44

The Photoelectric Effect
Particular Waves

Purpose

To observe the photoelectric effect.

Required Equipment and Supplies

electroscope
plastic strips
cloth patches of silk and wool
zinc plate (approximately 5 x 5 x 0.1 cm)
steel wool
lamp with 200-watt bulb
ultraviolet light source (mercury vapor lamp)
straws

Discussion

Albert Einstein is best known for his theories of special and general relativity. Interestingly enough, he was awarded the Nobel Prize for something entirely different—the photoelectric effect. In this experiment you will observe the photoelectric effect, which is the ejection of electrons from certain metals (in this case, zinc) when exposed to light.

Procedure

Step 1. Scrub the zinc plate with the steel wool to make it shiny. Place the zinc plate on the probe of the electroscope.

Step 2. Rub the white plastic strip with the wool cloth to negatively charge the strip. Touch the strip to the top of the electroscope. Notice that the leaves separate—evidence that the electroscope is charged.

Step 3. Observe the leaves of the electroscope for about one minute.

1. Does it discharge by itself?

Step 4. Touch the top of the electroscope with your finger. Note that the electroscope discharges.

2. Why did the electroscope discharge when you touched it?

Step 5. Rub the clear plastic strip with the silk cloth to charge the strip. Touch the strip to the zinc plate on the electroscope. Observe the leaves for one minute. Now touch the zinc plate with your finger to see whether the electroscope discharges.

3. Describe what happened to the leaves of the electroscope from the time you touched the charged acetate strip to the zinc plate.

Step 6. Perhaps electrons can be "blown away" from a negatively-charged electroscope by bombarding it with high intensity light. Charge the electroscope negatively, as in Step 2. Shine white light from a 200-watt light onto the zinc plate from a distance of 10 cm.

4. How does the electroscope react to the high-intensity white light?

Step 7. Recharge the electroscope negatively if its leaves have dropped. Now shine a 60-watt ultraviolet light on the zinc plate.

5. How does the electroscope react to the relatively weak, ultraviolet light?

Step 8. Perhaps the ultraviolet light is somehow making the air conductive. Charge the strip with a positive charge as in Step 5, and shine the ultraviolet light on the zinc plate again.

6. Does the electroscope discharge?

Step 9. In Data Table 44.1, indicate in each box whether the electroscope discharged or did NOT discharge during your tests.

Data Table 44.1

	BRIGHT VISIBLE LIGHT CAUSED THE ELECTROSCOPE TO:	WEAK ULTRAVIOLET LIGHT CAUSED THE ELECTROSCOPE TO:
NEGATIVELY CHARGED ELECTROSCOPE		
POSITIVELY CHARGED ELECTROSCOPE		

Analysis

7. If the *intensity* of the light is responsible for discharging the electroscope, which light source would discharge the electroscope better?

8. If the electroscope could not be discharged using high intensity white light, but was discharged using a weak ultraviolet light, the *intensity* of the light did not cause it to discharge. How is ultraviolet light different from visible light?

9. Rather than hypothesizing that light is composed of waves, consider that it is composed of particles called *photons*. Each photon carries a discrete amount of energy. According to your data, which type of photons seem to have more energy, visible-light photons or ultraviolet-light photons?

10. The energy of a photon is proportional to the frequency of the light. Photons of ultraviolet light possess enough energy to "eject" (or *ionize*) electrons trapped in the zinc metal. When the electroscope was *positively* charged, why did it *not* discharge when it was exposed to ultraviolet light?

11. Would an infrared heat lamp or a doctor's X-ray machine be better at discharging a negatively-charged electroscope? Why?