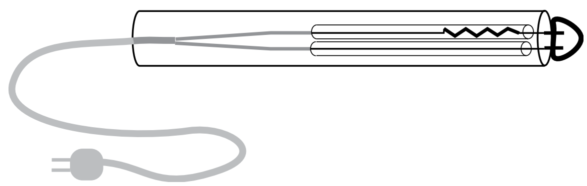
ICE Devices

Neon Lamp Cord: Experiments in Vision

With this small and simple lamp you can show your students how fast their eyes and brains work together. You can also discuss the interactions between electrons and atoms, and light emission. Background information about soldering appears at the end of these directions.



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15 min

Neon Lamp Cord: Experiments in Vision

By Ron Perkins

With this small and simple lamp you can show your students how fast their eyes and brains work together. You can also discuss the interactions between electrons and atoms, and light emission.

Materials

__ *1 neon bulb with 100 K dropping resistor (e. g. Radio Shack #272-1100 or replacement WW-4LDJ-0, from an electronics supplier)* ***or*** *a neon bulb (e.g. Radio Shack #272-712) and a 100 K resistor (e.g. Radio Shack #271-005)*

__ *1 2 m electrical lamp cord or extension cord with standard 120 V plug*

__ *1 15 cm, 1⁄4″-dia. heat shrink tubing (to fit over lamp cord)**

__ *1 14 cm, 1⁄8″-dia. heat shrink tubing (to fit over a single strand of the lamp cord) [if neon lamp and resistor are separate, you will need 20 cm]**

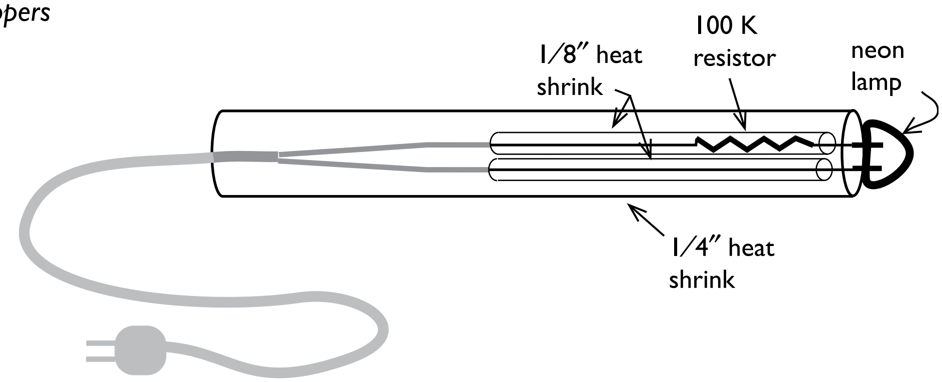
__ *soldering gun and solder [NOTE: tips and directions for soldering can be found on pages 24A–24C]*

__ *wire cutters and strippers*

__ *centimeter ruler*

__ *heat gun*

__ *scissors*



Preparation

1. If the neon bulb is separate from the 100 K resistor, you will have to solder them together. (**If they are already in a single unit, go directly to Step 2.**) ⚠ (Soldering tips can be found on pages 24A–24C.) To join the bulb and resistor:
   a. Twist a resistor lead and a neon bulb lead together and solder this joint. Keep the soldered connection as small as possible.
   b. Cut a 6-cm piece from the 1/8″-diameter heat shrink tubing and slip it over the resistor, **right up to the neon bulb.** Leave 1.5 cm of the loose end of the resistor wire exposed.
   c. Starting with the end nearest the bulb, use the heat gun to shrink the tubing. Set the bulb and resistor aside.

* Do *not* use electrical tape instead of heat shrink tubing.

2. If you are using an extension cord, cut off the receptacle end (not the plug). Slide the 1/4″ heat shrink tubing over the end of the 2-m electrical cord. Push it to the middle of the cord.
3. Pull apart the leads of the lamp cord to a distance of 15 cm. (If the dropping resistor is separate from the neon bulb, cut off 9 cm of one strand of the lamp cord.)
4. At the end of each strand of wire, strip off the insulation so that 1.5 cm of bare wire is exposed. Be careful not to cut through the wire.
5. Cut the 14-cm piece of 1/8″-diameter heat shrink tubing in half. Slide the pieces over each wire to the point where the two strands are joined.
6. Twist each bare wire of the lamp cord around a wire lead of the bulb with the resistor. Solder these connections. Keep the soldered connection as small as possible.
7. When the solder joints are cool, slide the lengths of 1/8″ heat shrink tubing towards the neon lamp **as far as they will go.** (If you needed to solder the resistor to the neon bulb, slide the heat shrink tubing only up to the end of the tubing covering the resistor.)

   ⚠ **Caution!** Make certain that the two wires are completely insulated by the heat shrink tubing, *Allowing any possibility that the two leads of the lamp may touch each other will make this a potentially very dangerous device. A short circuit will blow fuses or trip a circuit breaker.*
8. Starting with the end nearest the bulb, use the heat gun to shrink the tubing around each wire.
9. When cool, slide the larger heat shrink tubing up and 3 mm over the glass base of the neon bulb. Starting with the end nearest the bulb, use the heat gun to shrink the tubing around the cord.

Presentation

1. Plug the neon lamp cord into a 110 V AC power source. Turn off the room lights.
2. Twirl the glowing lamp in a large circle. A broken, dashed circle of light is observed. Experiment with the speed and radius of your twirling.

How does this work?

A. What happens in the neon bulb

When the voltage on the neon bulb is greater than about 40 V, electrons emitted from the anode are accelerated toward the cathode and collide with neon gas atoms (Figure 1).

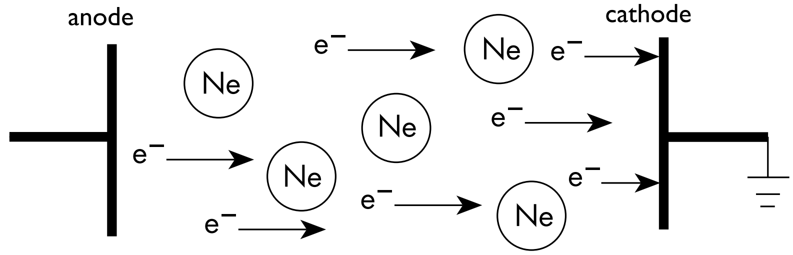


Figure 1. A neon lamp at ±40V.

Figure 2 shows how in the collision, the neon atoms are ionized (the incoming electron "chips off" an electron from the neon atom). If they collide again, the ionized atoms and electrons can recombine. Then there is excess energy that is released in the form of photons (light particles). This is the glow that we see around the cathode.

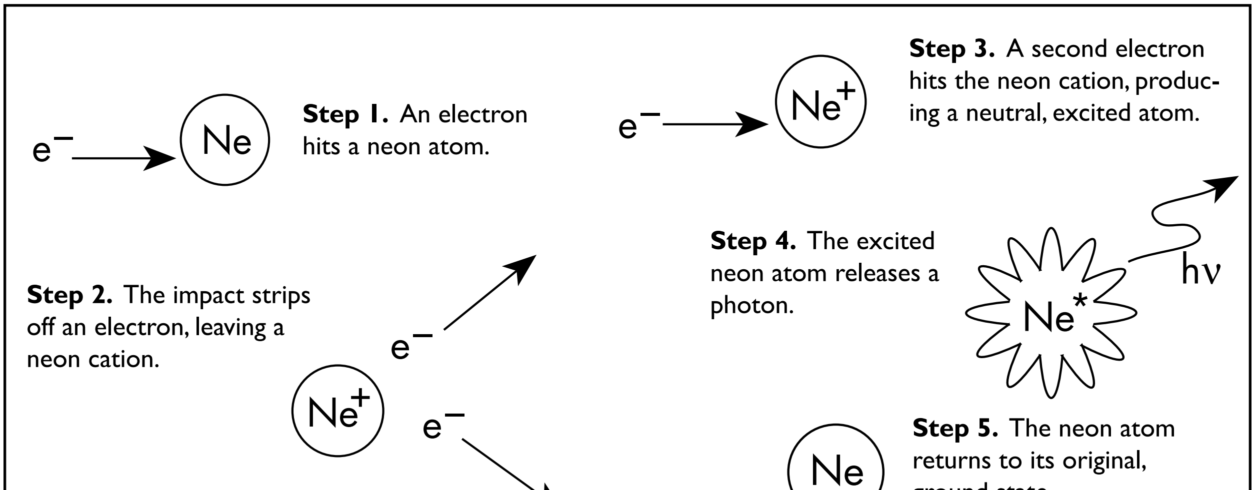


Figure 2.

If a constant voltage is applied, e.g., 40 V DC from a small power supply, excess energy is continuously released, resulting in an uninterrupted flow of light from the bulb. However, if an alternating voltage is used, that is, 110 V AC, the voltage, and hence the emitted light, fluctuates with time as shown in Figure 3. The lamp is on only when the voltage is above 40 V or below −40 V (shaded regions in Figure 3). Below 40 V the electrons don't have enough energy to ionize the neon atoms.

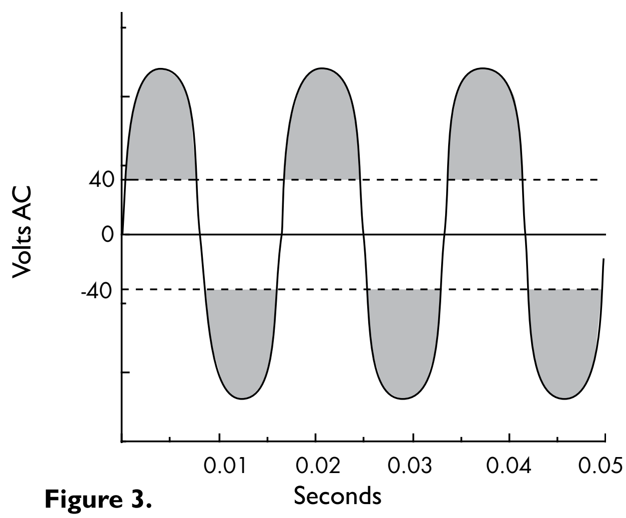


Figure 3.

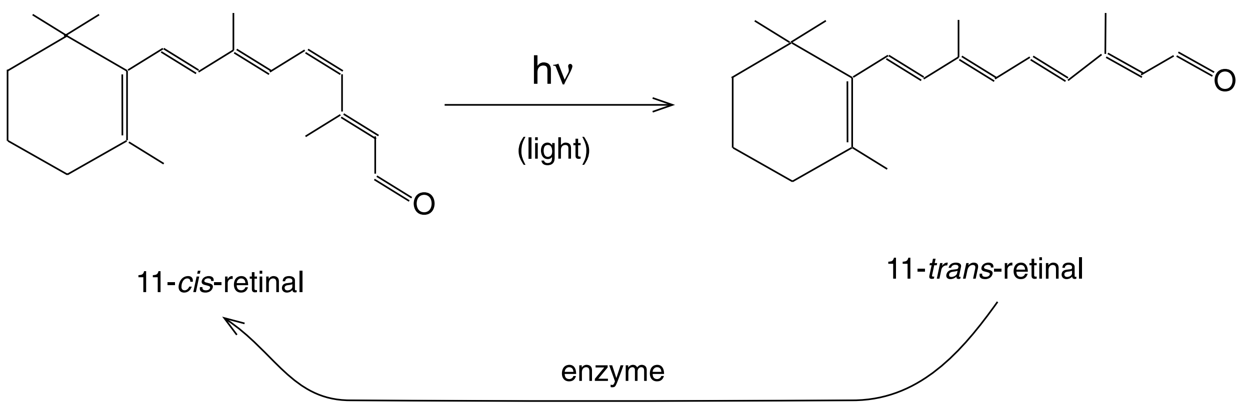
B. How your eye perceives it

At 60 Hz line frequency, this fluctuation (of 120 flashes per second) is too fast for one part of the retina to detect when the lamp is held still. However, when you move the lamp quickly you can see the fluctuation because different parts of the retina are stimulated.

When the lamp is moved, the streak of light observed with the DC source and the dashed circle with the AC source is due to the persistence of vision. One continues to "see" an image for about 0.1 second after the retina of the eye is stimulated. This means that if 60 Hz AC is used, about 12 flashes of light should be seen when the lamp cord is moved (0.1 sec × 120 flashes/sec = 12 flashes).

The chemistry of vision is quite well understood (*Chemical and Engineering News*, 28 November, 1983, pp. 24–36). The light-absorbing system, the chromophore, is within the rods and the cones of the eye. The chromophore contains 11-*cis*-retinal, or rhodopsin. Light causes this *cis* molecule to change to the *trans* form. This begins a series of chemical changes leading to a signal in the brain, "I see the light!" The message to the brain lasts for about 0.1 second.

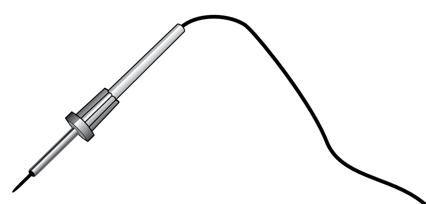
It has been known for many years that in the presence of high intensity visible light (about 380 nm wavelength) the *trans* form slowly converts back to the *cis*. Until recently, however, the mechanism in the presence of low intensity light has been unknown. Many thought that the liver was somehow involved in the vision system. In the June 1987 issue of *Chemical and Engineering News*, it was announced that "a membrane-bound enzyme, specific to the eye, converts all *trans*-retinal to *cis*-retinal in the absence of light."



Templates for Overhead Projection

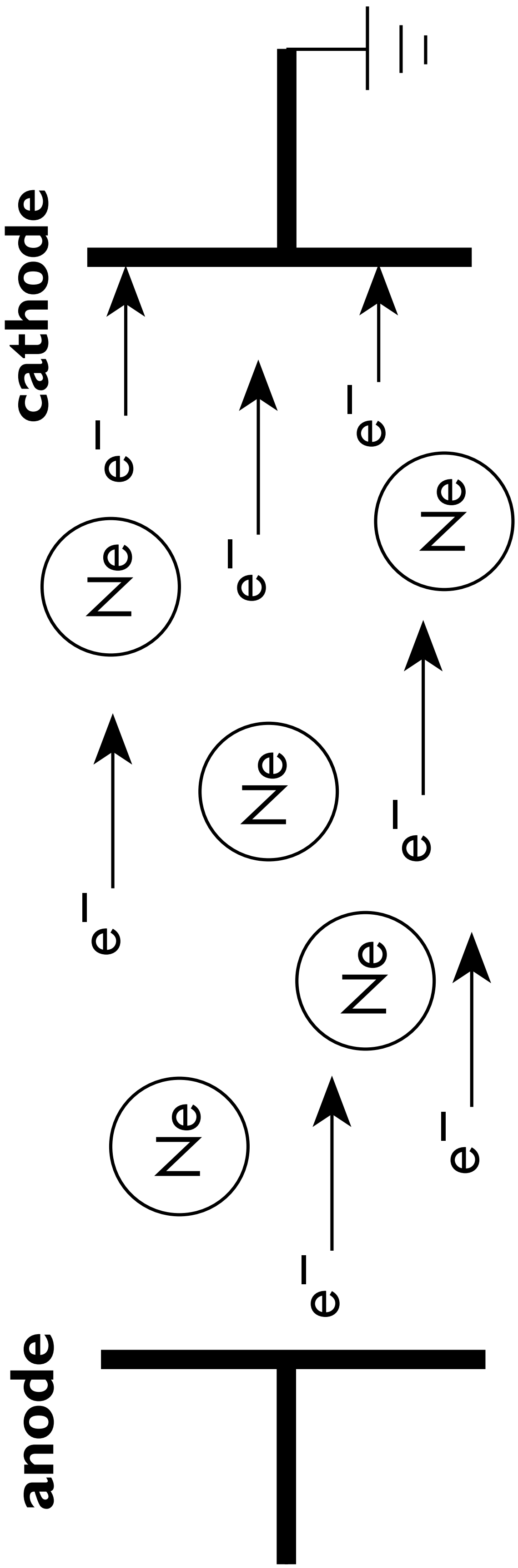
On the following pages are illustrations that may help you explain how a neon light bulb works and the chemistry of vision. We encourage you to photocopy these pages onto transparency sheets and use them in your classroom.

Soldering

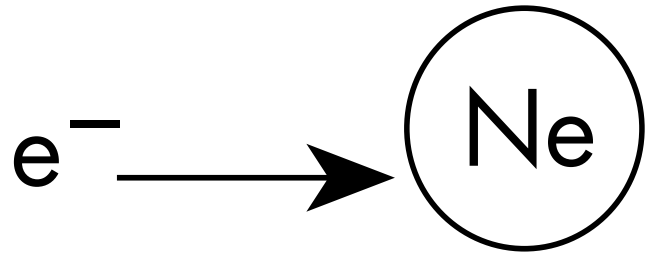


The notes on pages 24A–24C provide background information on these facets of soldering:

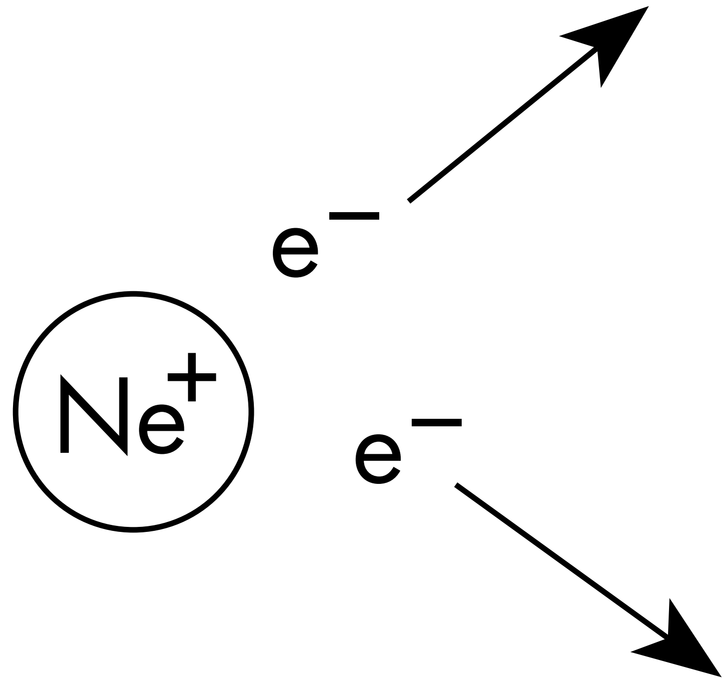
- Equipment
- Soldering Procedure—Soldering wire leads to a PC board, soldering wire leads to a wire, and soldering wire leads to multistrand wire
- Wire Stripping



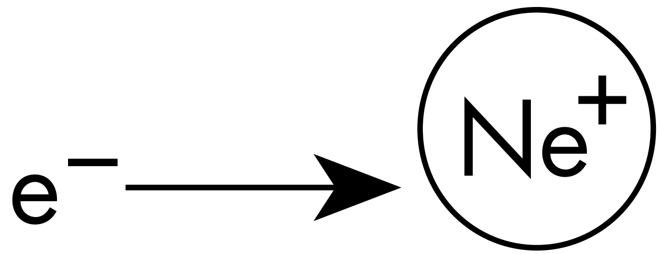
A neon lamp at ±40 V.



Step 1. An electron hits a neon atom.

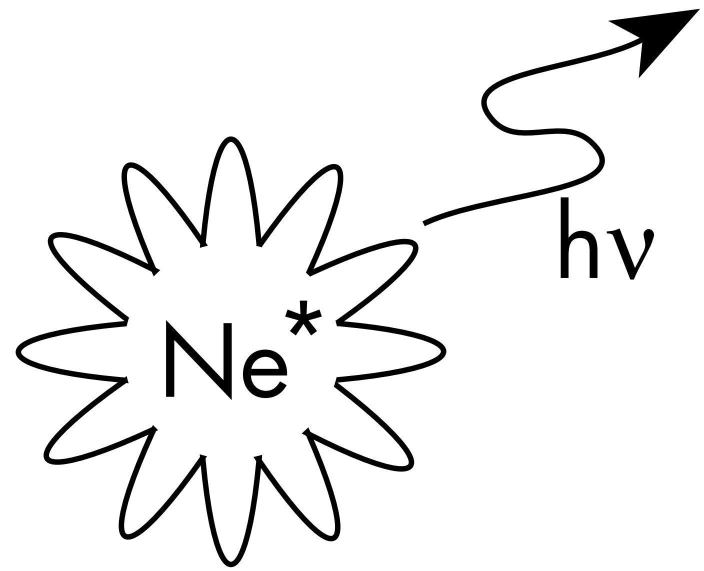


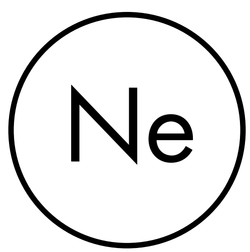
Step 2. The impact strips off an electron, leaving a neon cation.



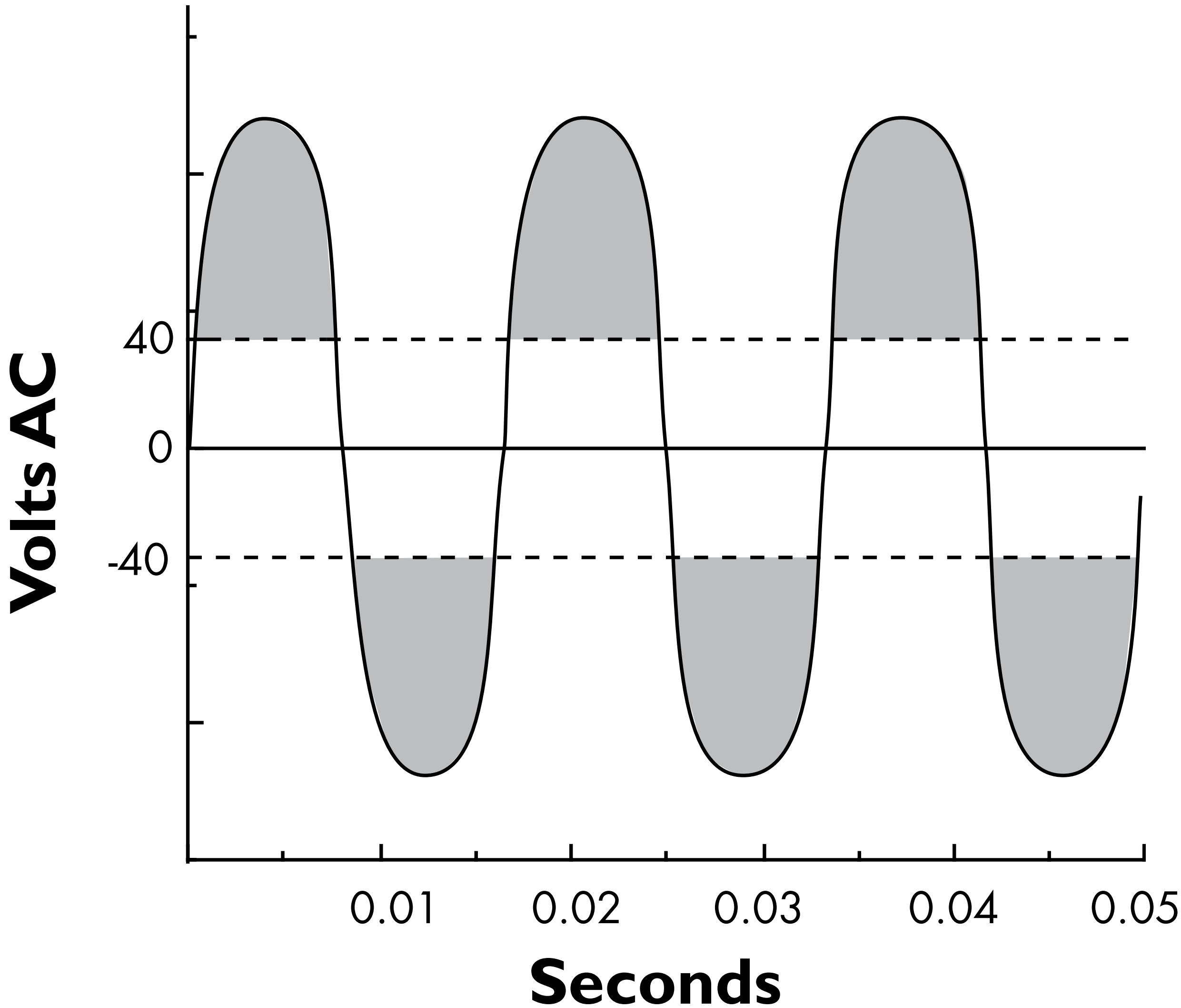
Step 3. A second electron hits the neon cation, producing a neutral, excited atom.

Step 4. The excited neon atom releases a photon.

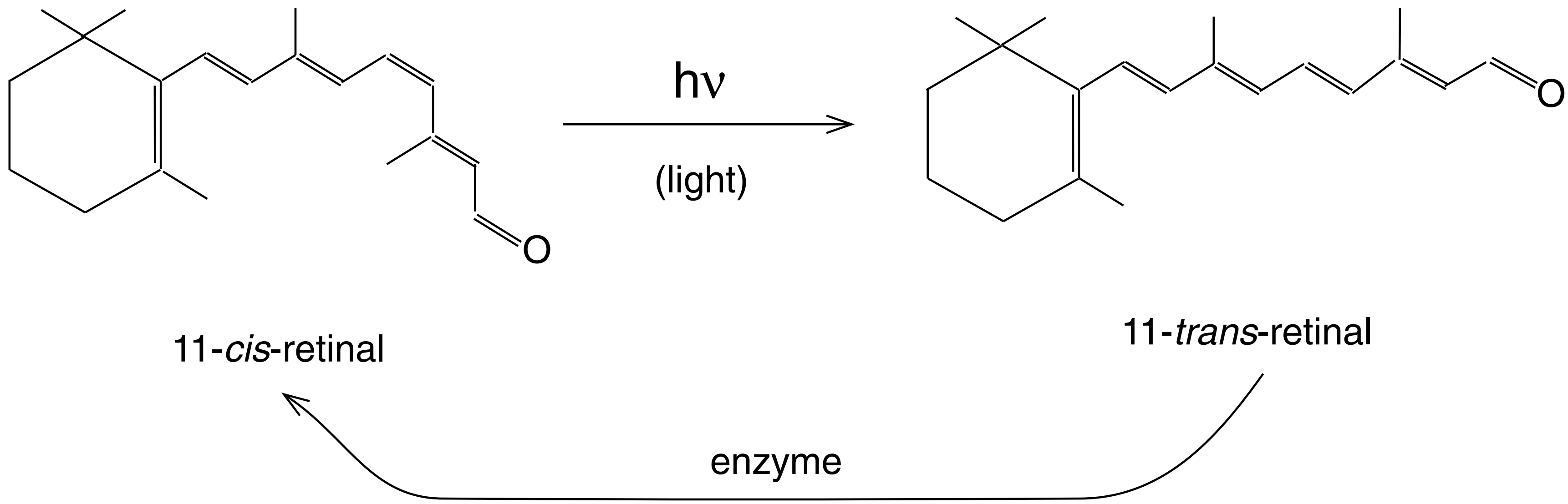




Step 5. The neon atom returns to its original, ground state.



The neon lamp is on when the voltage is more than 40 volts or less than −40 volts.



The light-absorbing system, or photodetector; the "chromophore" in your eye.

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Appendix: Soldering

Text by Carl Houtman, Illustrations by Christine L. Cargille

NOTE

To see a useful video about soldering, go to:

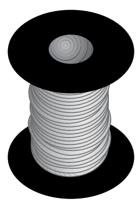
www.youtube.com/watch?v=BLfXXRfRIzY

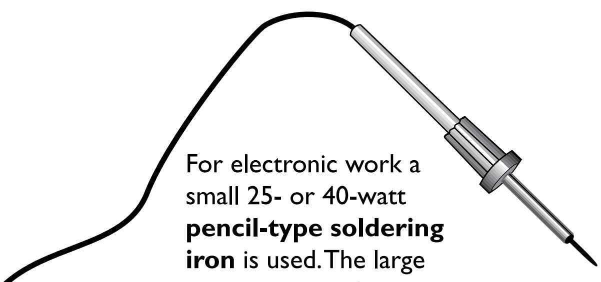
⚠ CAUTION ⚠

The tip of a soldering iron is extremely hot. Soldering is inherently a three-hand job: you need to hold the soldering tool and both pieces to be joined. However, it is best to use a vise or a clamp for the third hand, rather than a human assistant.

The equipment

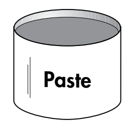
Soldering is a way to join two metal surfaces. For the "glue", one uses a low-melting-point alloy. For electronic or electrical work an alloy that is 40% tin and 60% lead is best, in contrast to the 50/50 solder that is used for plumbing connections. **Electronic solder** often has a rosin core to act as a flux to improve the "wetting", or coating, of the metal surfaces to be joined.

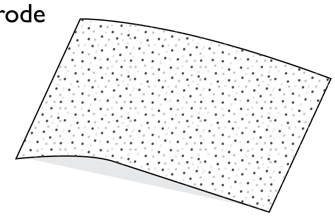




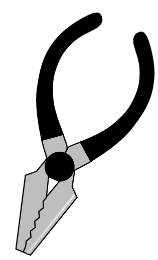
For electronic work a small 25- or 40-watt **pencil-type soldering iron** is used. The large gun-type irons do not have a fine enough tip.

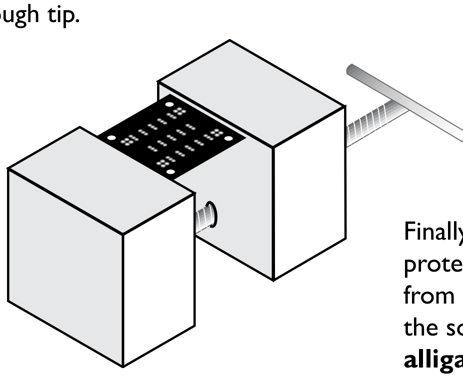
To clean and re-tin the soldering iron tip, use **tip cleaning paste** for electronic work from an electronics store. Do not use acid cleaners or acid flux—they will corrode your work. You can also gently **sand** the surface of the soldering iron tip until you have exposed the base metal.





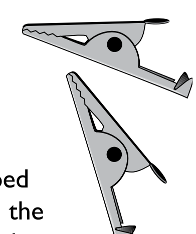
You will need **tweezers or pliers** or some other tools to hold small, very hot, delicate objects.





It will infinitely simplify your task if you have a **vise** or a **C-clamp** to hold one of the parts that you will be soldering—either the printed circuit (PC) board, if you are soldering components to it, or one of the wires, if you are soldering to a wire.

Finally, you may need to protect certain components from overheating during the soldering process. Small **alligator clips** can be clamped between the component and the joint to be soldered to act as heat sinks.



Soldering procedure

1. ⚠ **Clear away a work space** on a flameproof surface. **Put on safety goggles** to protect your eyes from hot rosin which might spatter.
2. **Take a sponge, or fold a paper towel** into quarters or eighths and **wet it**; place it next to the soldering pencil.
3. Plug in the soldering pencil and allow it a few minutes to get hot. **Check the tip:** Touch the tip of the soldering pencil to some solder. It should melt and coat the tip. If the solder rolls off the tip and does not coat it at all, you may need to clean the tip as described above. Then the solder will wet the tip surface.

   While soldering, **wiping the tip** on the damp paper towel (or sponge) will help clean it by removing the oxide that forms on the surface of molten solder. Wiping on a damp towel also keeps the tip from overheating and oxidizing. To wipe the tip, simply stroke it over the folded paper towel that is lying on the table.

   ⚠ Do **NOT** pick up the towel and rub it over the tip! If you do, you will severely burn your fingers.
4. The most important step in obtaining good solder joints is to **clean all the surfaces** carefully. Solder does not wet oxidized surfaces. When working on a printed-circuit board, rub the metal surfaces with fine steel wool. Other electronic components typically have non-oxidizing wires that don't need cleaning. Copper wires may need to be stripped to expose fresh metal. For help in wire stripping, see the relevant section below.

The next few steps will describe how to solder a wire lead of an electronics component to a printed-circuit (PC) board and how to solder a wire to a post or to another wire. An important point to remember when soldering *any* joint is that it is not sufficient to melt the solder and drip it all over the joint as one might do with glue. The pieces to be joined must be at the same temperature as the molten solder in order for the bond to be strong. Thus, *the soldering iron is used to heat the pieces to be joined, which in turn heat the solder.*

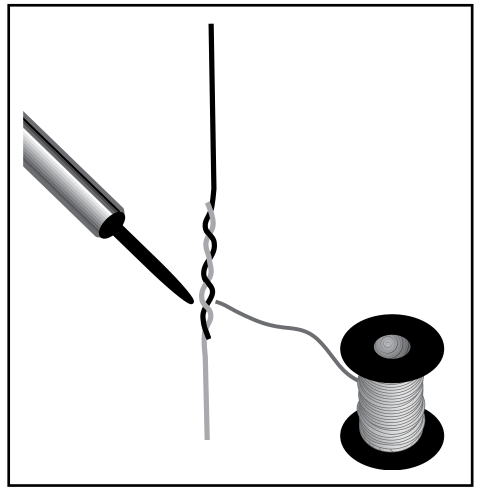
A. How to solder wire leads to a PC board

5. **Insert the wire leads** of the electronics component into the appropriate sockets of the PC board.
6. **Secure the board** in a vise or clamp.
7. If necessary, **clamp an alligator clip** between the joint and the (heat-sensitive) electronics component to minimize the heat transferred up the wire lead.
8. A *small* amount of solder should be on the tip of the soldering pencil to aid the flow of heat to the surfaces. Hold the soldering pencil in one hand and the solder in the other. Touch the hot tip of the soldering pencil to one side of the wire lead and to the soldering trace on the board. When the surfaces are hot (after about 30 seconds or so), touch the solder (not the pencil) to the other side of the wire lead. Do not let the solder touch the soldering pencil directly.

   After about 25 seconds, the heat from the soldering pencil should penetrate through the wire lead and melt the solder. The solder will flow onto the wire and onto the copper trace. The solder only flows onto hot surfaces.

9. Do not use too much solder or it will overflow onto adjacent leads or traces, creating a "solder bridge". If you make a solder bridge, first rub off any excess solder from the pencil tip on a damp paper towel. Reheat the joint to melt and remove the bridge. If this does not work, heat the joint until *all* the solder is molten and then tap the board on the table. If the solder is molten you should be able to shake it from the board.

B. How to solder wire leads to wire



10. **Make a firm mechanical connection** by twisting or crimping the wires together. Then, follow instruction number 8 above.

    If you do not make a good mechanical connection, you may make what is called a "cold solder joint". Cold solder joints form when the wires are moved as the solder is cooling. One can spot cold solder joints because they often have a rough surface while good joints have a smooth surface. Simply reheating a cold solder joint will correct the problem.

C. How to solder wire leads to multistrand wire

11. **Strip** 1–1.5″ of insulation from the multistrand wire. Twist the strands so that they spiral together. "**Pre-tin**" the strands: Hold the tip of the soldering pencil to one side of the wire and the solder to the other side. When the wire is hot enough, the solder will melt and penetrate among the strands. Allow to cool. Then, follow instruction number 10 above.

Wire Stripping

"Stripping" a wire refers to removing the insulation casing and exposing the copper wire. The easiest way to strip wire is to use wire strippers. These are designed to cut the insulation but leave the metal wire intact—they are like scissors with a small notch in the cutting edge. Care is required, however, since many wires are bigger than the notch.

Place the wire in the jaws of the stripper at the position where you want to remove the casing. Squeeze the stripper carefully. [If you are uncertain about how hard you need to close down the stripper, practice by trying to remove a very short piece (1 cm) of insulation.] You may want to rotate the stripper around the whole wire to get an even cut all the way around the insulation.

Once the insulation is cut, shove the stripper along the wire towards the end to push the casing off the bare wire inside. This is like taking off a sock by pushing it down from the top instead of pulling it by the toe.