PH160 LABORATORY 5

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Aim:

To study the emission spectra of Hydrogen, Neon and mercury vapours.

Apparatus:

Spectrometer, diffraction grating, mercury bulb, Hydrogen Bulb, neon bulb.

Theory:

When an atom or ion in substance got excited, they emit radiations of particular frequencies. These radiations are seen in the form of spectra. There are several types of spectra mainly,

- Continuous spectra-continuous band of colours is obtained.
- Absorption spectra-dark lines on a bright background.
- Emission spectra-bright lines on dark background.

In this experiment a diffraction grating optical spectrometer is used to study the spectra.

The diffraction grating provides the simplest and most accurate method for measuring wavelengths of light. It consists of a very large number of equidistant narrow parallel rectangular slit of equal width separated by equal opaque portion. The ruled widths are opaque to light and space between any two successive lines is transparent and act as parallel slits. Number of rulings per cm of grating used in visible region varies from 5,000 to 12,000 lines per mm.

The slits of a grating give rise to diffraction and the diffracted light interferes so as to set up interference patterns. Complete constructive interference occurs when the phase or path difference is equal to some whole number of the wavelength. In general the grating equation for constructive maxima is,

$$\mathbf{\sin\theta = Nm\lambda}$$

Where, m is called the order of the spectrum, λ the wavelength, N the number of lines per cm and θ
the diffraction angle measured with respect to the direction of the light incident on the grating.

1. **Calculation of difference (2θ):**
   =|Reading of right vernier-Reading of left vernier|

2. **Calculation of mean:**
   θ_1 for first vernier=(2θ of first vernier)/2
   θ_2 for second vernier=(2θ of second vernier)/2
   Mean(θ) = $(\theta_1+\theta_2)/2$

3. **Calculation of wavelength**
   - Assuming the wavelength of green line, 546nm, the no. of lines per mm is calculated

using equation, $N = \sin\Theta / m\lambda$ where m is the order.

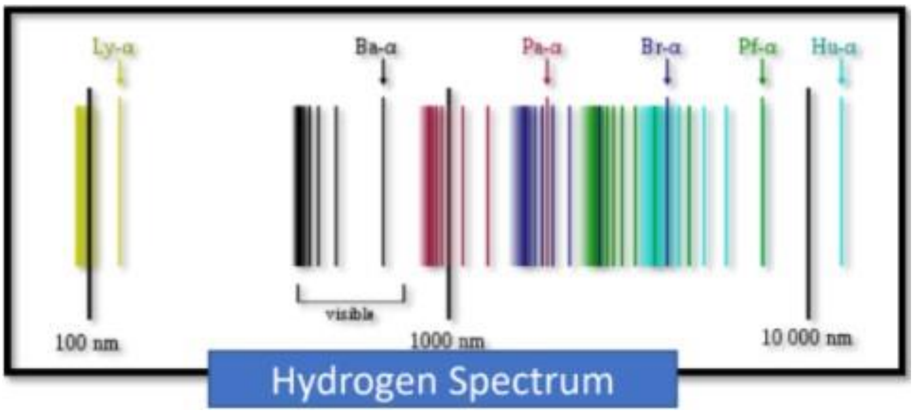
- Calculated value of N in this experiment= $\sin(90^{0}8')/(1*546)=1.8315*10^{-3}$/mm
- Further, using this value of N we calculate the wavelength of the other colours .
- In this experiment m=1, since we are observing the first order spectrum lines for hydrogen, mercury and neon.

Observation :

Least Count of the spectrometer =1 minute

A) Emission spectra of hydrogen

Colour of Spectral line	Reading of different Images				Difference (2Θ)		Mean (Θ)		Wavelength (λ)
	Left		Right						
	Ver1	Ver2	Ver1	Ver2	Ver1	Ver2	Var1	Var2	
Violet	346"22'	166"40'	14"12'	194"30'	332"10'	28"10'	166"5	14"3	410
Blue	345"46'	165"35'	15"20'	195"29'	330"26'	30"6'	165"13'	15"3'	434
Green	343"35'	163"25'	17"12'	197"21'	326"23'	34"4'	163"12'	17"2'	486
Red	337"54'	157"26'	23"39'	203"12'	314"15'	46"14'	157"8'	23"7'	656

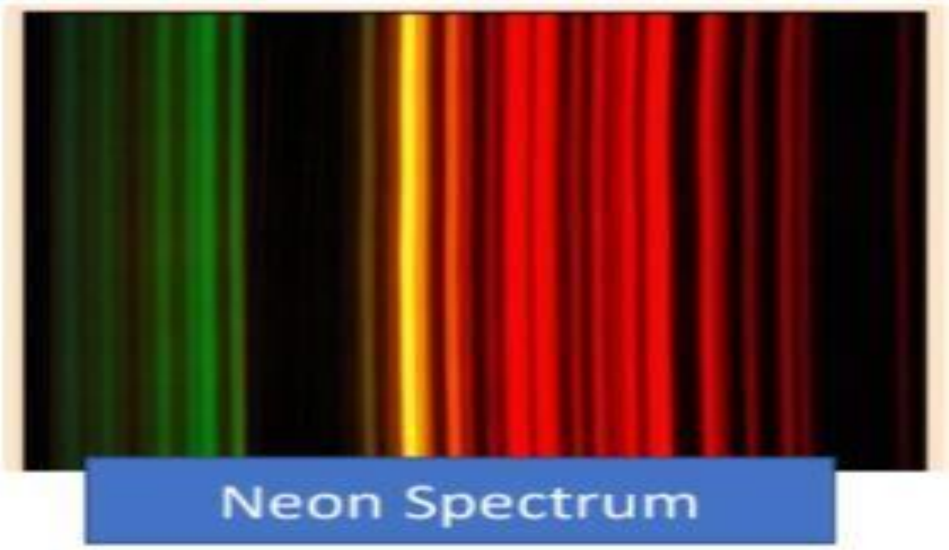


B) Emission spectra of mercury

Colour of Spectral line	Reading of different Images				Difference (2Θ)		Mean (Θ)		Wavelength (λ)
	Left		Right						
	Ver1	Ver2	Ver1	Ver2	Ver1	Ver2	Var1	Var2	
Green	341″22′	161″3′	19″11′	199″8′	322″11′	38″5′	161″5′	19″2′	546
Violet	346″3′	166″25′	14″8′	194″6′	332″55′	28″18′	166″27′	14″9′	420
Blue	345″45′	165″39′	15″27′	195″23′	330″18′	29″17′	165″9′	15″3′	464
Yellow	339″35′	159″15′	20″13′	200″9′	319″24′	41″6′	159″12′	20″3′	607
Red	336″29′	156″49′	23″8′	203″33′	313″21′	47″16′	155″10′	23″8′	714

C) Emission Spectra of neon

Colour of Spectral line	Reading of different Images				Difference (2Θ)		Mean (Θ)		Wavelength (λ)
	Left		Right						
	Ver1	Ver2	Ver1	Ver2	Ver1	Ver2	Var1	Var2	
Green	341″46′	161″8′	19″26′	199″21′	322″20′	38″13′	161″10′	19″7′	593
Yellow	339″38′	159″42′	20″14′	200″57′	319″24′	41″17′	159″12′	20″35′	585
Orange	337″42′	157″40′	22″20′	202″16′	315″22′	45″26′	157″11′	23″43′	607
Red	336″48′	156″50′	23″14′	103″12′	313″34′	53″38′	155″17′	26″17′	440



Calculations:

Determination of Rydberg's constant:

$$\frac{1}{\lambda_{\mathrm{vac}}} = R_{\mathrm{H}} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Here , $n_1 = 2$ and $n_2 = 3$

For different values of wavelengths, calculated value Rydberg constant=

Wavelength in nm	Rydberg constant
400	0.018012
445	0.01619
475	0.015168
650	0.011084
546	0.013195
570	0.01264
590	0.012211
650	0.011084

Average value of Rydberg's constant=$0.013698*10^9$= $1.3698*10^7$

Percentage Error=

$$= \frac{|\text{Accepted Value - Measured Value}|}{\text{Accepted Value}} \times 100\%$$

=$|1.097*10^7 - 1.3698*10^7| / 1.097*10^7 *100\%$

=24.86%

Results:

The wavelength of the prominent lines of the mercury spectrum are given in nanometre in the tabular column.

Number of grating per metre= 1.8315/m

Thank You