

Spectroscopy and Atomic Structure

Objectives

1. Identify unknown gases by comparing their emission spectra to known emission sources.
2. Draw a scale model of the hydrogen atom.

Student Materials

pencil
compass
mm scale
calculator

Introduction

Astronomers obtain most of their information about the stars from observations. One useful astronomical instrument for obtaining information about chemical composition is a spectroscope or spectrograph. This instrument has a grating that acts like a prism, splitting the light into its constituent wavelengths. All spectra can be classified into one of three groups which are defined by Kirchhoff's laws.

- 1st law: continuous spectrum is produced by a hot, glowing solid.
- 2nd law: emission spectrum is produced from a hot, rarefied gas.
- 3rd law: absorption spectrum is produced when a continuous spectrum passes through a cooler, less-dense gas.

A line spectrum can be used to determine the element(s) that are producing the spectrum. The spectral lines are the results of electrons moving from one shell into another. Shells are similar to orbits about the nucleus. The amount of energy required to jump or fall into another shell is specific to each element. Thus the spectral lines are a set of finger prints that can be used to identify elements.

In this exercise you will identify several unknown gases by observing their emission-line spectra. You will then use the wavelengths of the hydrogen Balmer lines to construct a model of the hydrogen atom.

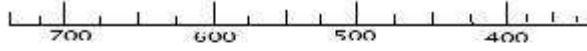
Procedure

Spectra

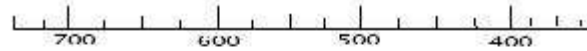
1. Obtain a spectrograph from your instructor.
2. Observe the unknown gases paying close attention to the strong lines only.
3. Compare these groupings of lines with the standard emission lines.
4. Write the identity of the unknown gases.

Looking through your spectrograph straight ahead you will see the light from the gas tube. Now look to the side and you will see a scale. On this scale you will see the emission lines from the gas in the tube. On the scale below, draw the emission lines of the various gases being as accurate as you can. For example, for Station 1, you should see violet, blue-green and red lines at 434 nm, 486 nm and 656 nm, respectively. This is the emission spectrum of Hydrogen, so you would write Hydrogen in the line provided next to the spectrum.

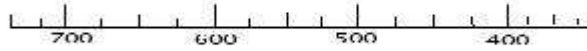
1.



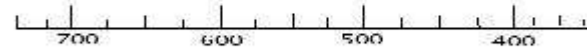
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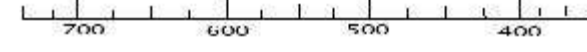
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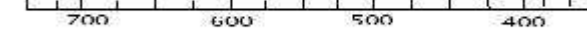
4.



5.



6.



Hydrogen Atom

You have observed the emission spectra of hydrogen. What you saw was red, blue-green and violet emission lines. Each of these lines has a particular wavelength which can be found in Table 1. These wavelengths are associated with the specific amount of energy it takes to jump to or from shell $n=2$, also known as the Balmer series. The radii of the shells or orbits of the hydrogen atom can be calculated from

$$R_n = \frac{\lambda}{(0.473)\lambda - 1630} \quad (1)$$

where R_n ($n=2,3,4..$) represents the orbital radii of the orbital shells 2,3,4, etc., and λ is the wavelength of the corresponding emission line.

1. Use equation (1) and the values of the emission lines in Table 1 to calculate the radius in units of \AA . Record your answers in Table 1.
2. On Figure 1, make a scale drawing of the electron orbits for shells $n=2,3,4$ and 5. Use a scale of $1 \text{\AA} = 1 \text{ cm}$. Place the nucleus about $2/3$ down the page. Use the compass to generate full circles about the nucleus. Note that shell $n=5$ will only partially fit on the page.
3. On your scale model, use arrows to indicate the three electron transitions you observed from the gas tube. Label each arrow with its corresponding color.

Table 1
Hydrogen Atom

Line Color	n	λ in \AA	R_n in \AA
red	3	6563	
blue-green	4	4861	
violet	5	4341	

Figure 1