# Lab 1: Atomic Spectrum of Hydrogen

**CHEM& 162: General Chemistry 2 w/ Lab**

**Pre-Lab Directions –due at the start of lab: (read carefully to avoid loss of prelab points!!):**

1. **Read** this entire handout before starting. **Print** and **bring it to lab.** You also need to carefully **read ‘The Lab Notebook & Report’ handout.**
2. Complete the **Lab 1 Prelab Quiz** on Canvas (before its’ deadline)
3. Update the **Table of Contents**: Find the Table ofContents at the front of your notebook: **add** lab #, lab title, and the page # for the 1st page of this lab report.
4. Starting on the first available new page, complete the following **in your lab notebook** usingpermanent **INK**: (don’t forget to place the hard cover behind each page!). Note: this work will be checked at the start of lab.

* **Header information:**  Add the Lab #, a Title, date of the lab, Your full name, your section letter, to the **top** of the report’s **1st page**. You will add your lab partners name here during lab.
* Write a **Purpose and Method section. IMPORTANT:** Follow the requirements set forth in ‘**The Lab Notebook & Report**’ handout. **Be sure to look at the sample lab report.** In addition, you can’t complete the ‘Method’ section without reviewing the **Lab 1 Post Lab Report file!**
* Title the **Data and Observations** section and draw **two separate data tables that are ready to use during lab;** one table is required for **Part I** and another for **Part II**.  *Use a ruler to make these tables and refer to ‘The Lab Notebook’ handout for the table format requirements.*

**Helpful Hints** for making the tables:

1. Read the procedure section of the handout to determine what is recorded in the lab. Create a table that will neatly organize and present this data. Add **headers** for the rows or columns to identify what is recorded in each cell. Draw practice tables on a separate piece of paper **before** drawing them in your lab notebook. Use a ruler!
2. Leave some room below and beside the tables, in case you need to add additional rows or columns during lab.

**INTRODUCTION**

When an electric current is passed through a sample of gas in a sealed tube the energy excites the electrons of the atoms, causing them to jump to **higher** energy levels. Atoms can also **absorb** energy from other sources, including light and heat. That energy is **emitted** as light when the electrons fall back from the higher to **lower** energy levels. When this light is passed through a prism the result is not a continuous spectrum, but a line spectrum. In other words, only certain wavelengths (λ) of light are observed. This observation strongly suggests that the energy absorbed/emitted by an electron is quantized, or restricted to certain discreet values. **Each line in the spectrum corresponds to a particular electronic transition between discreet energy levels.**

When an atom *absorbs* energy (ΔEatom ) in the form of light, heat, electricity, etc., an electron is excited to a *higher* energy level. Conversely, when an atom *emits* energy, usually in the form of light, an electron moves to a *lower* energy level. The absolute value of the energy difference between the two levels, ΔEatom, corresponds to the photon wavelength that is observed:

|ΔEatom| = |Efinal – Einitial| Ephoton =|ΔEatom| =  **= h**ν

Where, h = Planck’s constant = 6.626 x 10-34 J s , c = speed of light = 2.998 x 108 m/s and ν = frequency

In **Part I** of this experiment, you will measure the wavelengths of four lines in the atomic spectrum of hydrogen. The only lines you will be able to observe are those of the **Balmer series**, those lines that fall in the visible region of the spectrum (i.e. wavelengths between 400 and 700 nm). The lines of the Balmer series are the lines for which nfinal, is equal to 2 (i.e. nf = 2). Other transitions show up in other regions of the electromagnetic spectrum. For example, all transitions with nf = 1 fall in the UV region of the spectrum, while all transitions with nf = 3 fall in the infrared region. With different detection equipment we could observe those transitions as well.

Once you have determined the wavelength, λ, of each line you can use the Rydberg equation (below) to determine the transition that produced each line. In other words, given that nf = 2 (true for all lines in the visible region), you will solve for ninitial, ni, the energy level from which the "excited" electron fell.

Rydberg Equation: 

It is important to note that the Rydberg equation only works for *hydrogen*. While all elements produce a unique line spectrum, the Rydberg equation can only be used to calculate initial and final energy levels for hydrogen. Unfortunately, this equation does not work for atoms with more than one electron. This is due to the presence of additional electron-nucleus attractions and electron-electron repulsions that are not accounted for in the Rydberg equation. Nonetheless, you will view the line spectra of other elements when you are finished with hydrogen. However, no calculations will be required for these other elements.

In **Part II** of this experiment, the flame spectra of several different ionic compounds containing metallic ions will be observed and the information obtained will be used to identify three unknown salt samples. When a ***metal*** or ***metal ion*** is heated in a flame, the electrons are excited and promoted to higher energy levels just as they are in the gas tube. When excited electrons return to a lower energy level the energy absorbed is released as visible, infrared and/or ultraviolet light. Because each element has a unique electronic structure, the color that it produces is also unique. Thus the flame spectra can be used to identify an element. Not all substances produce an observable color when heated because visible light is only a small part of an elements line spectrum.

**PROCEDURE**

Label and record **qualitative observations** and **procedural notes** under a heading of ‘**Notes**’ as you complete the experimental steps. These notes must summarize **what was actually done** and **observed during lab**. You will (individually) turn in the pages from your lab notebook containing your prelab and lab work, before leaving the lab session.

Work in PAIRS to perform the following steps:

**Part I –Atomic Spectra of Hydrogen and Other Gases**  
The instructor will demonstrate the use of the spectroscope, and will change the gas tubes as necessary. The gas tubes become very hot when they are energized so do not touch them!

1. Obtain a *Project STAR* spectroscope. Check the calibration of the spectroscope by pointing it at one of the fluorescent lights in the room. The **green** spectral line should align with the scale at **546 nm**. If this is not the case, adjust the plastic scale (using an opened paper clip inserted into the small hole) until it does. If you are unable to get the green line on the 546 nm mark, record how many nanometers the calibration is off and use this value to correct for all future wavelength measurements that you make. Take note that the light from a fluorescent tube produces a bright-line spectrum (due to mercury vapor in the tube) superimposed over a continuous spectrum that is caused by the white light from the light source.
2. Point the spectroscope at the *hydrogen gas* lamp and make a **sketch** of the spectrum (include colors and approximate wavelengths), as you see it in your notebook. Be sure to **label your sketch**.
3. **Record** observed results in a formatted ***data table***which includes: *gas sample (e.g. hydrogen), wavelength, and color*

Be sure you observe **at least 3**, preferably 4, of the violet, blue, green and red lines in the hydrogen spectrum. The green line may be difficult or impossible to see. Each partner should record the data individually, then compare your readings and recheck any that are in doubt. (You will be using these values in calculations, so record the wavelengths carefully.)

1. Observe the spectrum of *several*other gases that are available, *e.g.,* Helium, Argon, Krypton, Neon, Mercury, Chlorine, etc. —if necessary, ask your instructor to change the gas discharge tube for you. No data or calculations are required for these gases. However, create a **labeled sketch** of **at least one** of them (include colors and approximate wavelengths). Be sure to include the identity of the gas.

**Part II - Flame Tests**

**Caution!** Hydrochloric acid (HCl) is corrosive and will burn human tissue! Immediately rinse any skin that contacts the acid. Immediately clean up any acid spills with the acid spill kit. **Notify your instructor!**

1. Obtain a small container of each of the following salts:

LiCl, KCl, SrCl2•6H2O, CaCl2•2H2O, NaCl, & three Unknown salts

1. Obtain at least 8 wooden sticks and immerse approximately 1 inch of their ends in DI water in a small beaker.
2. Place a small amount of a salt sample on a watch glass. Touch the moistened end of a clean wooden stick to the salt, causing a SMALL sample of salt to adhere to it. Gently wipe off any excess salt.
3. Hold the end of the wooden stick in the flame (**without** allowing it to catch on fire!). Avoid dropping the salt into the barrel of the Bunsen burner. **Record** a careful description of the flame color and the salt formula (or unknown ID). It is important to note that if the wooden stick catches on fire, it will cause a yellow flame color. This should not be confused with the flame color of the salts.
4. Dispose of the wooden stick in the container provided.
5. Repeat steps 3 thru 5 for each of the remaining salts and the three unknown salts. Be sure to record the unknown’s ID’s in the data table.
6. Dispose of the excess salt in the labeled waste container provided in the fume hood.
7. Rinse all *glassware* with DI water before putting it away. Put away all other items in their proper location, wipe down your entire lab bench, lock your lab drawer and wash your hands before leaving.
8. Check to be sure you completed the required ‘Notes’. **Turn in the pages** from your lab notebook with the first page header completed (add your lab partner’s name) **before leaving.**

**POST LAB REPORT Instructions:**

Open the **Lab 1 Post Lab Report\_Hydrogen Spectrum** file (on Canvas in the Lab Handout module) and **type** all of your responses into this MS Excel file, except as allowed in the directions provided. **Read the follow the directions carefully**!

**GRADING: (refer to the Lab 1 – Grading file on Canvas)**

1. **Lab 1 prelab quiz: Complete the quiz on Canvas** by the deadline.(5 pts – no late credit)
2. **Individual Lab Notebook work:**  Turn in the pages from your lab notebook containing the Purpose, Method, Data and Observations **before leaving lab**! Points will be deducted if the prelab work is not completed when the instructor checks it. (10 pts – no late credit)
3. **Post Lab Report:** Type your answers into the Lab 1 Report template, then print and turn in on the assigned due date. (20 pts)

*Acknowledgement: This lab is adapted from similar labs produced by my colleagues at GRC.*