

Atomic energy levels and line spectra

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

Hydrogen gas glows with a handful of distinct colours. In this lab you use a diffraction grating to measure the wavelengths of three of them and then show that each matches a drop to the second energy level of the hydrogen atom.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB E.1

Aim

To measure the wavelengths of three visible lines of the hydrogen spectrum with a diffraction grating, and to link each one to a transition between energy levels.

Equipment

- hydrogen spectrum tube in a holder with its power supply (operated by the teacher)
- transmission diffraction grating, 600 lines per mm
- metre rule, set up as a scale behind the tube
- narrow slit or card with a 1 mm gap, placed in front of the tube
- second metre rule or tape to measure the distance L
- dark room or a box to cut stray light

Safety

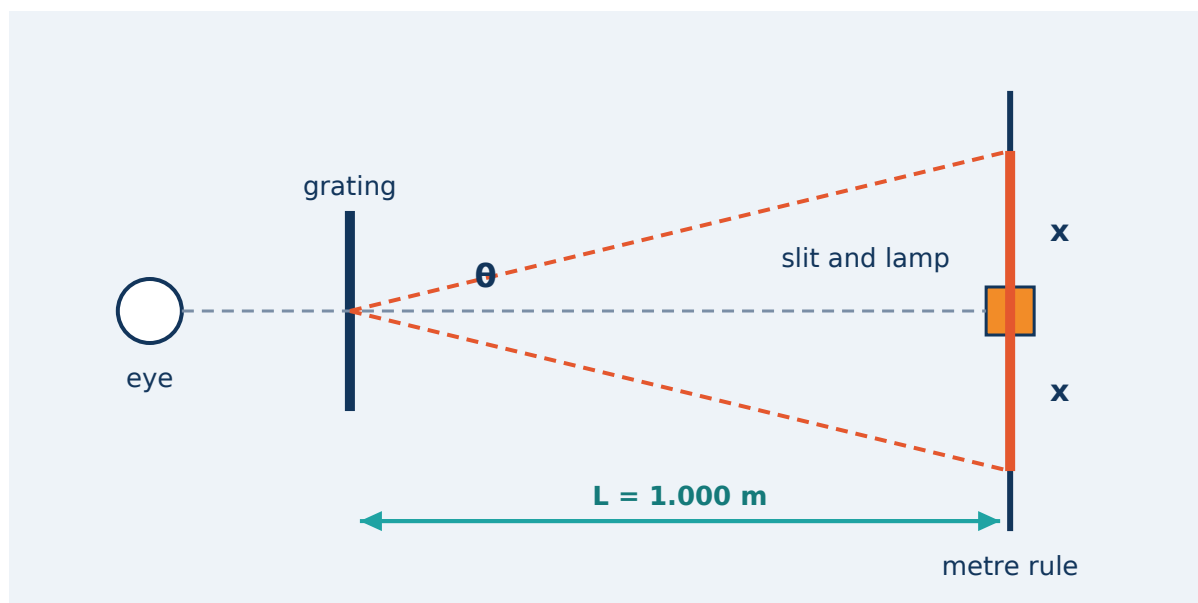
Safety

The spectrum tube runs at several thousand volts. Only the teacher may switch the supply on or off, and nobody may touch the tube or the terminals. Never look at the tube without the grating for long, and keep the tube from overheating by switching off between readings.

Method

1. Set the tube with its slit directly in front of the centre of the metre rule scale, and measure $L = 1.000$ m from the grating to the scale.
2. Hold the grating at the marked position, look through it towards the tube and find the first-order spectrum on each side of the central bright slit.
3. Ask a partner to read, on the scale, the distance x from the centre to each coloured line on the left side.

- Repeat for the same lines on the right side.
- Record the readings for the red, blue-green and violet lines in the table, then repeat once more and average if time allows.



Set-up for measuring wavelengths with a diffraction grating (not to scale).

Results

Sample readings with $L = 100.0$ cm:

Line colour	x left (cm)	x right (cm)	mean x (cm)
red	42.7	42.9	42.80
blue-green	30.4	30.7	30.55
violet	27.1	26.9	27.00

Analysis questions

Question 1 Averaging both sides

Explain why the distances x on the left and the right are averaged.

Question 2 Grating spacing

Calculate the spacing d between adjacent lines of a 600 lines per mm grating, in metres.

Question 3 Calculating wavelengths

Use the mean x values to find the angle θ for each line, then calculate each wavelength using $\lambda = d \sin \theta$ (first order).

Question 4 Comparing with accepted values

The accepted wavelengths are 656 nm, 486 nm and 434 nm. Calculate the percentage difference for each line and comment.

Question 5 Identifying transitions

Calculate the photon energy of each line in eV and identify the transition in hydrogen that produces it (levels $n = 2$ to 5 are at -3.40 , -1.51 , -0.85 and -0.54 eV).

Question 6 Uncertainty in the red line

The mean x for the red line is read to ± 0.1 cm. Estimate the percentage uncertainty in x , and suggest why the uncertainty in the wavelength is similar. State one improvement that reduces it.

Question 7 Second order

Predict, for the red line, where the second-order image would appear on the scale, and say why it may be hard to observe.