ACTIVITY 5

Exploring Photoluminescence

Goal

In the previous activity, we explored several types of luminescence and compared it with incandescence. In this activity, we will investigate luminescent materials that require light to emit light. These materials are called photoluminescent.

In a dark room, open the black envelope labeled "A" assigned by your instructor that contains an object that has been placed in it overnight. Take the object out of the envelope.

? Does object "A" emit light? If it does, in the space provided below describe the emitted light.

Turn on the lights and expose the object to the light. After a few seconds, turn off the lights.

? Does object "A" seem to emit light when the lights are on?

? Now, turn the light off again. Does light come from object "A" ? If it does, in the space provided below describe the characteristics of the emitted light.

Photoluminescence, unlike the other types of luminescence, requires light in order to emit light. As a result, the chart used in the first activity to identify the different types of luminescence (Figure 1-3) needs to be expanded to include Figure 5-1 illustrated on the following page.

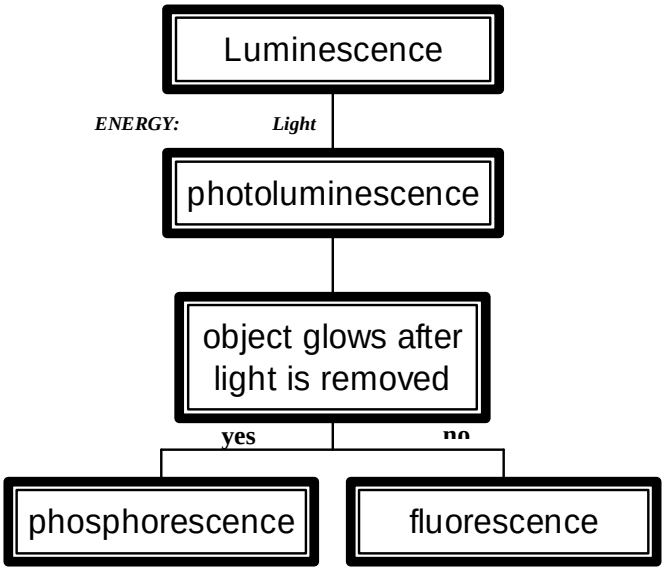

Figure 5-1: Photoluminescence Addition to Luminescence Chart

According to Figure 5-1, a photoluminescent object emits light or glows as a result of shining light on the object. An object that utilizes phosphorescence will glow-in-the-dark after the lights have been turned "off". A fluorescent object emits light only in the presence of light.

? Using the chart, what process of photoluminescence does object "A" utilize to emit light? Explain.

Caution: The UV light emitted from some black lights has the potential to cause eye damage! Don't look directly at the light and always wear safety goggles when using the black light.

In this part of the investigation, we will be using a fluorescent lamp and a black light. The fluorescent lamp emits visible light and is a common light source found in many businesses, schools, and homes. The black light is a special type of fluorescent lamp that emits nearly invisible and invisible light of high energy, called ultraviolet (UV) light.

Now, we are using the light from fluorescent tubes to study other photoluminescent objects. As you might suspect, fluorescent tubes use the fluorescence process. We said that light produced by fluorescence does not require electricity, yet a fluorescent lamp does. The process in which the fluorescent lamp operates will be explained in later activities.

The photoluminescent objects under investigation have been stored in a black plastic bag for a few days.

In a darkened room place the two objects, one at a time, on a piece of black paper. Turn on the fluorescent lamp and observe the appearance of each object in the light. After making the observations for one object, remove the object from the paper and place another object in its place. Your investigation should focus on answering the following questions:

- ? Does the color and appearance of the object change when the light strikes it?
- ? How does the brightness change after the light is turned "off"?
- ? How long is the light emitted by the object visible?

? In the space provided below, record your observations for each object.

Repeat the same procedures to illuminate the same two objects, but this time expose them to different colors of visible light (red, green, and blue) by using color filters. Color filters absorb all the colors of light emitted by "white light" source (i.e. fluorescent lamp) except for the color of light that is identical to the color of the filter. The color filter transmits this particular color of light. For example, a red color filter allows red light from the fluorescent lamp to be transmitted to the object. Your investigation should focus on answering the following questions:

- ? Does the color and appearance of the object change when the light strikes it?
- ? How does the brightness change after the light is turned off?
- ? How long is the light emitted by the object visible?

In the table provided below, record your observations for each object.

Color of Light	Object #1	Object #2
Red		
Green		
Blue		

Remove the color filters and now illuminate the two objects with the black light. Your investigation should focus on the same questions:

? Does the color and appearance of the object change when the light strikes it?
? How does the brightness change after the light is turned off?
? How long is the light emitted by the object visible?

. In the space provided below, record your observations for each object.

After completing the investigation, as a group use your observations and Figure 5-1 to identify the process of light emission for both objects. Record the results in the space provided below.

After each group has identified its photoluminescent objects as being either phosphorescent or fluorescent, each group should share its results with the entire class. The resulting discussion should focus on completing the following table and answering the following questions.

Phosphorescent Objects	Fluorescent Objects
glow-in-the dark toys	light sticks
watches	paraffin wax
toothbrushes	laundry detergent with whiteners
vinyl sheets	colored glass
stickers	fluorescent minerals
posters	clipboards
etc.	etc.

? Describe the characteristics (such as color, brightness, and duration) of light emitted by the phosphorescent objects.

? What conditions were required for light emission by the phosphorescent objects?

? Describe the characteristics of light emitted by fluorescent objects.

? What conditions were required for light emission by the fluorescent objects?

? How are phosphorescent and fluorescent objects similar?

? How are they different?

Fluorescent objects emit light immediately after absorbing light. When the light source is removed, the object immediately ceases to glow.

Phosphorescent objects continue to glow for some time even after the light source has been removed. Thus, phosphorescent objects are said to glow-in-the-dark. A phosphorescent surface exposed to visible light continues to glow even after the light is turned "off" because the energy absorbed from the light is released over a period of time. For example, phosphorescent ink is used to paint the hands of some watches. The paint absorbs light when illuminated and glows when the lights are turned "off".

While the visible light emitted by the fluorescent lamp can activate phosphorescent materials, fluorescent materials require UV light to produce their characteristic glow.

One practical application of phosphorescent materials is glow-in-the-dark tapes and signs used to identify escape routes during emergencies when visibility is reduced (Hanovia, 1996).

A practical application of fluorescence involves fluorescent markings on credit cards to determine whether the cards are real or counterfeit.

The U.S.Treasury Department is redesigning currency to make counterfeiting more difficult. One of the security features found on the new bills is a fluorescent thread found inside the paper. The thread's relative position indicates the currency denomination and glows red when exposed to UV light. This thread and other security features (such as micro-printing, color-shifting ink, portrait enlargement, and concentric fine lines) will eventually be added on all bills of $20 or greater.

The black light used in this activity is an artificial source of UV light. Other sources of UV light include tanning lamps, the lamps used to sterilize medical instruments, and the sun. Tanning and sterilization lamps emit light that is higher in energy than the UV light emitted by a "black light".

Only 1% of the UV from the sun is able to penetrate the earth's atmosphere. Fortunately, the ozone in the atmosphere prevents the very high energy UV light that can cause severe damage to our bodies from reaching us. Unfortunately, scientific studies have reported a reduction in the ozone concentrations in the atmosphere, which means more of the very high energy UV can now reach us.

Recall that UV light is higher in energy than visible light. Overexposure to UV in sunlight can cause sunburns that can eventually lead to skin cancer. Directly looking at UV light can also cause damage to the retina of the eye. As a result, one should not look directly into a source of UV light such as the sun or a "black light".

UV light has been used to examine fine art or old colored glassware that exhibit fluorescent properties. This colored glass, known by various names (*Canary*, *Vaseline*, *Topaz*, *Depression*, *Teaberry Gum*, *Burmese*, and *Pedal ware*) has been produced since the 1870's and comes in a variety of colors and shapes (Salman & Repko, 1996). Most of this glass exhibits strong fluorescence when exposed to UV light and is radioactive because of the uranium salts used to give the glass its characteristic color.

While humans cannot see UV light, researchers have found that birds and certain insects can see special colors in ultraviolet. For example, birds use natural UV light to select their mates. These special colors are produced when UV light bounces off their feathers. Researchers have found that female zebra finches prefer mates with particular patterns of these colors, among other characteristics (*Science News*, 1996).

Insects such as bees can also see special colors in ultraviolet. Since some flowers, which look alike in visible light, display very distinctive colors in UV light, bees are able to distinguish easily among flowers which look very similar to us (Schissel, 1996).

In this activity, we were able to examine the properties and applications of photoluminescent materials. In the previous activity, we explored the other processes of luminescence (that is electroluminescence, mechanoluminescence, chemiluminescence, and bioluminescence) and compared these processes of light emission with incandescence. The chart illustrated in Figure 5-4 summarizes the types of luminescence that we have investigated.

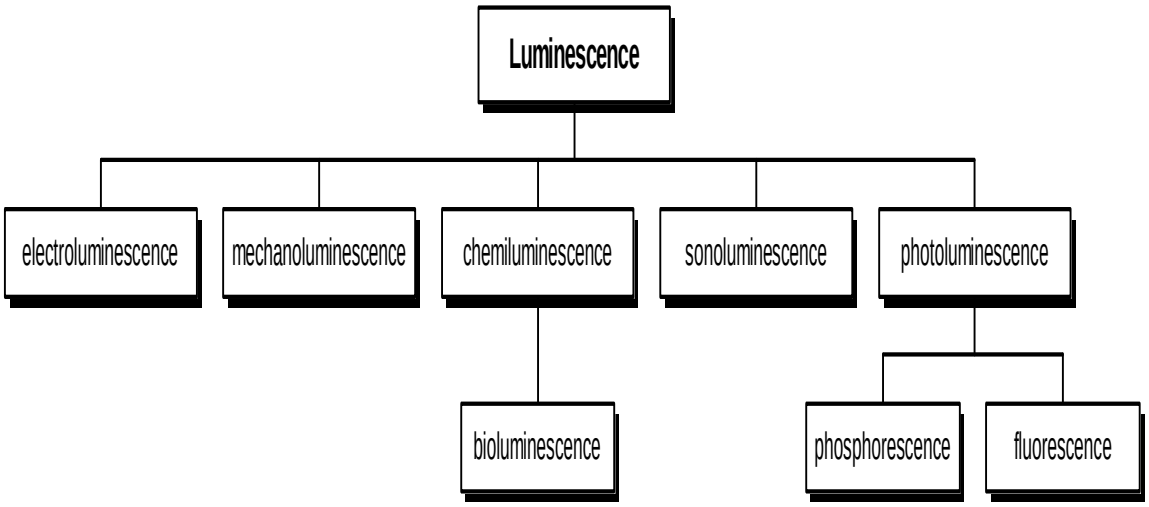

Figure 5-4: Types of Luminescence

In future activities, we will construct models to explain the properties observed for luminescent materials and the fluorescent lamp. Atoms that make up these materials play a key role in these models. In order to fully understand how atoms contribute to the operation of luminescent materials, we will study the light properties of these materials more carefully.

Optional Application Activity

Unlike birds and certain insects, humans cannot see UV light. We, however, can use special plastic beads to detect UV light. Some of these plastic beads have been stored in a black envelope or plastic bag.

Remove one of the beads provided by your instructor and expose it to the UV light emitted by the black light.

Remove another bead from the container and now expose it to the light emitted by a fluorescent lamp.

Remove another bead from the container and expose it to the natural light emitted by the sun.

? What happens to the beads when they are exposed to the light emitted by the black light?

? What happens to the beads when they are exposed to the light emitted by the fluorescent lamp?

? As a result of what happens to the bead when it was exposed to the light emitted by the fluorescent lamp, does the fluorescent lamp emit UV light?

? What happens to the beads when they are exposed to the light emitted by the sun?

? As a result of what happens to the bead when it was exposed to sunlight, does sunlight contain UV light? Explain.