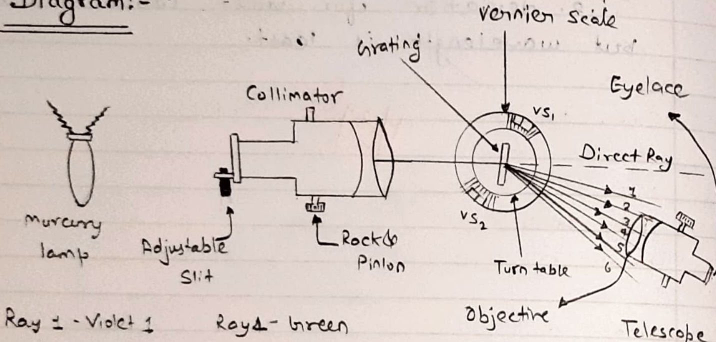
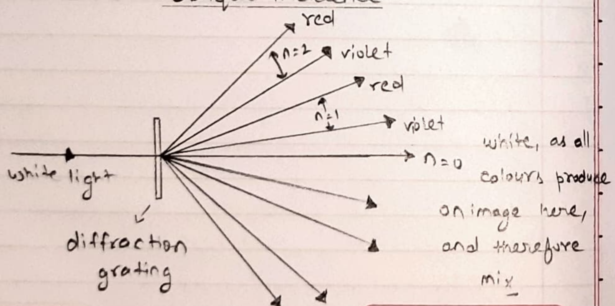
Diagram:-



Ray 1 - Violet 1
Ray 2 - Violet 2
Ray 3 - Blue
Ray 4 - Green
Ray 5 - Yellow 1
Ray 6 - Yellow 2

Spectrometer Arrangement

Oblique incidence



Experiment -

Object:- To determine the wave length of prominent lines of mercury by plane transmission diffraction grating with the help of spectrometer.

Apparatus:- Mercury Source, spectrometer, Diffraction grating, Magnify lens.

Theory and Formula:- When a light passes through a small aperature whose dimensions are comparable with the λ of light then light deviates from its rectilinear path and bends round the corner of the placed aperture of its geometrical shadow, this phenomenon is called diffraction. Because the source and the screen are placed effectively at infinite distance from the diffracting element it forms a class of fraunhoffer diffraction. An arrangement consisting of a large member of parallel slits equal opaque space is called diffraction grating. The distance between the centers of two successive slits is called the grating element. If "a" is width of the slit and "b" is the distance between the two slits. Then $(a+b)$ is called the grating element. Measurement of the wave length of prominent lines of mercury by plane transmission diffraction grating with the help of spectrometer. The wavelength λ of any spectral lines can be calculated by the formula:-

$$(a+b)\sin\theta = n\lambda$$

or

$$\lambda = \frac{(a+b)\sin\theta}{n}$$

where

$(a+b)$ = grating element
θ = angle of diffraction
n = order of the spectrum.

Observation :-

(1.) Least count of the spectrometer scale
minimum value of Main Scale = ½ Degree
Total Number of lines on vernier Scale = 30

$$\text{Least Count} = \frac{\text{Minimum Value on main Scale}}{\text{Total Number of lines on Vernier Scale}}$$

$$= \frac{1}{2} \times \frac{1}{30} = \frac{1}{60} \text{ (Degree)}$$

Calculation:-

(i) Calculation of grating element -

No. of lines on grating $N = \underline{15000}$ (lines per inch)

Grating element $(a+b) = 2.54/15000 = 1.69 \times 10^{-4}$ cm

(ii) Calculation of λ

$$\lambda = [(a+b)\sin\theta]/n$$

λ for first order spectrum - $(n=1)$

$\lambda_{violet} = (1.69 \times 10^{-4}) \sin(12.61)/1$

$= 0.3689 \times 10^{-4}$ cm $= \underline{3689\ \text{Å}}$

$\lambda_{Green} = (1.69 \times 10^{-4}) \sin(16.37)/1$

$= 0.4763 \times 10^{-4}$ cm $= \underline{4763\ \text{Å}}$

$\lambda_{Red} = (1.69 \times 10^{-4}) \sin(18.75)/1$

$= 0.5432 \times 10^{-4}$ cm $= \underline{5432\ \text{Å}}$

(2) The number of lines per inch on the grating surface is $(N) = 15000$ lines per inch

Grating element $(a+b) = \frac{1}{N} = \frac{1}{15000}$ inch $= \frac{2.54}{15000}$ cm

Observation Table :-

Order of Spectrum	Colour of light	Kind of Vernier	Spectrum on left side reading of telescope (a)			Spectrum on right side reading of telescope (b)			$2\theta = \lvert a-b \rvert$	Mean θ in Degree
			M.S.	V.S	Total	M.S	V.S	Total		
First order (n=1)	Violet	V_1	157	10	157.16	182.5	6	182.6	25.44	→ 12.61
		V_2	338	5	338.08	3	5	3.08	25.00	
	Green	V_1	153.5	5	153.58	186	2	186.03	32.45	→ 16.37
		V_2	333	3	333.05	6	6	6.10	33.05	
	Red	V_1	151	7	151.11	188	10	188.16	37.05	→ 18.75
		V_2	331	11	331.18	9	8	9.13	37.95	

Reading

$(360 - 331.8) + 9.13 = 37.95$

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Result:-

wave length of each colour:-

$\lambda_{violet} = 0.3689 \times 10^{-4}\,cm = 3689\ \mathring{A}$

$\lambda_{Green} = 0.4763 \times 10^{-4}\,cm = 4763\ \mathring{A}$

$\lambda_{Red} = 0.5432 \times 10^{-4}\,cm = 5431\ \mathring{A}$

Precaution:-

1. Height of Source, slit, lens, and grating on all riders should be same.
2. All riders must be aligned along one common axis.
3. Slit, grating should be vertical and parallel to each other.
4. Grating should be fixed for normal incidence.

Industrial Application:-

1. A spectrometer is used in spectroscopy for producing spectral lines and measuring their wavelengths and intensities.

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2. They are used in astronomy to analyze the radiation from astronomical objects and deduce chemical composition. The spectrometer uses a prism or a grating to spread the light from a distant object into a spectrum.

Viva- Questions with Answer

Q1 What is diffraction?
Ans The process by which a beam of light or other system of waves is spread out as a result of passing through a narrow aperture or across an edge, typically accompanied by interference between the wave forms produced.

Q2 What is diffraction grating?
Ans It is an optically flat glass plate on which large number of equidistant parallel lines is ruled by a fine diamond pen.

Q3 What is grating element?
Ans It is the distance between the centers of any two sucessive ruled lines or transparent stripes.

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Q4 What is the difference between prism & grating spectrum?

Ans In grating spectrum violet colour is least deviated and red colour is most deviated but in prism the reverse is true.

Q5 When will the even order spectra disappear?

Ans They will disappear if the size of opaque lines and transparent stripes is made equal.

Q6 Why does red colour deviate the most in case of grating?

Ans This is so because in case of grating $\sin\theta = n\lambda/(e+d)$ i.e angle of diffraction is proportional to the wavelength and the wavelength of red is maximum.

Q7 What gives a more intense spectrum - prism or grating?

Ans A prism gives a more intense spectrum because in prism entire light is concentrated into one spectrum while in the case of grating spectra of light of different orders.

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Q8 Why is light incident on the side of grating which has no rulings?

Ans To avoid refraction of diffracted light.

Q9 Define dispersion of light?

Ans The process of splitting of white light into its constituent colours is called disperson of light.

Q10 Describe essential parts of spectrometer?

Ans Collimator, prism table, telescope

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