

Flame Test Lab and the Electromagnetic Spectrum

Lesson Plan, Student Version, Teacher Version and Supplemental Materials

Topic:

- Atomic Structure
- Electromagnetic Spectrum

Subject/Grade Level:

- 8th Grade Physical Science

Lab Duration:

- Day 1: Introduce electromagnetic spectrum, wave properties and conservation of energy
- Day 2: Pre-lab activity and safety awareness
- Day 3: Data collection
- *Days 4-10: In-class writing, follow-up discussions, peer review and final drafting (*Honors only*)

Materials:

- *Unknown* Flame Test Solutions in methanol (0.5 M)
 - Lithium (LiCl) - Pink
 - Strontium (SrCl₂) - Red/Orange
 - Sodium (NaCl) - Yellow
 - Boric Acid (H₃BO₃) - Green
 - Copper (CuCl₂) - Blue
 - Potassium (Kl) - Purple
- 50/100 mL Beakers
- 10 mL Graduated Cylinder
- Watch Glasses
- Matches and Candle
- Visible Spectrum and Energy Card

Middle School 8th Grade Physical Science Standards:

3. Structure of Matter: Each of more than 100 elements of matter has distinct properties and a distinct atomic structure. All forms of matter are composed of one or more of the elements. As a basis for understanding this concept:
 - a. Students know the structure of the atom and know it is composed of protons, neutrons and electrons.
9. Investigation and Experimentation: Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:
 - e. Construct appropriate graphs from data and develop quantitative statements about the relationship between variables.
 - f. Apply simple mathematical relationships to determine a missing quantity in a mathematical expression, given the two remaining terms.
 - g. Distinguish between linear and nonlinear relationships on a graph of data.

Inquiry Objective:

- Students will be able to design a hypothetical fireworks, setting color, shape, fuse type, etc. parameters, based on their understanding electron excitation and wave properties.

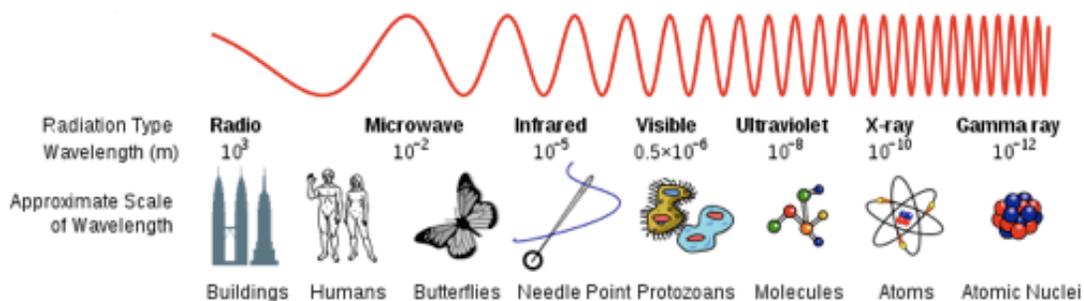
Learning Objectives:

- Students will be able to observe and measure λ (wavelength) emitted by an excited state electron.
- Students will be able to use the modified equation $c = \lambda\nu$ to calculate ν (frequency).
- Students will be able to use the modified equation $E = h\nu$ to calculate E (energy).
- Students will be able to plot λ versus E and identify linear relationships.

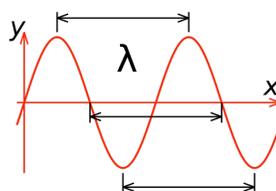
Background Information: Atomic Structure and Electromagnetic Spectrum

- **Bohr Model:** Depicts the atom as a small, positively charged nucleus surrounded by negatively charged electrons that travel in circular orbits (n) around the nucleus. When determining the atomic structure of an element, electrons must first fill the lowest energy-state orbitals until they become full and only then can electrons begin to fill higher energy orbitals. In addition, orbitals hold a specific number of electrons.

- **Conservation of Energy:** Energy absorbed by the atom will be equal to the energy emitted by the atom, even if energy has changed forms.
- **Electromagnetic Spectrum:** The electromagnetic spectrum includes all possible frequencies of electromagnetic radiation, with wavelengths ranging from kilometers (radio waves) to 1×10^{-12} m (gamma radiation).

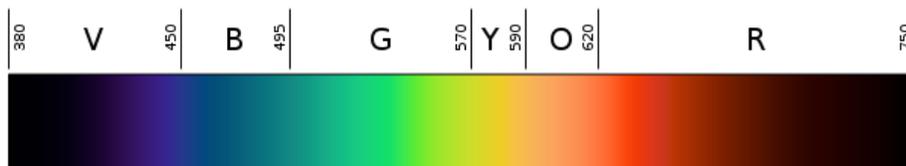


- **Wavelength (λ):** Distance over which a wave's shape repeats itself.



- **Frequency (ν):** Number of times a wavelength repeats itself per unit time.
- **Visible Light Spectrum:** Range of wavelengths within the electromagnetic spectrum that is visible by to the human eye (390-750 nm)

Color	Frequency	Wavelength
violet	668–789 THz	380–450 nm
blue	631–668 THz	450–475 nm
cyan	606–630 THz	476–495 nm
green	526–606 THz	495–570 nm
yellow	508–526 THz	570–590 nm
orange	484–508 THz	590–620 nm
red	400–484 THz	620–750 nm



Instructional Design: This activity includes three lab sections, including pre-lab, data collection and analysis and applied topics.

- **Part 1:** In the Pre-Lab students will review vocabulary and complete written response questions covering the basic components of waves, including wavelength and frequency, and will practice identifying these components from a sample spectra.
- **Part 2:** In this section students will complete a flame test of three *unknown* salt solutions. For each unknown solution, students will observe the color of the flame and estimate the wavelength using a reference card. Students will continue to practice wave vocabulary and draw each observed wavelength on a blank spectrum.
- **Part 3:** This section requires students use wavelength data collected in Part 2 to determine the frequency and energy in kJ/mol (even though moles are not covered in middle school) of each flame test by using modified Speed of Light and Planck-Einstein Equations. The constants (c and h) have also been adjusted so that students can complete the calculations by hand without having to worry about scientific notation. After calculating frequency and energy, students will plot their data to show the linear relationship between frequency and energy. Finally, students will identify their unknown solutions by comparing their calculated energies to a reference card.

- **Part 4:** In Part 4, students will be introduced to real world applications of topics covered in the Flame Test Lab. This activity includes a reading assignment, reading comprehension questions and applied calculations which tie Parts 1-3 together. Students will also have an opportunity to design their own firework, including shape and colors, and then calculate frequency and energy.

Equations and Variables: Equations have been modified to remove scientific notation for purposes of complete calculating solutions by hand. *The speed of light has been modified to 3000 nm/s and Planck's constant has been modified from 6.626×10^{-34} J s/ photon to 40 kJ s/mol.*

Name	Equation	Variables
Modified Frequency Equation	$\nu = \frac{c}{\lambda}$	ν - Frequency (s^{-1}) c - Modified Speed of light (3000 nm/s) λ - Wavelength (nm)
Modified Planck–Einstein Equation	$E = h\nu$	E - Energy (J) h - Modified Planck's constant (40 kJ s/mol) ν - Frequency (s^{-1})

Assessment: Students assessment will be based on the completion and accuracy of Parts 1-4 plus, including:

- Writing in complete sentences
- Organized data tables and graphs
- All calculation steps shown with correct final answers
- Identification of unknown elements in solution

Honors Assessment: Students assessment will be based on the completion and accuracy of Parts 1-4, as well as formal lab report using the provided outline and rubric.