Name: Class:

ACTIVITY 1

Exploring Light Emitting Processess

Goal

In this activity, you will investigate the physical properties of different luminescent materials and compare these properties to those associated with a common incandescent lamp.

Matter emits light through various processes that convert other forms of energy to light. For example, light is emitted as a result of heat from the flame of a candle or fireplace. Light is also emitted by energy released by breaking or grinding a substance such as sugar or a piece of candy. Energy created from mixing some chemicals and by some living organisms such as the firefly can emit light. In this unit, we will explore common, everyday materials and devices that utilize these processes to emit light. Later, we will find that the unique, observable properties associated with light-emitting materials and devices can be explained by quantum principles. In the first activity, we will explore materials and devices associated with each light-emitting process.

The most common, everyday light sources other than the sun are incandescent lamps, also known as light bulbs, found in every household and place of business. The light bulb contains a solid tungsten filament that emits light when energy is provided by an external energy source such as a battery or electrical power plant.

? Examine the incandescent lamp that you have been provided. Can you see the filament?

Observe the light emitted by the incandescent lamp provided.

? In the space provided below, describe the color, and intensity of light emitted by the lamp.

Carefully place your hand near the top of the lamp without touching the lamp.

Be careful not to touch the incandescent lamp especially if it is a household lamp.

? Does the incandescent lamp emit any heat? How can you tell?

The process in which light is emitted by the incandescent lamp is appropriately called incandescence or "hot light". Incandescence is the process by which a heated substance emits light. Inside the lamp, the tungsten filament is heated by electrical energy. Some of this energy becomes the light that you see while the rest of the energy is emitted as heat. A typical incandescent lamp is very inefficient at emitting light. About 5% of the energy becomes light; 95% is emitted as heat.

We will now explore the properties of another device, a light emitting diode (LED), which emits light in a different way. LEDs are typically used as ON/OFF indicator lights in electrical appliances such as televisions, VCR's, and stereos. The numbers in some alarm clocks, radios, and microwave ovens are displayed by LEDs. Large video displays in places of business, sporting events, and concerts utilize LEDs. For example, the music group *U2* during their 1997 *POPMART* tour was using a 56 feet x 170 feet video screen consisting of LEDs. The low voltage requirements needed to operate LEDs as well as their small size and mass makes them an attractive light source to use with these applications.

We will use a small circuit board for this exploration.

Connect the battery snap to the circuit and observe the light emitted by the LED. If no light is emitted, use the small screwdriver to turn the screw on the end of the blue rectangular device until light is emitted.

? In the space provided below, describe the light emitted by the LED in terms of its color and intensity.

Carefully touch the top of the LED.

? How is the LED similar to the incandescent lamp in terms of physical and light properties?

? How are they different?

? What type(s) of energy was (were) required for the LED to emit light?

? Do you think that the light emitted by the LED was due to incandescence? Explain.

A device that uses a similar process to emit light as the LED is the Lime Lite® night-light that emits a faintly glowing green light when plugged into the household power supply.

We will now continue the investigation by exploring other ways in which matter can emit light.

Place aWint-o-green™ Lifesavers® mint in a plastic sandwich bag and close the bag. Take the bag with the mint and a pair of pliers into a dark location and let your eyes adjust to the darkness. Crush the mint with the pair of pliers and observe what happens.

Be careful not to crush your fingers.

? In the space provided below, describe what you observed.

? What type(s) of energy caused light emission?

? Was the emitted light due to incandescence? Explain.

We will now examine the properties of a light stick. Remove the light stick assigned by your instructor from its wrapper and activate the light stick by bending and snapping it to break the inner glass vial. Shake the contents.

> Be careful not to puncture the light stick! Although the contents of the light stick are non-toxic and non-corrosive, the contents may permanently stain your clothing.

? In the space provided below, describe your observations.

? What type(s) of energy was (were) required for the light stick to emit light?

? Did you detect that the light stick changed temperature after it was activated?

? Was the light emitted by the light stick due to incandescence? Explain.

? Do you know of any other objects that emit light in the same way as the light stick?

We will now observe the light emitted by glow in the dark objects.

Take a ball or other glow-in-the-dark object and observe it in a darkened room. Then take it to a bright light and expose it to the light for awhile and return to the darkened room.

? In the space provided below, describe your observations.

? What type of energy caused the glow-in-the-dark object to give off light?

? Was the emitted light due to incandescence?

The LED, Wint-o-green™ mints, glow-in-the-dark objects, and light stick did not involve an appreciable emission of heat or rise in temperature.[1] As a result, the process was not incandescence or "hot light". To quote Polonius from Hamlet (Act I, Scene 3), "These blazes, give more light than heat." The process in which light is emitted by a material with very little change in the material's temperature is called luminescence or "cool" light.

Luminescence can take many forms. As you observed in your exploration, luminescence can involve different forms of energy. Light emission as result of adding electrical energy is called electroluminescence. An LED emits light by the process of electroluminescence.

Light emission caused by adding mechanical energy to a material, such as by crushing Wint-o-green™ Lifesavers®, results in mechanical deformation of the material and is called mechanoluminescence or triboluminescence. Other examples of mechanoluminescent light include that seen by pulling apart adhesives like Curad®-brand bandage wrappers or by grinding table sugar. Flashes of mechanoluminescent light have also been observed during earthquakes when large pieces of rock slide past one another (National Public Radio, 1996).

Glow-in-the-dark objects do not give off light unless they are first exposed to another source of light. The source of energy for these objects is the original light source. When an object absorbs light of one energy or color and then gives off light at a different color or energy this is called photoluminescence. Glow-in-the-dark and fluorescent materials fall under this category. We will explore these two photoluminescent processes in a later activity.

1 With this discussion of heat and temperature and the 1996 summer release of the movie, Independence Day, one is reminded of the classic science-fiction story of The War of the Worlds by H.G. Wells in which the invading Martians use a powerful heat ray to conquer the people of Earth. Wells describes this heat ray as a "flaming death, this invisible, inevitable sword of heat that caused pine trees to burst into fire and every dry furze bush became with dull thud a mass of flames". For more information about the book, look for the book at your school library or check out the following web site: http://fourmilab.ch/etexts/www/warworlds/b1c5.html.

For the case of the light stick, mechanical energy was supplied to break the glass vial found inside. The emission of light, however, is the result of a spontaneous, energy-producing chemical reaction that occurs when the chemicals in the glass vial mix with those in the rest of the light stick. The energy from the chemical reaction was converted into light and the resulting light emission is called chemiluminescence. Small light sticks can be found in clear golf balls that are used to play golf at night. Light sticks can be found at amusement parks or specialty stores as necklaces and headbands. They can also be found in bait and tackle shops to be used as lures for night fishing.

If a chemical reaction that converts energy into light occurred in a living organism, the organism exhibited bioluminescence. Fireflies and certain types of ocean plankton, bacteria, algae, plants, shrimp, jellyfish, shallow sea creatures (for example, flashlight fish and luminous brittle stars), and deep-sea creatures (for example, squid and lantern fish) emit bioluminescent light. Bioluminescence will be discussed in more detail in Activity 5.

Flashes of blue-green light have been observed when a gas bubble, trapped in a liquid and exposed to sound (audible to ultrasonic), expands and contracts. This type of luminescence, which occurs in bubbles, is called sonoluminescence. Sonoluminescence can continue for hours (Glanz, 1996; Crum, 1994; Barber, 1992).[2]

Eihard Wiedemann developed a classification chart in 1889 to differentiate between incandescence and luminescence. (See Figure 1-1.) Read the chart from top to bottom. Based on whether the emission of light involved a substantial increase in temperature, use the chart to identify the type of light emission from any lighted object.

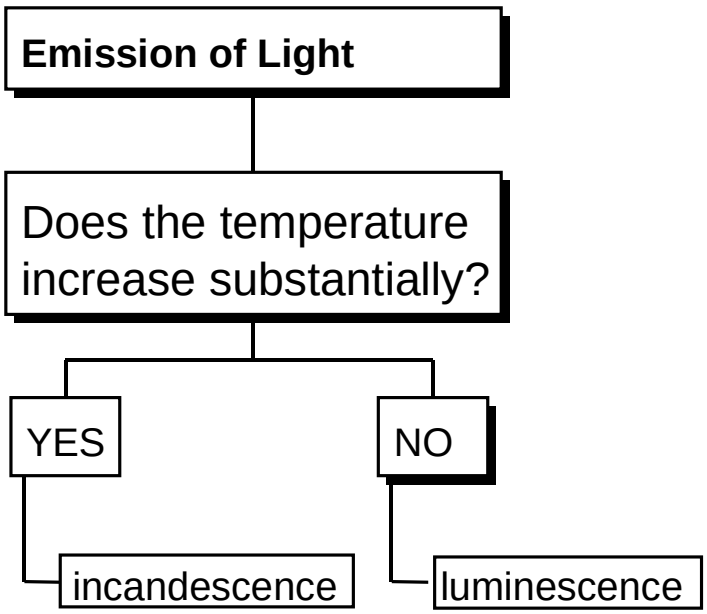

Figure 1-1: Processes of Light Emission

[2]Sonoluminescence was the subject for the movie, *Chain Reaction*, which was released August of 1996. To learn more about "Hollywood's" version of sonoluminescence and the movie, investigate the following website: http://movieweb.com/movie/chainreaction/index.html.

The chart illustrated in Figure 1-2 expands on Wiedemann's classification scheme and summarizes the results of your exploration.

In this activity, we differentiated between incandescence ("hot light") and luminescence ("cool light") and explored materials that emit light through various types of luminescence. In the next activity, we will continue our exploration of luminescence by focusing on luminescent materials that must absorb light in order to emit light.

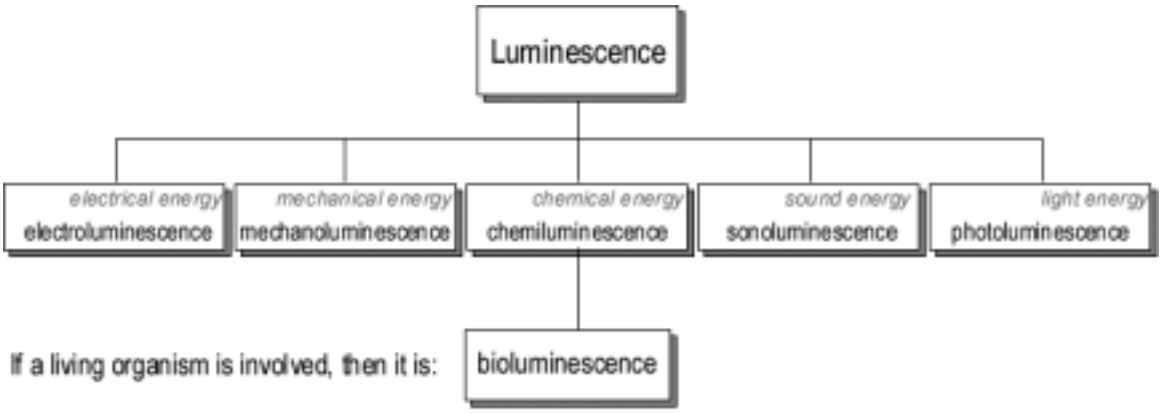

Figure 1-2: Types of Luminescence

Homework Activity:

1. Below each luminescent category of Figure 1-2, identify the investigated object or device that exhibits the corresponding method of light emission.

2. For the luminescent phenomena that you didn't investigate in class, search the Internet or library to learn more about those particular phenomena. Use the recommended Web sites that are found through out this activity as a starting point.