Lab 1: Atomic Spectrum of Hydrogen

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

Due date: Post Lab Report is due Oct. 8th

# PURPOSE:

The purpose of this assignment is to produce a lab report using data collected in lab and examine the atomic spectrum of hydrogen, as well as the atomic emissions of other atoms.*(****Caution****: do not copy this and use it as your lab’s Purpose statement; read the ‘Lab Notebook & Report’ for more information.)*

## **Skills:** After you complete this assignment, you will be able to:

* Read documents and summarize the scientific process described in them.
* Collect and record quantitative data and detailed observations that can be interpreted by others.
* Analyze data, both quantitatively and qualitatively, and communicate logical conclusions based on the applicable scientific concepts.

## **Knowledge:** This assignment will improve your understanding of the following chemical concepts:

* The relationship between changes in electron energy levels, changes in an atom’s energy, and frequency of light emitted (electromagnetic radiation)
* Interpretation and use of the Rydberg equation, as well as the equation that relates energy to the frequency (or wavelength) of a photon of light.

# TASKS *(use the links below for more information)*

1. Carefully read and follow the directions provided in the box on the following page before you start working on the prelab assignment. Complete the [Prelab assignment](#prelab) **before the lab session** and bring your lab notebook to lab.
2. Complete the [Procedure](#procedure) described in this handout **during your lab session**. Bring your lab notebook, a pen, and a copy of this lab handout to lab. Since this is the first lab of the quarter, remember to bring your *approved safety goggles* and lab coat, if you have one. If you have long hair, also bring a hair tie. Be sure to wear long pants and closed toed shoes.
3. Complete the [Post Lab Report](#postlab) **after the lab session**, and turn it in by the due date. Open the Lab 1 Post lab report Excel file provided on Canvas and refer to your lab notebook as you complete it. Again, be sure to read the *directions provided in the file carefully!* After you are finished, print your file, sign it in the box provided, and turn it in to your instructor by the posted due date.

# CRITERIA: (refer to the [grading details](#grading) on the last page of this handout)

1. **Lab 1 prelab quiz:** Complete the lab quiz on Canvasby **its deadline**.(5 pts – no late credit)
2. **Lab Notebook work:**  Tear out and turn in the perforated pages from your lab notebook containing the Purpose, Method, Data and Observations **before leaving lab**! (10 pts – no late credit)

Refer to the document, ‘The Lab Notebook and Report’ for examples of lab notebook page entries.

1. **Post Lab Report:** Type your answers into the Lab 1 Post Lab Report template, then print and turn it in at the start of class on the **assigned due date**. (20 pts – no late credit)

# Prelab Assignment Directions

***Read carefully to avoid loss of prelab points – no late credit is possible!***

1. **Read** this entire handout before starting this work. **Print the Procedure section** and **bring it to lab**. You also need to carefully **read ‘The Lab Notebook & Report’** handout.
2. **Prelab Notebook Work**: Get out your lab notebook and an ink pen. *Complete the steps below in your lab notebook* - don’t forget to place the hard cover behind each page before writing! (If this work is not complete when your instructor checks at the start of lab, you *will* lose points and these are *not* recoverable!)
   1. Add this lab to the **Table of Contents** at the front of your **lab notebook**; include the Lab #, a title for the lab, and the page # of the 1st page of this new lab report.
   2. Find the first available new page and complete the **header information** at the **top** of this page:

**Header information:**  the Lab #, a Title, date of the lab, your full name, your section letter. (add your lab partners name here during lab.)

* 1. Write both a **‘Purpose’** and a **‘Method’** section for this lab according to ‘The Lab Notebook & Report’**. Reminder**: do not plagiarize this handout or any other source!
  2. Immediately after your Method section, label the ‘**Data and Observations’** section. Then draw and format **two separate** **data tables**, one for Part I and another for Part II. *These tables must be complete, except for the data that will be recorded during the lab.* **One table** is required for **Part I** and the **second table** is for **Part II**.

**IMPORTANT:** Refer to the requirements for data tables in ‘**The Lab Notebook & Report**’. Be sure to review the **example lab report pages** provided at the end of that document.

1. **Prelab Quiz:** After completing all of the above work, take the **Lab 1 Prelab Quiz** on Canvas.

# 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 discrete values. **Each line in the spectrum corresponds to a particular electronic transition between discrete energy levels.**

When an atom *absorbs* energy 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 total energy of the atom changes as result of this electron energy level ‘transition’. The absolute value of the energy difference between the two levels or the change in atom energy, ΔEatom, corresponds to the photon wavelength (or ‘line’ in the atomic spectrum) that is observed. The absolute value is used because the energy of a photon of light is always positive.

|ΔEatom| = Ephoton =  **= h**ν

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

In **Part I** of this experiment, you will measure the wavelengths of four visible 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 the final electron energy level, nfinal, is equal to 2 (i.e. nf = 2). Other electron transitions show up in the ultraviolet (UV) and infrared (IR) 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 IR region. With different detection equipment we could observe those transitions as well.

Once you determine the wavelength,λ, of each line, the Rydberg equation (below) is used to determine the transition that produced each line. In other words, given that nf = 2 (for all lines in the visible region), you can 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. You will view the line spectra of other elements when you are finished with hydrogen; however, no calculations are required for these other elements.

In **Part II** of this experiment, the flame spectra of several different ionic compounds (salts) containing metallic ions are observed and this information obtained is 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 ‘**Observations’** as you complete the experimental steps in Part I and II. ‘Observations’ are a record of qualitative observations you make while performing the lab; they can also help identify experimental errors that occur during the data collection.

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.

**CAUTION:** **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. Hydrogen’s Spectrum:

(a)Point the spectroscope at the *hydrogen gas* lamp. **Label and** **sketch** the spectrum for hydrogen (include colors and approximate wavelengths), as you see it in your notebook. (b) **Record** observed results for **hydrogen ONLY** in a formatted ***data table***which includes: *gas sample (e.g. hydrogen), wavelength, and color*

Be sure to observe **at least 3***, preferably 4*, of the violet, blue, green and red lines in the hydrogen spectrum. Hints: The violet line at ~ 410 nm may be difficult or impossible to see. **Don’t record** a ~540 nm line, as this is due to interference from the room fluorescent lighting!

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 these wavelengths carefully.)

1. Other Gas Spectrum: 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, label (which gas is it?) and sketch the spectrum of one of them** (include colors and approximate wavelengths).

## **Part II - Flame Tests**

**This is an explanation point in the middle of a red triangle.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 several wooden sticks and immerse at least 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 wet 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 stick in the flame. *Avoid dropping the salt inside the Bunsen burner. Avoid catching the stick on fire; it will cause a yellow flame color that will interfere with the salts true flame color*.
4. Carefully observe the flame color. Label (which salt is this?) and **record a** *detailed* observations of the flame color. Then summarize this observation by writing one or two words in the **data table** for each salt. 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 IDs 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. Staple together and **turn in the perforated pages from your lab notebook before leaving lab**. Be sure to add your lab partner’s name(s).*You will lose lab points if you fail to do this….*

# POST LAB REPORT Requirements:

* After the lab session, open the ***Lab 1 Post Lab Report*** file (on Canvas in the Lab Handout module).
* **Read and follow** the directions provided in this file carefully!
* **Type** all of your responses into this MS Excel file, *except as allowed in the directions provided*.
* **Print** your completed file and **check** the printed page(s) to be sure all of your answers are legible.
* **Don’t forget to sign** the ‘acknowledge’ box at the top of the first page or you risk a loss of 5 points!
* **Turn it in** to your instructor by the posted due date.

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

# Lab Assignment Grading Criteria:

## Prelab and Lab work:

### Purpose: (*0 pts if too similar to someone else’s – or plagiarized from handout!*) Points

|  |  |
| --- | --- |
| Describes the scientific goals of lab, mentions the technique used and any relevant chemical reaction equations. | 1\* |
| Uses complete sentences, good grammar and correct spelling; Objective writing style (no I, we, etc.) | 1\* |

### Method: (0 pts if too similar to someone else’s – or plagiarized from handout!)

|  |  |
| --- | --- |
| Provides an overview of the general procedure followed in this lab, includes data, how it is collected and equipment used. | 1\* |
| Complete sentences, good grammar and correct spelling; Objective writing style (no I, we, etc.) | 1\* |

### Data and Observations:

|  |  |
| --- | --- |
| Two data tables are properly formatted (title, headers, ruler used to draw borders) | 1\* |
| Part I Data table contains all required data | 1Δ |
| Two labelled sketches; one for hydrogen and one for other gas | 1Δ |
| Part I Qualitative observations are labelled, detailed, descriptive and understandable. | 1Δ |
| Part II Data table contains all required data | 1Δ |
| Part II Qualitative observations are labelled, detailed, descriptive and understandable. | 1Δ |

\*part of the prelab work, no late credit. Δ completed during lab, no late credit

**Other possible point deductions**: loss of prelab credit (up to 5 pts), incomplete 1st page header. (loss of ½ to 1 pt)

Prelab and Lab work: **10 pts possible**

## Post Lab Report\*

### Part I Points

|  |  |
| --- | --- |
| Q#1: highest w/ explanation | 1 |
| Q#2: lowest w/ explanation | 1 |
| Q#3: Calculations for all lines from table, unrounded and rounded n values provided. | 4 |
| Q#4: Calculations for all lines from table, sig figs | 4 |
| Q#5: Explanation is logical, references predicted and actual results stated correctly, complete sentences. | 2 |
| Q#6a: Calculations for all lines from table, sig figs | 3 |
| Q#6b: includes logical reference to % error values. | 1 |

### Part II Points:

|  |  |
| --- | --- |
| Q#7: Identification is correct and is based on the observed data, explanation is logical, complete sentences, good grammar and spelling are used. | 3 |
| Q#8: Explanation is logical, reasonable and believable, complete sentences, good grammar and spelling. | 1 |

**Other possible point deductions**: Part I or Part II Table not completed (-1 pt), no signature (-5 pts), Late work (2 pts per day late)

Post Lab Report\*: **20 pts possible**

## Overall Grade: Lab Report: 30 pts possible

Prelab Quiz: 5 pts possible

**Total Lab Assignment: 35 pts possible**

\* REMINDER: If the post lab is not completed and turned in for grading (if late, must be turn in within 4 days of due date), it will count as an incomplete lab and only 3 incomplete labs are allowed in this course.