**Atomic Emission Activity**, by Brandon Scott

**Description:** This activity demonstrates the quantized behavior of nuclear electronic transitions using atomic emission. This exercise involves two parts; the first involves using spectroscopes to analyze the atomic emission spectra of light emitted from illuminated atomic gas tubes, as well as sunlight, and the second involves identifying unknown salt solutions based on observations of the colors given off by burning known salt solutions.

**Grades/Disciplines:** Grades 7-12, chemistry or physical sciences class

**Length:** 10 min powerpoint presentation followed by 30-45 min lab

**Standards: National Framework**

 PS1: MATTER AND ITS INTERACTIONS

By the end of grade 12 students should be able to:

* neutrons, surrounded by electrons.
* The periodic table orders elements horizontally by the number of protons in the atom’s nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
* The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.

**PS4.B: Electromagnetic Radiation:** ***What is light?***

***By the end of grade 12***students should be able to:

* **Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons.**
* **The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. Quantum theory relates the two models. (Boundary: Quantum theory is not explained further at this grade level.)**
* **Because a wave is not much disturbed by objects that are small compared with its wavelength, visible light cannot be used to see such objects as individual atoms.**
* **All electromagnetic radiation travels through a vacuum at the same speed, called the speed of light. Its speed in any other given medium depends on its wavelength and the properties of that medium.**
* **When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. Atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. These characteristics allow identification of the presence of an element, even in microscopic quantities.**
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Scientific and Engineering Practices

**Practice 4: Analyzing and Interpreting Data**

**Goals**

**By grade 12, students should be able to:**

* **Analyze data systematically, either to look for salient patterns or to test whether the data are consistent with an initial hypothesis.**
* **Recognize when the data are in conflict with expectations and consider what revisions in the initial model are needed.**
* **Use spreadsheets, databases, tables, charts, graphs, statistics, mathematics, and information technology to collate, summarize, and display data and to explore relationships between variables, especially those representing input and output.**
* **Evaluate the strength of a conclusion that can be inferred from any data set, using appropriate grade-level mathematical and statistical techniques.**
* **Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.**
* **Collect data from physical models and analyze the performance of a design under a range of conditions.**

**Materials:**

Spectroscopes

Atomic gas tubes (H, Ar, Ne, etc.) and lamp

Bunsen Burners

Pt wire loops

Goggles

Hydrochloric acid, 1M

Potassium Chloride

Sodium Chloride

Calcium Chloride

Barium Chloride

**Background information:** Understanding of the Bohr model of the hydrogen atom, spectroscopy, and atomic emission spectra. Proper safety considerations should be exercised when using the Bunsen burners, atomic gas tubes/lamp, and hydrochloric acid.

**Concepts Taught:** The Bohr model of the Hydrogen atom describes the quantized behavior of nuclear electronic transitions observed from an illuminated hydrogen gas tube through a spectroscope in the form of an emission spectrum. Emission spectra of different elements are unique and detectable from illuminated gas tubes, burning salt solutions, and interstellar medium. The continuous emission of sunlight, which is a result of blackbody radiation, is compared to line spectra of fluorescent lights and illuminated atomic gas tubes. Observing and recording the colors given off by burning different salt solutions of known composition are used to identify unknown salt solutions, as well as relative electronic transition energies of different elements. Finally, students are asked to write down two questions about the activity; one that could be answered using a similar experimental setup and one that would require further scientific development.

**Vocabulary:**

Spectrum – a plot of electromagnetic intensity/brightness as a function of wavelength

Atomic Emission – the spectrum of all of the electronic transitions of an energized atom, observed as sharp color bands through a spectroscope.

Quantized – assuming only discrete, non-continuous values

**Take-away Message:**

The true power of nanotechnology comes from being able to manipulate the quantum characteristics of matter. Atomic emission is one of the most accessible ways to demonstrate these characteristics to students in a classroom without having to rely on expensive equipment or complicated concepts. Asking students to write down two questions about the concepts taught in the activity allows them to self-assess their understanding of the topic, as well as incorporate their own interests and curiosities regarding the information they just learned.