighted average of these isotopes gives an atomic mass of 20.18 amu.

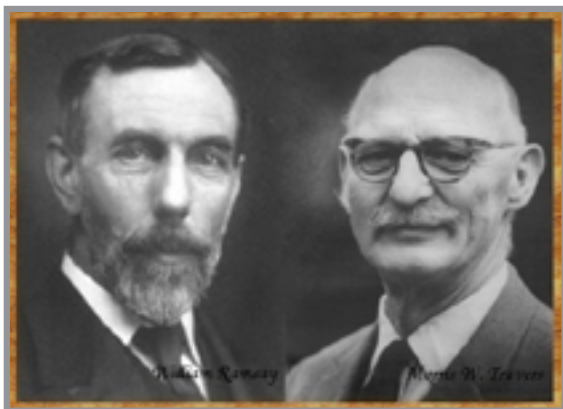
Neon gas is present in the atmosphere at about 1 part in 65,000. The melting and boiling points of the element are less than three degrees apart at 24.56K and 27.07K respectively. It is the fifth most abundant element in the universe. Interestingly, the Galileo spacecraft discovered neon in the upper part of Jupiter's atmosphere. Because of its density, 0.008999 g/cm<sup>3</sup>, if a balloon were filled with Neon, it would rise in the air but at a slower rate than a balloon filled with helium (density 0.001785 g/cm<sup>3</sup>).

Isotope	Mass	Natural Abundance (atom%)
<sup>20</sup> NE	19.99	90.48
<sup>21</sup> NE	20.99	0.27
<sup>22</sup> NE	21.99	9.25

## Discovery and History

Neon was discovered in 1898, by British scientists William Ramsay and Morris Travers. Both Argon and Helium were known elements at the time and Ramsey and Travers assumed that there must be an element between these noble gases. After unsuccessful attempts to derive this new element from minerals, Ramsay hypothesized that the new gas might be "hidden" by the other inert gases. So Ramsay and

Travers froze a sample of argon and then slowly evaporated the argon under reduced pressure, collecting the first sample of gas that came off. This gas was different from argon. In order to obtain its emission spectrum, the scientists applied a voltage to a sample of the gas in a closed tube. Ramsey later wrote *"the blaze of crimson light from the tube told its own story and was a sight to dwell upon and never forget. . . For the moment the actual spectrum of the gas did not matter in the least, for nothing in the world gave a glow such as we had seen."*<sup>(1)</sup> They named the new gas Neon, which is the Greek for "new". Neon is still obtained commercially by the fractional distillation of liquid air.



# Mechanism of Light Production

How do we explain the bright red orange light produced by a charged neon tube? First we must understand that the energy of electrons is quantized. That means that all electrons have very specific energies. The electrons in energy levels of an element can be excited to higher energy levels by the absorption of electrical energy. These "excited states" can lose energy in the form of light. The light produced by elements in a gaseous state, has discrete energies corresponding to the difference in energies between the ground state orbital and the excited state orbital. This means that different wavelengths or colors of light are emitted.

$$E = h\nu \quad \text{and} \quad \nu = c/\lambda \quad \text{therefore:} \quad E = hc/\lambda \quad E = \text{energy}$$

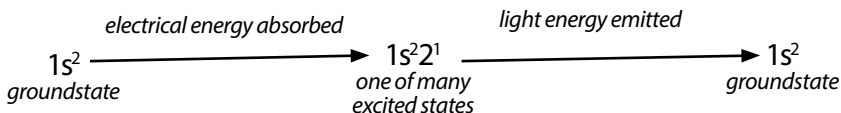
$h$  = Planck's constant

$c$  = speed of light

$\lambda$  = wavelength of light

$\nu$  = frequency

**For example, for the element He:**



Each element has a very specific visible emission spectrum (400-700nm), which can be used to identify the element.

For the element, neon, with 10 electrons, there are many transitions possible resulting in a complex line emission spectrum. Below is an image of the emission spectrum of Neon along with a continuous spectrum for comparison:



The sum total appearance of all of the lines in the neon spectrum is a bright orange red. Other elements or elements mixed with neon in the gas state will give different color lights, and therefore different emission spectra. The line spectra of Ne, and other elements, can be observed using elemental spectrum tubes and a quantitative spectroscope (featured below).



# Uses of Neon

## Neon Lights

What a wonderful surprise when Ramsey and Travers first saw the red/orange light produced from applying a voltage to a tube filled with neon. Not long after their discovery, Georges Claude, a French engineer created neon lighting for indoor use. He demonstrated neon tube lighting in 1910 at the Paris Motor Show.

Very few people liked the color of the lights for their homes. So,

instead, in 1912, Claude's company began selling neon discharge tubes as advertising signs. The concept was a success and was introduced in the US in 1923. Neon lights are everywhere. "Your name up in neon lights" is telling someone they are famous. Those neon lights usually refer to Broadway or Times Square. Think of Las Vegas's Strip, just a few short years ago, all of those signs were lit up using Neon lights. Today, LED lights are replacing many of these Neon lights. Neon however remains a valued lighting system, because it is usable in cold places. This is the reason why aircraft beacons and different types of aircraft utilize neon as their source of light.



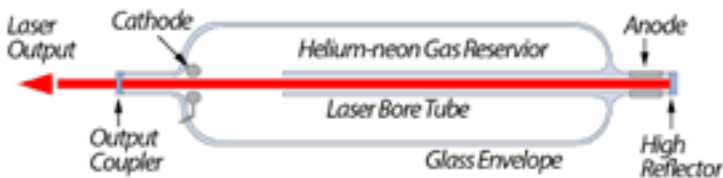
## Helium/Neon Lasers

Lasers are powerful beams of light that can be strong enough to be seen miles away in the sky, cut through metal, or used as an alternate to conventional surgery. Miniature lasers are used in the classroom as pointers, or are used to read music on CD's or barcode scan purchases in retail stores. Helium neon lasers were the first gas lasers developed. Most operate at 633nm in the red portion of the spectrum.

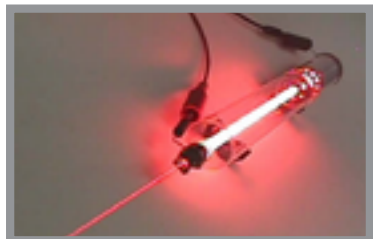
### How do lasers work?

The white light in a flashlight is made up of light of different wavelengths, which are out of phase with each other. Lasers produce light of only one wavelength (monochromatic) and all the light waves are in phase (coherent).

In the He/Ne laser, Helium atoms are excited by a voltage source. These excited Helium atoms collide with Neon atoms producing excited Neon atoms, which emit light at 633nm. This light travels down a tube, which has mirrors at both ends. The light bounces back and forth but one of those mirrors allows a small portion of the coherent light to pass through it, producing a laser beam.



The Helium/Neon lasers are quite inexpensive and are used in lab demonstrations and as pointers in the classroom. They are also used to read optical discs and to scan bar codes.

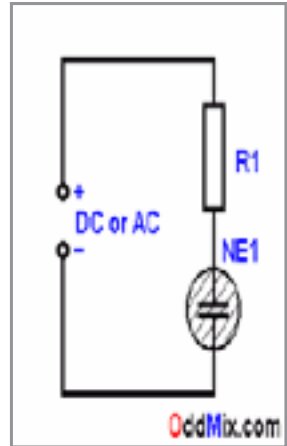


He-Ne Laser

## Voltage Indicators

A simple application for a small neon tube is as a high voltage detector. A resistor and neon glow tube in series is usually used. Resistor R1 (in the diagram) is always required in all glow tube circuit to prevent the tube from destruction due to excessive current. The value of R1 is selected to produce a tube current of only a few mA [milliamperes] while allowing useable brightness. Since voltage detectors are made to work at a wide range of voltages, the changing brightness is a good indicator of voltage supplied.

This basic voltage indicator circuit is useable on both **AC** (Alternating Current) and **DC** (Direct Current) as long as the available voltage exceeds the tube's ionization voltage, usually about 65volts.



## Cryogenics

Neon can also be used as a cryogenic refrigerant. Cryogenics is the science of the effects of very low temperatures. Cryogenic liquids, most often liquefied gases such as helium, neon or nitrogen, are often used in industrial and medical applications. The electrical resistance of metals decreases as temperature decreases resulting in what is called "superconductivity". These very cold metals, or superconductors, can be used to produce very strong magnets for MRI systems. Other applications of cryogenics include freezing of foods and the preservation of some biological materials such as human blood, tissue, and embryos. Cryogenics is also used to destroy certain cancers.



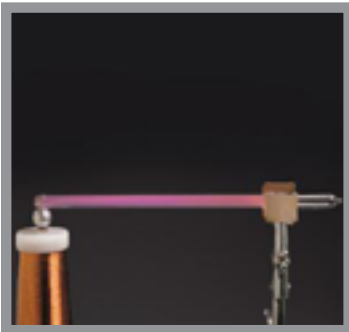
Neon has 40x more refrigeration capacity than liquid helium per unit volume of liquid and three times more capacity than liquid hydrogen. It is, of course, much safer than the highly flammable hydrogen and it can be used when temperatures as low as those of liquid helium (4K) are not required. Unfortunately, it also much more expensive than helium and that somewhat limits its use. HTS (High Temperature Superconducting) Generators use Neon as coolant. (The "high" refers to temperatures greater than 4K). These generators are used for powering ships in the navy. They are conveniently small and their operation at cryogenic temperatures prevents corrosion.

# Teach All About Neon with these Hands-on Materials:

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Click item or search by item number to see complete product details and current pricing available at [boreal.com](http://boreal.com).



## Neon Wand

*Glowes with Characteristic Brilliance!*

- Contains neon at reduced pressure.s

The neon gas glows when the tube is held in, or passed through a high frequency field, or a high voltage field, even though the tube has no electrodes. 10mm D x 25cm L.

**Please Note:** Not recommended for use with anything that produces a voltage higher than 75,000 volts.

**Item Number:** [6115703](#)



## Extra Bright Laser Pointer

*Ideal for basic optics and economical.*

- Beam width is approximately 7mm at 10m
- Operates on two AAA batteries (included)
- Storage case supplied

Due to the greatly increased sensitivity of the eye to the shorter wavelength light, the red beam appears much brighter than a comparable 680nm beam. No bigger than a fountain pen and weighing only a few ounces, the pointer is easy to use — just point the laser in the desired direction and press the button. The durable metal housing protects the instrument in the lab. This 635nm laser pointer doubles as an ideal light source for basic ray optics and a useful presentation tool. The pointer's bright beam results from a shorter wavelength than the more usual 675nm while keeping the power output in the same 3–5mW range.

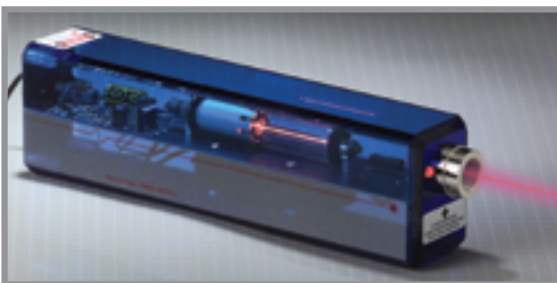
**Item Number:** [470111-384](#)



## Helium-Neon Lasers, Continuous Wave Lasers

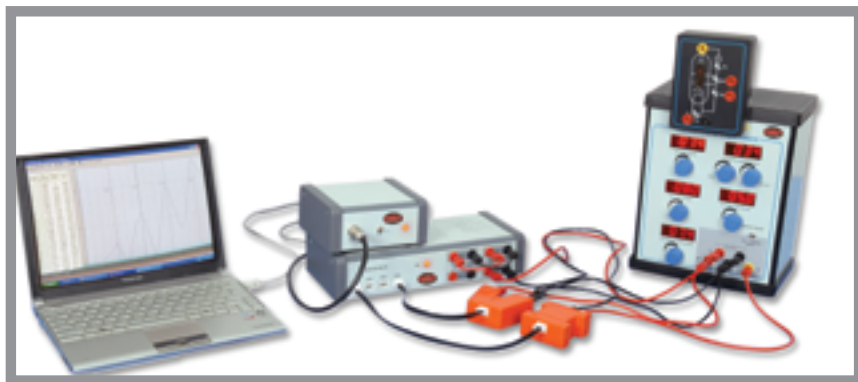
### *Ideal Classroom Instruments for all Optical Work*

Ruggedly constructed lasers with hard-seal tubes for long life. Each is housed in a transparent blue, impact-resistant acrylic housing with positive grip rubber feet. The output end incorporates a manual beam-blocking safety shutter, and has a threaded mount for standard beam-shaping accessories. The rear panel carries the power switch and jack for connecting the included power adapter (UL approved, for 115V AC). A standard 1/4-20 threaded hole



in the base accepts a stand rod for optical bench or tripod mounting (not included on 5.0mW model). The lasers emit red light with a wavelength of 632.8nm in the TEM<sub>00</sub> mode. Includes full color instruction manual. Continuous Wave (CW) Lasers emit a continuous beam of light with only small output power variations after warm-up. They are suitable for most applications. Modulated Lasers have additional jacks (3.5mm audio) to allow a varying signal of 600Hz–20kHz to be input for modulating the output beam intensity. This is used for measuring the speed of light and for optical signal transmission experiments. An economical low power laser for laboratory work or classroom demonstrations. Class II, 0.5 mW, 14½ x 3¾ x 2¼".

**Item Number:** 160414



## Franck Hertz, with Tube 110V

### *Witness visible energy transfer between atoms.*

This classic physics experiment demonstrates how energy is transferred from electrons as a result of inelastic collisions while passing through Neon gas. The transfer of energy occurs in discrete steps corresponding to the excitation by such collisions of distinct energy level transitions in the neon atoms. When atoms are excited, they can be viewed directly, making it possible to detect zones where the light and excitation is more intense. Experiment includes a Franck–Hertz unit, data logger with software, 230V power supply, Neon tube, current sensor, voltage sensor, and leads. System requirements: Windows 98/ME/2000/XP/VISTA/7/8/10 (Pro and Home); does not support Mac OS.

**Item Number:** 470121-634

## Quantitative Analysis

### Spectroscope

#### *Makes Reading Emission and Absorption Spectra Easy*

Your students can use this affordable spectroscope to analyze flame tests and spectrum tubes, making readings from 5000 to 7000Å with a  $\pm 50\text{\AA}$  accuracy. The 20cm-long sturdy plastic case holds a good diffraction grating with an easy-to-read scale. Includes instructions with suggested experiments.

**Item Number: 254996**



*(1) Morris William Travers, The Discovery of the Rare Gases, 1928, Edward Arnold and Co.*

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