Diffraction Spectroscopy

Name________________________________ ID________________________ TA________________

Partners____

Date______________________________________ Section____________________________________

Caution

The light tubes will be very hot, and those use high voltage source. Please handle with care; otherwise it may result in serious personal injuries.

1. Emission Line Spectra (Qualitative Analysis)

Pick up the hand-held spectroscopes, and look at a fluorescent light. That has the mercury emission lines. The scale should be adjusted so that the bright green line in the spectrum of it is at 546 nm.

☑ The name of gas in tube: ____ **(I)**

➢ Apparent color of the glowing gas: ________________________________

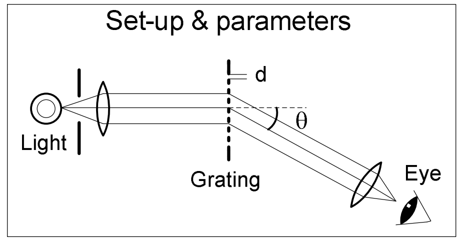
Colors	Wavelengths (nm)

☑ The name of gas in tube: ____ **(II)**

➢ Apparent color of the glowing gas: ________________________________

Colors	Wavelengths (nm)

Question: What you observe here is matched with the reference line spectra?



2. Emission Line Spectra (Quantitative Analysis)

Use the heavy-duty spectrometer. Make sure that you have the diffraction gratings.

- Calculation of d (the spacing between adjacent slits):

  1/N (N is the number of the slits per unit length) = d = ________________________(m)

  Find the formula in page 4.

  Wavelength: $\lambda = d\sin\theta/m$ (where m is the order, and usually it is 1.)

☑ The name of gas in tube used in **(I)**: ____

θ	Experimental λ	Accepted λ

☑ The name of gas in tube used in **(II)**: ____

θ	Experimental λ	Accepted λ

Question: Comparing with the results in part 1, and the ref. values, discuss the results in part 2.

3. Identifying an Unknown Gas

Pick up the unlabeled gas tube, and use both methods in parts 1 & 2. Then determine the name of gas.

θ	Experimental $\lambda = d\sin\theta$	λ from hand-held spectrometer	Accepted λ

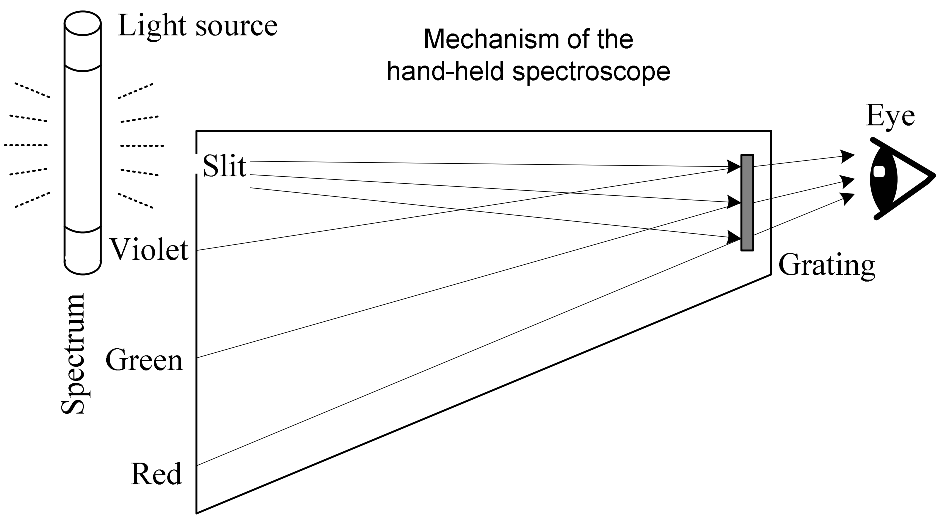
Question: Considering all the previous experiences and ref. values, what gas is this?

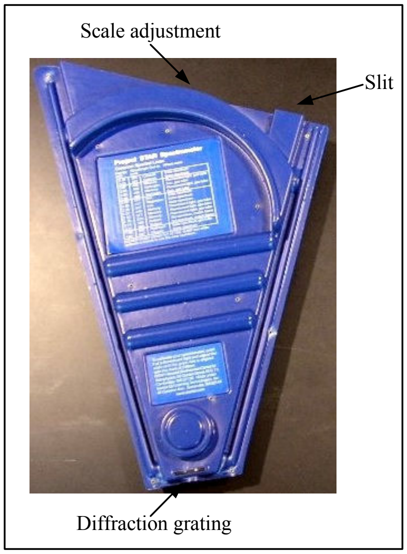
Lab Procedure for Spectroscopy

Use the provided gloves to avoid burning your fingers and a nasty shock with the high voltage.

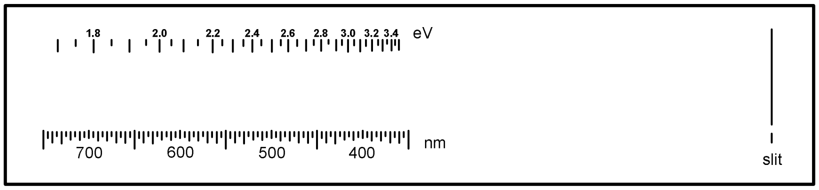
1. Emission Line Spectra (Qualitative Analysis)

- **As you see the following figure, aim the slit (on the right side of the spectrometer) at the object being analyzed and look though the diffraction grating straight ahead at the spectrum on the scale.**





- **Look at an incandescent bulb through the spectrometer. Make sure a continuous spectrum of colors from red to violet.**
The various colors are described by wavelength in nanometers (nm) on the bottom of the scale and by the energy of the particle of light, photon, expressed in electron-volts (eV). An electron volt is a unit of energy defined to be the work done on an electron in moving it through a potential difference of one volt; namely, 1 eV = 1.6022×10^{-19} J.



- **Now look a fluorescent light through the hand-held spectrometer.**
The most common type of fluorescent light will have the mercury emission lines superimposed on a continuous spectrum. The scale should be adjusted so that the bright green line in the spectrum of the fluorescent light is 546 nm (notice the small mark on the scale). If needed, adjust the scale by inserting the tip of a pen or pencil into one of the sprocket holes on the film, or use your finger to do it.

- **Install a known gas tube.**

- **Record the name of the gas and the apparent color on the data sheet.**

- **Record the color of the spectral lines and the wavelengths on the data sheet.**
  Hold the spectrometer horizontally so that the vertical slit is aligned with the vertical glowing tube.

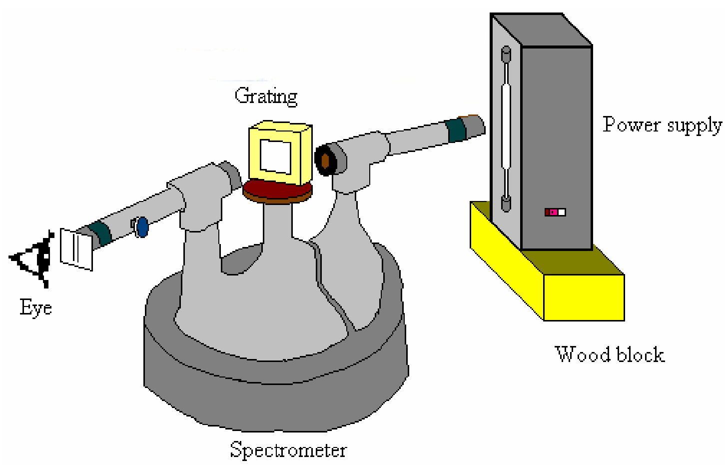
- **Compare the results with the "Description of Spectra" attached to the last page.**

- **Repeat the same process for the other known gas tube.**

2. Emission Line Spectra (Quantitative Analysis)

Through the second part, use also the hand-held spectrometer to assist your partners.

- **Set up the heavy-duty spectrometer in front of a gas tube installed.**
  This is very subtle, so be careful about the position of the object lens and the gas tube. See the following figure. Adjusting the height of gas tube with some wood block is the hint so that you can find the spectrum lines.



- **Calculate the spacing between adjacent slits, which is given by 1 ÷ N (the number of the slits per unit length).**
  You need to use meters to express the spacing. 1 inch = 0.0254 meters. Convert the units first, and then calculate the spacing from N.

- **As shown in the above figure, make the angle with the eye-piece side, and then, find the spectrum lines.**

- **Read the angle, and calculate the wavelength, using the given equation.**
  The equation is: $\lambda = d \sin\theta / m$. Most likely, what you find is when $m = 1$. When m is more than 1, the spectrum lines become very faint.

- **You will do this quantitative one three times. The last one should be used the unknown gas tube.**
  Use also the hand-held spectrometer. Try to find the name of gas by using a spectrum chart and the description.

Description of Spectra
(Referred from PASCO)

Model 4605 HYDROGEN (H_2 gas). Strong violet, blue and red lines are obvious, although others may be seen.

Color	**Wavelength, nm**
Violet	420
Violet	440
Blue	490
Red	670
Red	670

Model 4617 DEUTERIUM (isotopic variant of H_2). Spectrum is the same as for H_2, unaffected by neutron.

Color	**Wavelength, nm**
Violet	420
Violet	440
Blue	490
Red	670

Model 4604 HELIUM (He gas). Strong spectrum with 2 violet, 2 green, 1 yellow and 2 red lines being prominent.

Color	**Wavelength, nm**
Violet	400
Violet	400
Violet	400
Blue	450
Blue	455
Blue	455
Blue	480
Green	500
Green	510
Yellow	585
Red	650
Red	680
Red	720

Model 4609 NITROGEN (N_2 gas). Strong spectrum of many lines from violet to red.

Color	**Wavelength, nm**
Violet	400
Violet	405
Violet	410
Violet	415
Violet	420
Violet	425

NITROGEN (Continued)

Violet	440
Violet	445
Blue	500
Blue	505
Blue	520
Green	530
Green	540
Green	550
Green	560
Yellow	580
Yellow	585
Yellow	590
Red	600
Red	615
Red	620
Red	625
Red	630
Red	635
Red	640
Red	645
Red	650
Red	660
Red	670
Red	675
Red	680
Red	685

Model 4610 OXYGEN (O_2 gas). Very weak spectrum covering violet, blue/violet, green and red (2 lines) regions.

Color	**Wavelength, nm**
Violet	440
Violet	440
Blue	490
Green	525
Green	540
Green	540
Green	550
Green	565
Red	615
Red	625
Red	660
Red	665

Model 4611 WATER (H_2O vapor). Three strong hydrogen lines and weak spectrum from oxygen.

Color	**Wavelength, nm**
Violet	430
Violet	440
Blue	490
Green	520
Green	540
Green	550
Green	560
Red	605
Red	610
Red	665

Model 4612 AIR (About 80% N_2, 20% O_2 gasses). Strong spectrum is effectively the same as that of pure N_2. See NITROGEN.

Model 4613 CARBON DIOXIDE (CO_2 gas). About 6 intense lines from carbon (C) superimposed on the spectrum from oxygen (O). See CARBINIC ACID.

Model 4602 CARBONIC ACID (H_2CO_3 vapor). Spectrum resembles that of carbon dioxide, plus conspicuous red line from hydrogen.

Color	**Wavelength, nm**
Violet	415
Violet	425
Violet	445
Violet	455
Blue	490
Green	510
Green	520
Green	530
Green	540
Green	565
Red	610
Red	620
Red	630
Red	660

Model 4608 NEON (Ne gas). Strong spectrum of multiple lines in green, yellow, orange, red. Note absence of violet lines. Used in "neon lights."

Color	**Wavelength, nm**
Blue	475
Blue	490

NEON (Continued)

Green	510
Green	525
Green	560
Green	570
Yellow	580
Yellow	590
Yellow	600
Red	605
Red	610
Red	615
Red	620
Red	660
Red	665
Red	670
Red	685
Red	705
Red	715

Model 4600 ARGON (Ar gas). Weak multiple lines, most intense in violet, least intense in red.

Color	**Wavelength, nm**
Violet	420 (Hazy)
Violet	440 (Hazy)
Violet	460
Green	495
Green	525
Green	550
Green	550
Green	560
Green	570
Yellow	595
Red	610
Red	625
Red	630
Red	640
Red	650
Red	660
Red	670
Red	680
Red	710
Red	720

Model 4614 KRYPTON (Kr gas). Strong spectral lines in violet, green, orange and red portions.

Color	**Wavelength, nm**
Violet	430 (Hazy)
Violet	440 (Hazy)
Violet	450
Violet	455

KRYPTON (Kr gas) (Continued)

Blue	490
Green	560
Green	565
Green	570
Yellow	590
Red	610
Red	630
Red	650
Red	665

Model 4616 KRYPTON 86 (^{86}Kr gas). Isotopic variant of naturally occurring krypton, which is mainly ^{86}Kr. Spectrum is not noticeably changed, as with hydrogen and deuterium.

Model 4615 Xenon (Xe gas). Weak spectrum of 2 violet and 2 green lines.

Color	**Wavelength, nm**
Blue	470
Blue	470
Green	485
Green	485
Green	500
Green	500
Red	625
Red	640

Model 4607 MERCURY (Hg vapor). Strong spectrum composed of 3 violet, 1 green, 1 yellow and 1 orange lines. Mercury lamps are used as light sources for these wavelengths.

Color	**Wavelength, nm**
Violet	450
Violet	450
Violet	450
Violet	460
Green	500
Green	505
Green	560
Yellow	590
Yellow	590
Red	610
Red	625
Red	660
Red	680
Red	720
Red	730

Model 4603 CHLORINE (Cl_2 gas). Medium intensity multiline spectrum from violet to orange, with 3 stronger lines in the blue/green region.

Color	**Wavelength, nm**
Violet	445
Violet	455
Blue	485
Blue	485
Green	510
Green	520
Green	520
Green	540
Green	545
Green	570
Yellow	590
Red	600
Red	625
Red	635
Red	655
Red	665

Model 4606 IODINE (I_2 vapor). Strong spectrum with lines so closely spaced that appearance is “blurry”, especially in orange/red region.

Model 4601 BROMINE (Br_2 gas). Strong, multiple line spectrum from violet to red, with about 7 prominent lines.

Color	**Wavelength, nm**
Violet	420
Violet	425
Violet	450
Violet	450
Blue	475
Blue	480
Blue	480
Blue	480