**Empowering Science Teaching and Learning Carol Standefer**

**Assignment #12 - Lesson #1**

**Development of the Current Atomic Model**

**Unit Title: Arrangement of Electrons in Atoms**

**NGSS Performance Expectations:**

* HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms
* HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media
* HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

|  |  |  |
| --- | --- | --- |
| **Science and Engineering Practices** | **Disciplinary Core Ideas** | **Crosscutting Concepts** |
| Developing and Using Models  Planning and Carrying Out Investigations  Using Mathematics and Computational Thinking | Structure and Properties of Matter   * each atom has a charged sub-structure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons * The repeating patters of the Periodic Table reflect patterns of outer electrons   Wave Properties   * The wavelength and frequency of a wave are related to one another by the speed of travel of the wave | Patterns  Cause and Effect |

**Time:** Three 70-minute class periods

**Objectives:**

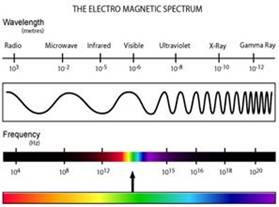
* Students will be able to demonstrate their understanding of wave properties using mathematical formulas.
* Students will show beginning understanding of the patterns that exist on the Periodic Table and how to use the Periodic Table to predict properties of elements (students will understand that different elements have different atomic emission spectra). This understanding will be demonstrated by the students’ ability to carry out an investigation in which they determine flame colors of different elements. The students will also have a beginning basis for understanding how the structure of matter affects its properties.
* Students will be able to identify the cause of the unique atomic emission spectra by being able to show a model of an electron moving from the excited state to the ground state.

**Introduction: *What causes the different colors in a fireworks display?***

* Show video clip: <https://www.youtube.com/watch?v=gZMTifa3tkl>
* Have students discuss question in table groups (2-4 students) for 2-3 minutes
* Bring class together for sharing of ideas and questions from individual groups

**Lesson:**

1. Light has characteristics of waves and particles. (show picture of the Electromagnetic Spectrum with visible light spectrum highlighted. (can find these images on-line or with textbook curricula)

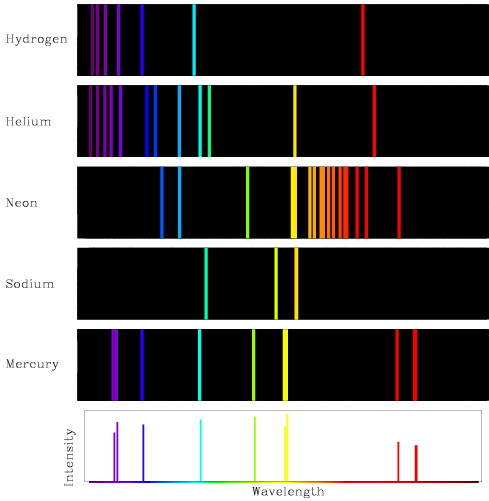


* 1. Wave Description:
     1. Access prior knowledge of wave properties and the inverse relationship of frequency and wavelength
     2. Speed of light: c = 3.00 x 108 m/s
     3. All electromagnetic waves travel at the speed of light
     4. Class practice on c = νλ (see attached)
  2. Particle Description:
     1. Photoelectric effect video – <https://www.youtube.com/watch?v=4EkogMWJJFg>
     2. Review concepts
        1. Photons: bundles of energy
        2. Planck’s constant (*h*): 6.626 x 10-34 J•s
        3. E = hν or E = *hc*/λ
        4. Energy and frequency directly related
     3. Class practice on E=*h*ν problems (see attached)

\* *Relevance: The photoelectric effect causes electrons to be ejected from the surface of a metal when light of high enough frequency this the metal’s surface. This phenomenon is utilized in electric-eye door openers, light meters, and photovoltaic cells.*

* 1. Electrons exist only in specific energy states for atoms of each element.
     1. Show image of atomic emission spectra for several atoms. (on next page; again, these images can be found on-line or in textbook curricula)
     2. Each element has a unique emission spectrum (like fingerprints for atoms)
     3. Certain frequencies of light are emitted when electrons fall from an excited state to the ground state for that particular atom

\* *Relevance: Atomic emission spectra are how scientists can determine the make-up of distant stars and other objects in the universe.*



1. Flame Test Lab

This lab experience gives students hands on experience of identifying unknown metals by the colors of the flames produced when the solutions are burned. Students will be integrating the three dimensions of NGSS as they perform and work through the analysis questions of the lab. The lab also serves as a summative assessment for the lesson.

*\* Relevance: Flame tests can be used by forensic scientists to identify unknown compounds.*

**Chapter 4 Practice Problems Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Per: \_\_\_\_**

**c =** νλ **c = speed of light (3.00 x 108 m/s)** ν **= frequency** λ **= wavelength**

1. Determine the frequency of light whose wavelength is 3.67 x 10-5 m?
2. What is the wavelength of light with a frequency of 6.35 x 108 Hz?
3. Calculate the frequency of light whose wavelength is 4.257 x 10-7 cm?
4. What is the wavelength, in nm, of light with a frequency of 2.76 x 1016 Hz?

**E = *hν* E = photon energy *h* = Planck’s constant (6.626 x 10-34J•s) ν = frequency**

1. Determine energy, in joules, of a photon whose frequency is 4.65 x 1017 Hz.
2. Calculate the energy of a photon of radiation with a wavelength of 1.00 x 10-3 nm.
3. What is the frequency of a photon with energy of 4.53 x 10-16 J?
4. What is the wavelength of light with energy of 3.347 x 10-19 J per photon?

**Flame Test Lab**

**Chemistry Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Per:\_\_\_\_**

Your company has been contacted by John and Jane Smith, who have just discovered some abandoned, rusted barrels of chemicals in the vacant lot behind their home. Each of these barrels have begun to leak colored liquids that flow through their property before emptying into a local sewer. The Smiths want your company to identify the compounds in the liquids as they are concerned that it may potentially be hazardous to their health. Initial work indicates that each is a dissolved metal compound. Many metals, such as lead have been determined to be hazardous to our health. Many compounds of these metals are often soluble in water and are therefore easily absorbed into the body.

Electrons in atoms jump from their ground state to excited by absorbing energy. Eventually, these electrons fall back to their ground state, re-emitting the absorbed energy in the form of light. Because each atom has a unique structure and arrangement of electrons, each atom emits a unique spectrum of light. This characteristic light is the basis for the chemical test known as a flame test. In this test, the atoms are excited by being placed within a flame. As they re-emit the absorbed energy in the form of light, the color of the flame changes. For most metals, these changes are easily visible. However, even the presence of a tiny speck of another substance can interfere with the identification of the true color of a particular type of atom.

To determine what metals are contained in the barrels behind the Smith’s house, you must first perform flame tests with a variety of standard solutions of different metal compounds. Then you will perform flame tests with the unknown samples from the site to see if they match any of the solutions you’ve used as standards.

**Objectives:**

* To observe the different colors of light given off by excited metal ions.
* To relate the colors of a flame test to the behavior of excited electrons in a metal ion.
* To identify an unknown metal ion by using a flame test.

**Safety:**

* Wear safety goggles; confine long hair and loose clothing
* Do not touch any chemicals
* Call your teacher in the event of a spill

**Procedure:**

1. Your group may begin at any lab station. You will be rotating through all stations. Each station will contain either a known substance or an unknown substance. Wooden splints will be soaking in the solutions at each station.
2. Put on safety goggles and light your Bunsen burner. Adjust it so that you have a blue flame.
3. Take one wooden splint out of the solution and place it into the flame of the Bunsen burner. Record the color of the flame in the appropriate place on the Data Table.
4. Rinse the splint thoroughly under water and dispose of it in the container provided by your teacher.
5. Repeat the above until you have observed all known and unknown solutions and recorded the flame colors.

**Data Table:**

|  |  |
| --- | --- |
| **Metal Compound (Salt)** | **Flame Color** |
| Potassium Chloride (KCl) |  |
| Copper (II) Nitrate [Cu(NO3)2] |  |
| Barium Chloride (BaCl2) |  |
| Sodium Chloride (NaCl) |  |
| Strontium Chloride (SrCl2) |  |
| Copper (II) Chloride (CuCl2) |  |
| Lithium chloride (LiCl) |  |
| Calcium Chloride (CaCl2) |  |
| Unknown A |  |
| Unknown B |  |
| Unknown C |  |
| Unknown D |  |

**Analysis:**

1. Identify each unknown solution.
   1. Unknown A:
   2. Unknown B:
   3. Unknown C:
   4. Unknown D:

**Use figure 1.1 on page 98 of your book to answer question 2.**

1. We did not test any mercury compounds in this lab.
   1. Why would it be a bad idea to do a flame test with mercury salts in this lab?
   2. If the light from a heated mercury sample is separated by a prism, it is found to contain several colors, including orange, violet, indigo, green, and yellow-green.
      1. Which of these colors has the highest frequency?
      2. Which of these colors has the longest wavelength?
      3. Which of these colors has the highest photon energy?
   3. The wavelengths of the colors mentioned above are 577 nm, 436 nm, 615 nm, 405 nm, and 546 nm. Which wavelength is which color? (write the color on the line)

577 nm 436 nm 615 nm 405 nm 546 nm

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* 1. Calculate the frequency, in Hertz, of the highest energy type of light in c. (Show your work!)

1. Many elements (for example, calcium and sodium) have very similar flame tests when viewed with the naked eye. What is a possible way to distinguish between the elements?
2. Barium emitted several colors, including red, orange, yellow, green, blue, and violet! The most prominent wavelength emitted had a wavelength of 455 nm. Calculate the photon energy of this light. (Show your work!)
3. The most prominent type of light emitted by the sodium had a photon energy of 3.37 x 10-19 J. Determine the wavelength, in nanometers, of this light.
4. Some stores sell jars of “fireplace crystals.” When sprinkled on a log, theses crystals make the flames blue, red, green, and violet. Explain how these crystals can change the flame’s color. What ingredients would you expect the crystals to contain?