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Let It Glow Kit

LGT-325

Introduction:

Energy comes in many forms: energy of motion, energy of position, thermal energy, sound energy, and many more. Light is also a form of energy. It's easy to say that an object that is hotter or moving faster has more energy than another object, but what does it mean for light to have more energy? Most people assume that brighter light has more energy than dimmer light. But that's only part of the story. In this experiment, your students will learn how color affects light's energy.

SAFETY FIRST!

Review these guidelines closely with students before the activity. Be sure to outline the physical and academic consequences for failure to follow all safety procedures!

Warn students very strongly about the dangers of looking directly into the laser beam. Shining the beam into their own eyes or the eyes of their classmates can cause serious injury and damage.

Consequences for students recklessly playing with the lasers should be outlined before giving out the supplies for the activity.

If you are concerned, you may prefer to complete the portions of the procedure with the laser yourself and have your students perform the analysis.

Materials:

- 3" x 3" phosphorescent vinyl
- red, blue, yellow, and violet transparent gel filters
- laser pointer
- white light
- dark room (you provide this)

NOTE: *Make sure you unscrew the laser's cap and remove the piece of paper between the batteries. You may need to remove all the batteries. Take care to put the batteries back in the laser in the correct direction.*

Key Question:

What colors of light cause a glow-in-the-dark square to glow?

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Key Terms:

Energy: Energy is the ability to do work. Energy can come in different forms such as light energy, heat energy, energy of motion, or chemical energy. Energy cannot be created or destroyed, but it can change from one form to another.

Intensity: The strength of something. Brighter light has a higher intensity.

Photon: A packet of light energy. Different colors of light have different amounts of energy in their "packets."

Transparency: Letting most of the light through without scattering it. Objects behind such a material can be seen clearly.

Wavelength: The distance from one wave peak to the next.

Before the activity, students should know:

- A rainbow is made of red, orange, yellow, green, blue, indigo, and violet light.
- Different colors of light have different wavelengths.
- Energy is never created or destroyed.

After the activity, students should be able to:

- Describe why the glow-in-the-dark square will only glow when it is hit with certain colors of light.
- Explain how the color of light is related to its energy.
- Explain why the colors of a rainbow are in a certain order (ROYGBIV).

The Science behind Glowing in the Dark:

Light is a very interesting entity. You may have heard it said that light is both a particle and a wave. It may be better to phrase this as "light has both wave and particle properties."

This experiment is essentially a do-it-yourself tabletop version of one of the most famous physics experiments of all time—the photoelectric effect. It was the photoelectric effect that led scientists to develop the idea that light had particle properties.

Probably the best way to think about this mind-bending notion is to picture photons as little packets of waves. Different colors of photons have different wavelengths. Blue and violet photons have shorter wavelengths than red or yellow ones. The shorter the wavelength, the more energy a wave has. This is why we get sunburned by ultraviolet rays but not by infrared rays. Because the ultraviolet rays have high energy, they can burn our skin.

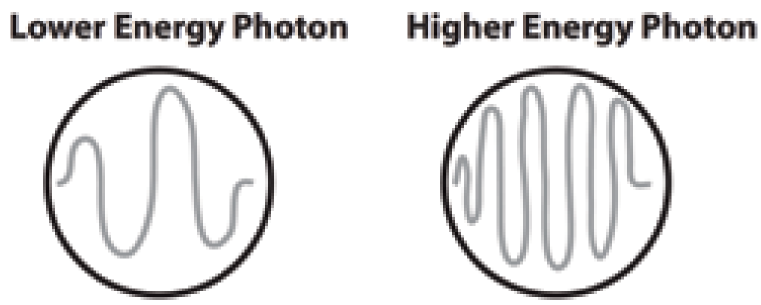
The glow-in-the-dark material in your kit is made up of special molecules called phosphors. Electrons sit in different energy levels. To move to a higher energy level, they need energy from photons. When photons from a light source hit the molecules, they excite the electrons and make them jump up to a higher energy level.

But the electrons don't stay up there forever. When they fall back down to a lower energy level, something has to happen to the energy they are losing because we know that energy can't be created or destroyed. The energy the electrons lose pops out as photons. The energy of a photon is based on its wavelength. If you think of the colors of the rainbow, red has the least energy and violet has the most energy. Energy increases as you go from red to violet. This is why the colors of the rainbow are in a certain order: the colors are arranged by the order of energy.

Electrons have specific energy levels at which they like to sit. They can't just have any old amount of energy; they must sit at specific energy levels. To get an electron to jump from one energy level to a higher level, it must be hit by a photon with a high enough energy. So if the difference in energy from one level to the next is the energy a blue photon carries, then if the electron is hit by a red photon, it won't jump up to a higher energy level. It will just sit right where it is and the red photon will simply continue on its way. But if that same electron is hit by a blue (or even violet) photon, it will jump up and then eventually fall down and emit a photon as it falls down. One really cool thing to realize is that this particular electron which needs a blue photon to jump up could be hit by hundreds, millions, or even quadrillions of red photons and it still won't budge. It must have the energy of a blue photon or higher.

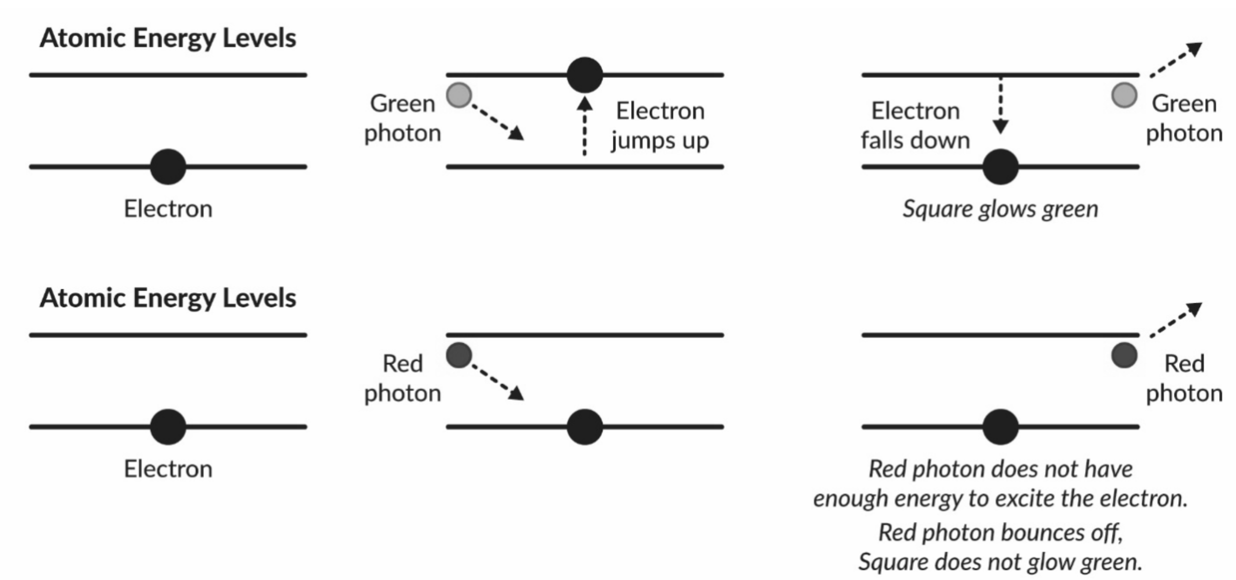
In this experiment, students will allow only certain colors of light to be used to "charge up" their phosphorescent squares. Because the squares glow green, you know that the difference in energy level for the electrons must be the energy in a green photon because as the electrons fall down, they are emitting green photons. The students will be using violet, blue, red, and yellow light to charge up their squares. Blue and violet photons have enough energy to make the electrons jump up. Red and yellow do not.

When your students are asked to predict which colors will make the square glow, they will almost inevitably say the yellow light will make the square glow the brightest and then be shocked when the yellow doesn't glow at all. They predict this because the yellow gel filter is very light and lets the most amount of light through. But as we said before, it doesn't matter how many photons are hitting an electron if the photons themselves are not of a high enough energy.



In the last part of the experiment, your students will charge up the square with white light and then "write" on it with a red laser. This is an interesting phenomenon because red light, which is less energetic than green light, should be able to be transformed into green light. In this case, the square already has enough energy to glow green, and the red laser is just making it glow brighter by adding a bit more energy. It doesn't need all of the energy of green light to glow—it just needs a little extra kick. So it may seem like red light is being turned into green light, but that is not the case.

You (and your students) might be asking "Is it possible to have a wave with more energy than a violet wave or less energy than a red one?" Visible light is just the tip of the iceberg. In fact, microwaves are just like light waves, only they have much less energy than red light with a wavelength of a few centimeters and x-rays have much more energy than violet light.



SIX STUDENT PAGES TO FOLLOW

Please photocopy and distribute the next six pages to your students.

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Student Name: ____

Introduction:

Have you ever wondered what makes your favorite glow-in-the-dark t-shirt glow? Have you ever wondered why you have to “charge it up” before you can impress your friends with its stunning glow? Have you ever wondered what would happen to the shirt if you stood in red light instead of white light? Well, this experiment will answer all those questions and more.

Materials:

- 3" x 3" phosphorescent vinyl
- red, blue, yellow, and violet transparent gel filters
- laser pointer
- white light
- dark room (you provide this)

Key Question:

What colors of light will cause a glow-in-the-dark square to glow?

Getting Started:

To get a glow-in-the-dark material to glow, what do you have to do to it first?

Will any material glow, or does it have to be a special type of material?

Why are the colors of the rainbow displayed in a certain order?

Setting Up the Experiment:

NOTE: *Make sure you unscrew the laser’s cap and remove the piece of paper between the batteries. You may need to remove all the batteries. Take care to put the batteries back in the laser in the correct direction.*

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Student Name: ____

Procedure:

1. In a darkened room, hold a white light about one foot over the vinyl square for about a minute.

2. Turn off the white light and observe the vinyl square. What has happened? What color is the square glowing?

3. Examine the four transparent gel filters and predict what will happen if you place each one on top of the vinyl and expose it to light. Record your predictions.

Red: ____

Yellow: ____

Blue: ____

Violet: ____

4. Place one of the gel filters on each corner of the vinyl and again hold the white light about one foot above the square for about a minute.

5. While you are waiting, indicate on the drawing below which color is on which part of the vinyl (see sample).

SAMPLE

6. Turn off the white light and then remove the gel filters and observe your vinyl. On your drawing, indicate which sections of the square are glowing.

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Student Name: ____

Procedure (continued):

7. Allow your vinyl to **fully** discharge. The best way to do this is to turn it over on a desk so no light is present. Then, in the darkened room, use the laser pointer to "write" on the vinyl. What do you see? Why did this happen?

8. Again, charge up the square in white light without the gel filters. Then use the laser pointer to again "write" on the square. What happens? Thinking back to the experiment with the gel filters, is red light more or less energetic than green light? How is it possible to make the square glow brighter green by applying red light?

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Student Name: ______________________________

Analyzing Your Results:

1. When you first charged up the vinyl square and then put it in a dark room, why was it glowing?

2. When you put the gel filters over the vinyl square, you only allowed light of certain colors to get through and charge up the square. Which colors charged up the vinyl and made it glow?

3. Write down the colors of the rainbow in order. Circle the colors that allowed the square to glow and cross out the colors that did not.

4. Do you see a pattern? Explain.

5. On which side of green are the non-glowing colors?

6. On which side are the glowing colors?

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Student Name: ______________________________

Analyzing Your Results (continued):

7. In a rainbow, violet light has the most energy and red light has the least. What can you say about the energy of light that was needed to charge up the vinyl square? Does it have to be more or less than green?

8. Thinking back to the experiment with the gel filters, is red light more or less energetic than green light? How is it possible to make the square glow green by applying red light?

9. Which gel filter colors allowed the vinyl to glow?

a. blue and violet
b. red and yellow
c. red and blue
d. violet and yellow

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ANSWER KEY for Analyzing Your Results

1. When you first charged up the vinyl square and then put it in a dark room, why was it glowing?
Because the electrons moved to a higher energy level after they were activated by the light.

2. When you put the gel filters over the vinyl square, you only allowed light of certain colors to get through and charge up the square. Which colors charged up the vinyl and made it glow?
Blue and violet.

3. Write down the colors of the rainbow in order. Draw a circle around the colors that allowed the square to glow and cross out the colors that did not.

~~R~~ **O** **~~Y~~** **G** **B** **I** **V**

4. Do you see a pattern? Explain.
Yes. Only the colors at the upper end of the spectrum activated the vinyl (those with the shorter wavelengths).

5. On which side of green are the non-glowing colors?
On the left side.

6. On which side are the glowing colors?
On the right side.

7. In a rainbow, violet light has the most energy and red light has the least. What can you say about the energy of light that was needed to charge up the vinyl square? Does it have to be more or less than green?
The energy of light that charged up the vinyl square had to be higher (more) than green.

8. Thinking back to the experiment with the gel filters, is red light more or less energetic than green light? How is it possible to make the square glow green by applying red light?
Red light is less energetic than green light. In order for the square to glow green with the red light, the square has to be already energized.

9. Which gel filter colors allowed the vinyl to glow?

- **a.** **<u>blue and violet</u>**
- b. red and yellow
- c. red and blue
- d. violet and yellow

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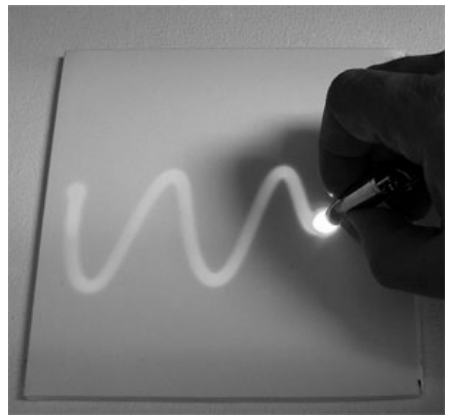
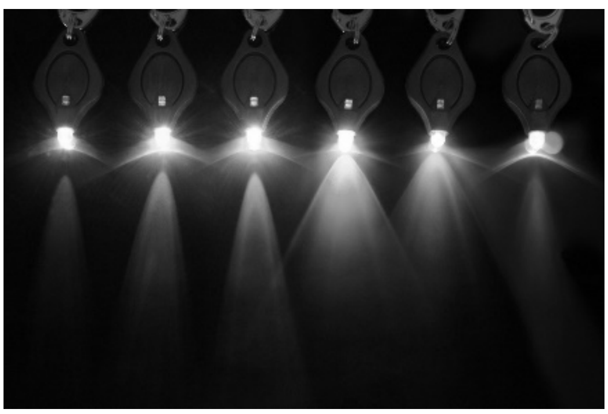
Write and See Square (SS-910)



Move the violet light across the Write and See Square and observe the brightly glowing trail. Violet light has enough energy to excite the phosphorescent pigment in the vinyl. The excited pigment then slowly releases energy as green light. Red light does not have enough energy to affect the pigment. Contains a mounted sheet of phosphorescent vinyl ~15 x 15 cm (6 x 6 in.) and an incredible Violet Photon Light LED flashlight on a keychain ring.

Photon MicroLights (LED-AST)



These small, unbelievably bright micro-flashlights are available in a spectrum of colors and perfect for a variety of experiments and student applications. Although MicroLights are not lasers, and therefore not monochromatic, they come extremely close with their ultra-high intensity LEDs to a specific wavelength (except, of course, for white). Available in red, orange, yellow, green, blue, violet, and white. Violet, with wavelength of 405 nm (see chart for other wavelengths), is close enough to the UVA spectrum to excite fluorescent minerals or even hidden fluorescent dyes on currency and credit cards. Replaceable lithium batteries included.

Liquid Light Demo (SS-9)

Demonstrate the primary colors of light without an expensive light-box! When red, green, and blue light are mixed, you get white. Included with each kit are six light sticks (two red, two green, two blue), and the equipment and instructions for experiments and demonstrations.