Atomic and Electron Structure with Light: Open Inquiry Lab

Overview

How can we study particles that are so small? Evidence-based experiments are the key to answering this question. In this activity-stations lab kit, you will have a chance to perform your very own experiments that lead to discovering the model of the atom. A virtual reality spectrum tube activity allows the study of emission spectra and the identification of an unknown. Observe the resultant glow when different LEDs are shone on a phosphorescent sheet. Finally, a quick mix of chemicals produces light also known as chemiluminescence—in a beaker. What do all of these experiments have in common? Let's find out!

Focus on Science Practices

SEP 1 Asking Questions and Defining Problems
SEP 2 Developing and Using Models
SEP 4 Analyzing and Interpreting Data
SEP 5 Using Mathematics and Computational Thinking

Materials Per Group

Activity 1: Atomic Spectra, A Virtual Reality Experience

- This virtual reality activity is done on the FlinnPREP™ platform; no materials are needed.

Activity 2: Phosphorescence

- LEDs, red, blue, and white
- Phosphorescent vinyl sheet, 1

Activity 3: Make Your Own Glow Stick Solution

- Hydrogen peroxide, H_2O_2, 3%, 8 mL
- Luminol, 0.05 g
- Potassium ferricyanide, $K_3Fe(CN)_6$, 0.3 g
- Sodium hydroxide solution, NaOH, 5%, 25 mL
- Water, distilled or deionized, 1000 mL
- Beakers, 600-mL, 2
- Erlenmeyer flask, 1-Liter
- Funnel, large
- Graduated cylinder, 25-mL
- Ring stand and ring

Safety

Hydrogen peroxide is an oxidizer and skin and eye irritant. Sodium hydroxide solution is corrosive, very dangerous to eyes, and skin burns are possible. Much heat is evolved when sodium hydroxide is added to water. If heated to decomposition or in contact with concentrated acids, potassium ferricyanide may evolve poisonous hydrogen cyanide fumes. Wear chemical splash goggles, chemical-resistant gloves and a chemical-resistant apron.

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Procedure

Activity 1: Atomic Spectra, A Virtual Reality Experience

Click on the Atomic Spectra virtual reality activity and follow the screen prompts. Determine the unknown from the following options, and explain your answer based on the emission spectrum.

a. Air

b. Water vapor

c. Mercury and iodine

Activity 2: Phosphorescence

1. Define phosphorescence.

2. Observe the materials needed for this activity. Based on your definition of phosphorescence, describe which materials serve as an excitation source in the phosphorescent strip.

3. Turn on the LEDs by flipping the switch to an ON position. Describe the colors of the LEDs. Refer to the visible region of the electromagnetic spectrum. List the wavelength region of each.

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4. Carry out and plan the experiment. Which LEDs have enough energy to cause the phosphorescent strip to glow?

Activity 3: Make Your Own Glow Stick Solution

1. Define chemiluminescence.

2. Prepare Solution A by adding 0.05 g of luminol and 25 mL of 5% sodium hydroxide solution to approximately 400 mL of distilled or deionized (DI) water. Stir to dissolve the luminol. Once dissolved, dilute this solution to a final volume of 500 mL with DI water.

3. Prepare Solution B by adding 0.3 g of potassium ferricyanide and 8 mL of 3%hydrogen peroxide to approximately 400 mL of DI water. Stir to dissolve the potassium ferricyanide. Once dissolved, dilute this solution to a final volume of 500 mL with DI water.

4. Set up the equipment as shown in Figure 1.

5. Turn down the lights. The room should be as dark as possible.

6. Pour Solutions A and B into the large funnel simultaneously. As the two solutions mix, chemiluminescence begins.

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Analyze and Interpret

1. **SEP Identify Unknowns** The unknown spectrum is a mixture of gases. Select the best answer from the following options, and explain your answer based on the emission spectrum.
   a. Air
   b. Water vapor
   c. Mercury and iodine

2. **SEP Use a Model to Evaluate** Return to Figure 1 of the Background section. How is this figure similar to the emission spectra witnessed in the virtual reality activity?

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3. SEP Use Models Observe the following visible spectrum values.

Representative Wavelength, nm	Wavelength Region, nm	Color	Complementary Color
410	400–425	Violet	Yellow-green
470	425–480	Blue	Orange
490	480–500	Blue-green	Red
520	500–560	Green	Red-Violet
565	560–580	Yellow-green	Violet
580	580–585	Yellow	Violet
600	585–650	Orange	Blue
650	650–700	Red	Blue-green

a. Which colors of visible light correspond to short wavelengths?

b. Which colors of visible light correspond to long wavelengths?

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4. **SEP Use Math** Observe Figure 1 in the Background section. Using Equation 1, calculate the energy (ΔE) corresponding to each line in the observed atomic emission spectrum of hydrogen.

5. **SEP Identify Patterns** Which colors of light had enough energy to cause the glow-in-the-dark effect in the phosphorescence activity?

6. **SEP Use Math** From the following equation, calculate the minimum energy a photon must have to cause the strip to phosphoresce, or glow.
$E = hc/\lambda$

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