Experiment 3.
Atomic and Molecular Structure

Experimental Procedure

Lab 402

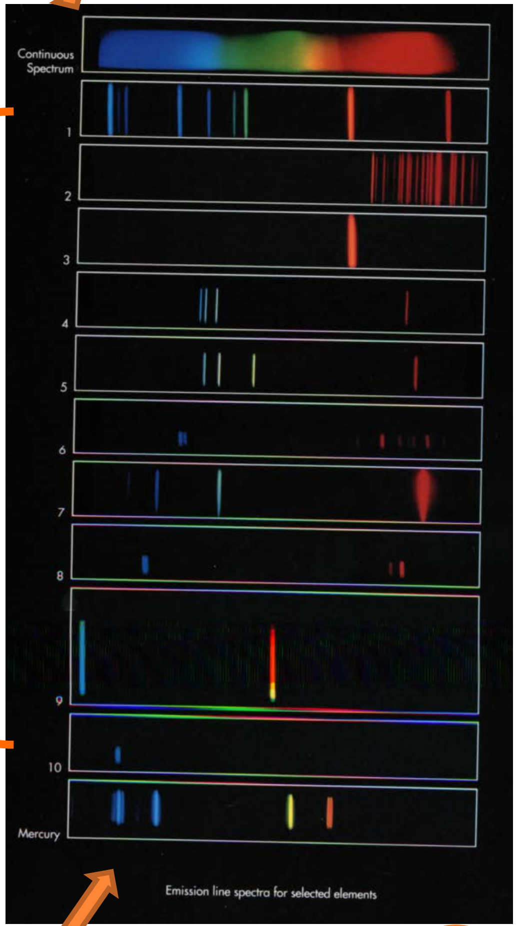
A. The mercury spectrum

1. The color plate

Notice the various experimental emission line spectra on the color plate (It is on the back cover of the book).

A continuous spectrum appears at the top, the line spectra for various elements appear in the middle (unknown elements, 1~10), and the Hg spectrum appears at the bottom.

Continuous spectrum



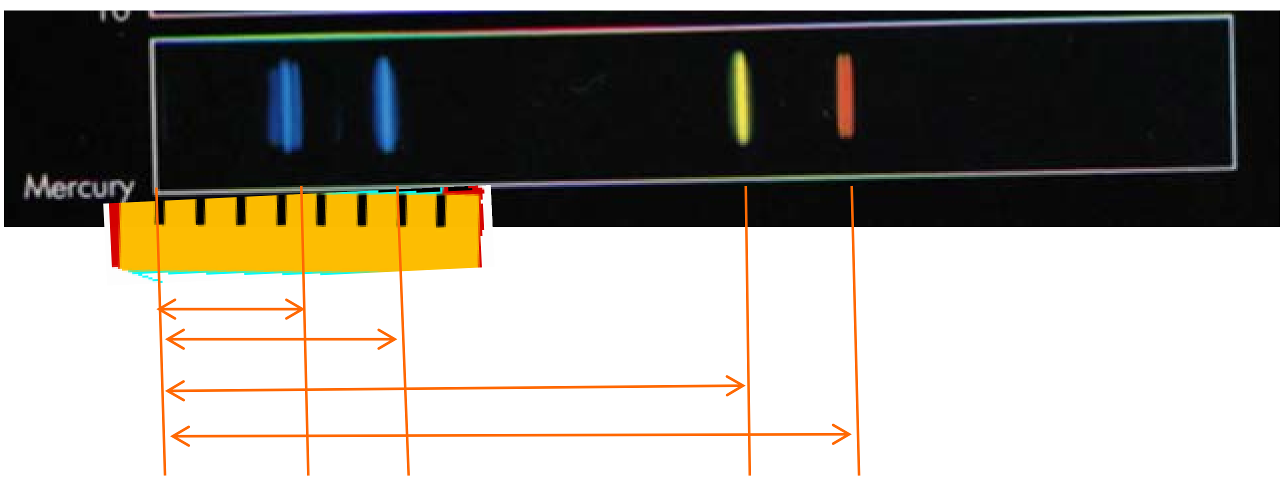
Unknown elements (1~10)

Hg spectrum

2. Calibrate the spectra of the color plate

Match the lines of Hg spectrum on the color plate with the wavelengths in Table D3.4.

Use a ruler to measure where the lines of Hg spectrum are located.



The distances between two lines of spectrum is proportional to the differences between the wavelengths of themselves.

So using the lengths we measured and the wavelengths in **Table D 3.4**, we can know wavelengths of any lines on the color plate by measuring their locations.

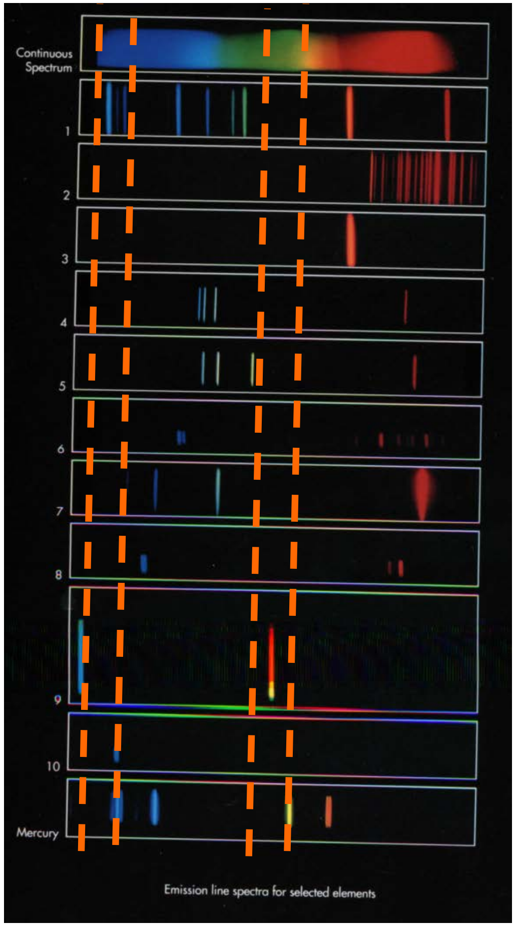


Table D3.4 Wavelengths of the Visible Lines in the Mercury Spectrum	
Violet	404.7 nm
violet	407.8 nm
Blue	435.8 nm
Yellow	546.1 nm
Orange	577.0 nm
Orange	579.1 nm

B. The spectra of elements

1. Hydrogen spectrum

Use **Figure D3.3**, page 158, to identify which of the emission spectra on the back cover is that of hydrogen. Justify your selection.

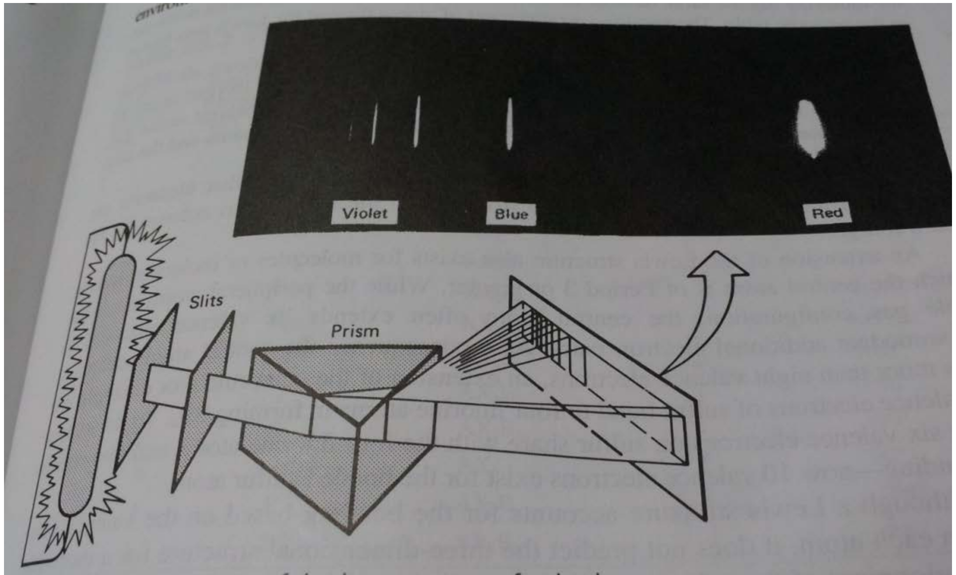
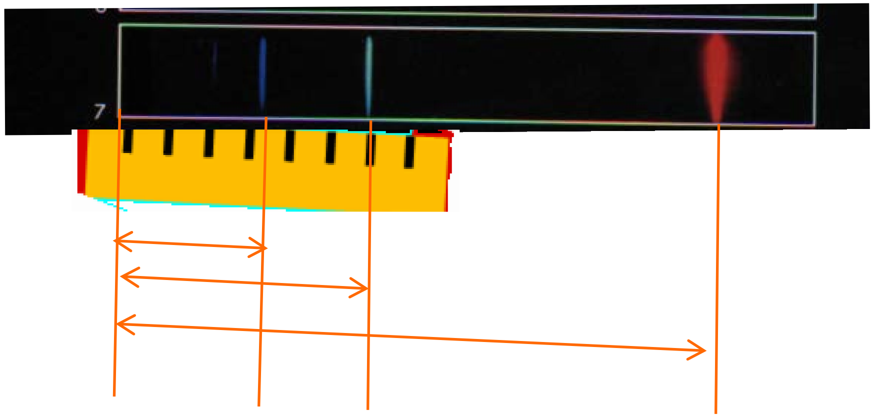


Figure **D3.3** Formation of the line spectrum for hydrogen

2. Unknown spectra

Your TA will assign to you one or two emission spectra from the color plate (1~10).

Use a rule to measure where the lines of spectra are located.

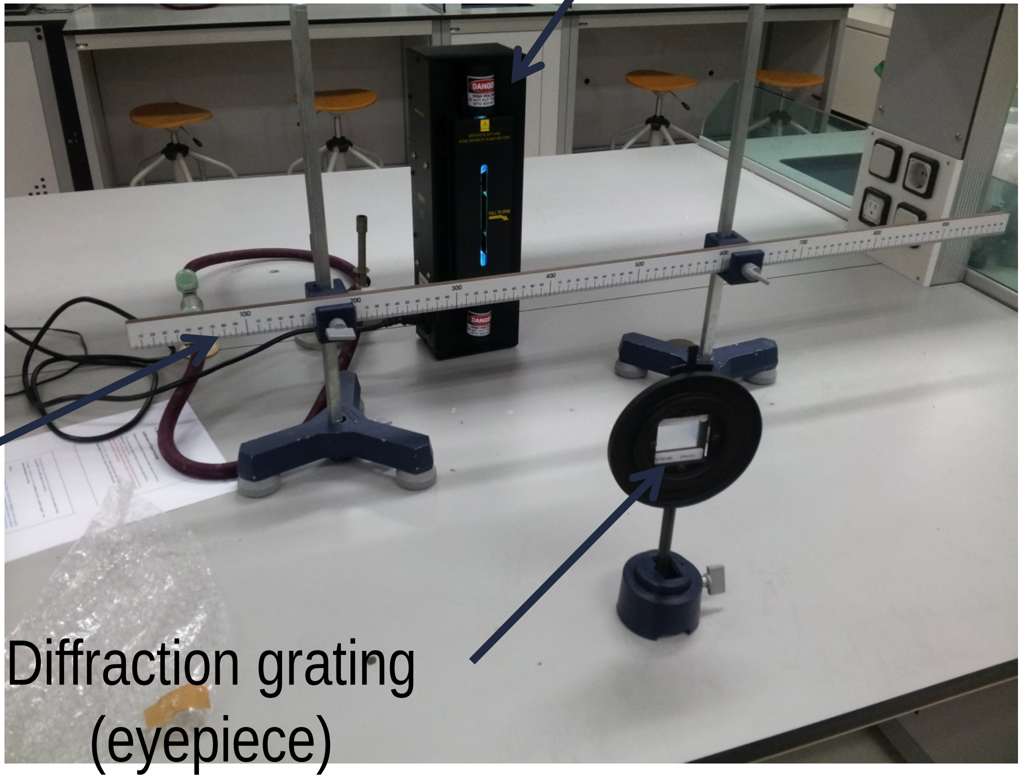


Calculate the wavelengths of them by using the data from Hg spectrum and **Table D 3.4**.

Compare the wavelengths of the most intense lines with the data in **Table D.3.5**. Identify the elements having the assigned spectra.

Additional Experiment
: Observing Real Spectra

Lamp holder

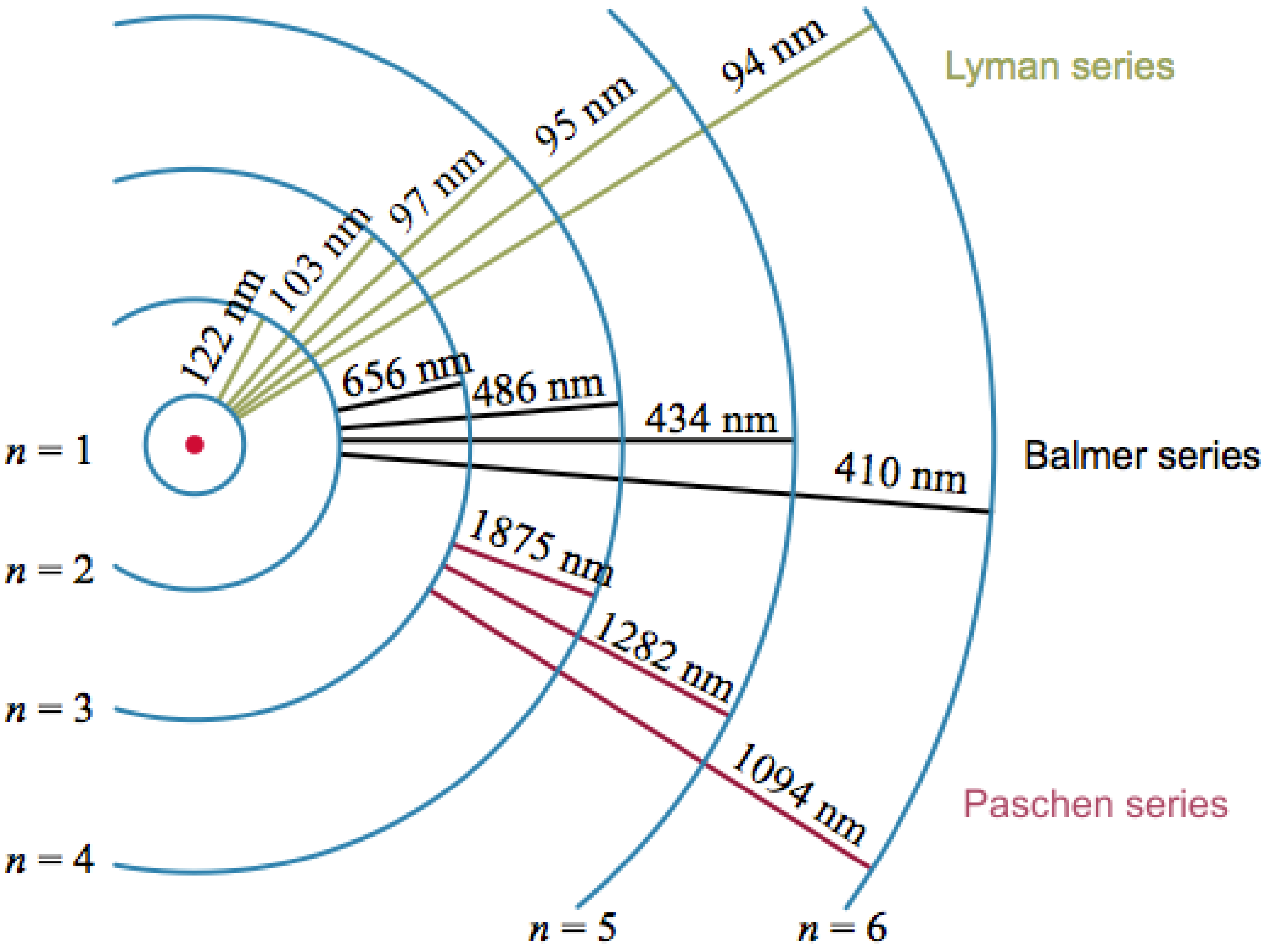


Ruler

Diffraction grating (eyepiece)

Spectrum Tubes contain one or more elements as gaseous atoms or molecules. Energy is supplied through an electric field applied between electrodes at the ends of the tubes. Ions and electrons formed by the field are accelerated; collisions convert the increased Kinetic energy to other types, one being electronic. Electrons in energetic or excited atoms occupy one of many well-defined states. An electron with high energy E_3 will return to a lower energy state E_2 simultaneously emitting a photon of energy $E_3-E_2 = \Delta E = hc/\lambda$; where $h = 6.63 X 10^{-30}$ J-s is Planck's constant, $c = 3X10^8$ m/s is the speed of light and λ is the wavelength of light (in meters) in the emitted photon.

Each excited atom type emits characteristic wavelength determined by energy level differences ΔE present in that species. One may observe a particular color with the eyes; analysis with a spectrometer will reveal a series of sharp (monochromatic) emission lines.



Lyman series
94 nm
95 nm
97 nm
103 nm
122 nm
656 nm
486 nm
434 nm
410 nm
Balmer series
1875 nm
1282 nm
1094 nm
Paschen series
n = 1
n = 2
n = 3
n = 4
n = 5
n = 6

There are springs in both end-side of lamp holder so you can easily put the lamp inside the holder.

1) Turn on the power supply and then turn on power-supply switch to illuminate the Mercury lamp.

(CAUTION: *The power supply develops several thousand volts. Do not touch any portion of the power supply, wire leads, or lamp. Do not look directly at any of the lamps while they are illuminated.*)

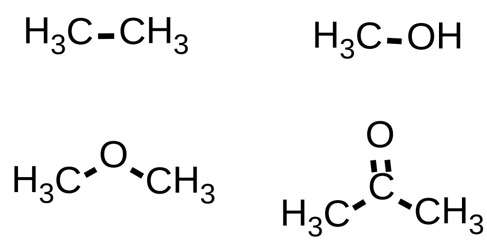
2) Look in to the eyepiece (make sure that the scale is visible but not so brightly lighted the mercury spectral lines will be obscured.).

* Tube life is extended if operation is cyclic for no more than 30 seconds "on", 30 seconds "off" etc., increasing the usable life of the tubes.


300
400

C. Infrared Spectra of Compounds (Homework)

Match of molecules with infrared spectrum (Figure D3.5A~5D). The absorption bands characteristic of atoms in bonds are listed in **Table D3.2**, page 158, to assist in the match.



Molecules

Table D3.2 Infrared Absorption Bands for specific Atoms in Bond Arrangements in Molecules

Atoms in Bonds	Wavenumbers (cm^{-1})	Wavelengths (μm)
O-H	3,700 to 3,500	2.7 to 2.9
C-H	3,000 to 2,800	3.3 to 3.6
C=O	1,800 to 1,600	5.6 to 6.2
C-O	1,200 to 1,050	8.3 to 9.5
C-C	1,670 to 1,640	6.0 to 6.1

■ Video clip

About molecular structures

- **VSEPR Theory**
- **Polarity**
- **Hybrid orbitals**
- **Molecular orbitals**

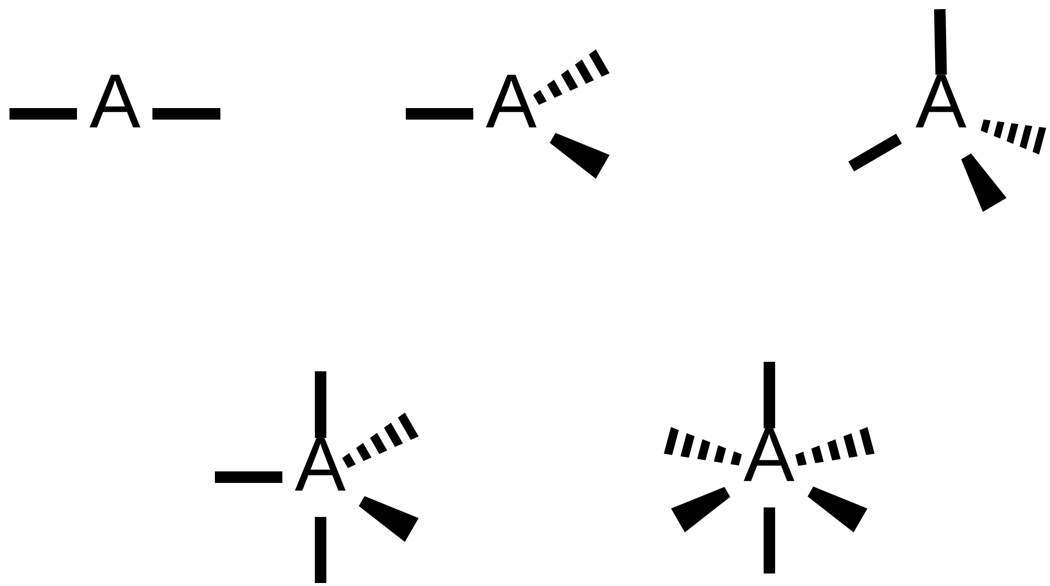
(From Standard Deviants, DVD, Learn CHEMISTRY 3)

D. Structure of Molecules and Molecular Ions

1. Five basic structures

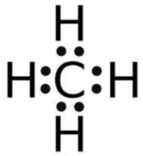
By using molecular model set provided by TA, construct the five basic three-dimensional structures shown in **Table D3.3**, page 159.

Five Basic three-dimensional structures from Table D3.3



2. Determine three dimensional structures

On a separate sheet of paper, set up the following table (with eight columns) for each of the molecules/molecular ions in 'D. Structure of Molecules and Molecular ions' on the ***Report Sheet*** (164p.) that are assigned to your group. Determine their geometric shapes and approximate angles by using the molecular model set and a protractor.

molecule or molecular Ion	Lewis Structure	Valence Shell Electron Pairs	Bonding Electron Pairs	Nonbonding Electron Pairs	VSEPR Formula	Approx. Bond Angle	Geometric Shape
CH_4		4	4	0	AX_4	109.5 °	tetrahedral