UE5020100

LINE SPECTRA

OBJECTIVE

Record and interpret the Balmer series of lines for hydrogen other line spectra in the visible region

SUMMARY

The line spectra of light-emitting atoms are uniquely characteristic for each specific chemical element, although they become increasingly complex for elements with higher atomic numbers. By contrast, that part of the line spectrum of hydrogen atoms that lies within the visible region can be explained simply on the basis of the Bohr model of the atom.

EXPERIMENT PROCEDURE

- **Record the line spectrum of hydrogen.**
- **Determine the frequencies of the H_α, H_β, H_γ and H_δ lines of the Balmer series for hydrogen.**
- **Calculate the Rydberg constant.**
- **Record and interpret line spectra of inert gases and metal vapours.**

REQUIRED APPARATUS

Quantity	Description	Number
1	Digital-Spectrometer LD	1018103
1	Spectrum Tube Power Supply (230V, 50/60 Hz)	1000684 or
	Spectrum Tube Power Supply (115V, 50/60 Hz)	1000683
1	Spectrum Tube Hydrogen	1003409
1	Barrel Foot, 1000 g	1002834
Additionally recommended:		
1	Spectrum Tube Helium	1003408
1	Spectrum Tube Neon	1003413
1	Spectrum Tube Argon	1003403
1	Spectrum Tube Krypton	1003411
1	Spectrum Tube Mercury	1003412
1	Spectrum Tube Bromine	1003404
1	Spectrum Tube Iodine	1003410

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BASIC PRINCIPLES

Light emitted by atoms of an electronically excited gas gives rise to spectra consisting of many individual lines, which are clearly distinguishable from one another, although they may be quite tightly packed in some parts of the spectrum. The lines are uniquely characteristic for each chemical element, because each line corresponds to a transition between particular energy levels in the electron shell of the atom.

The emission spectrum of hydrogen atoms has four lines, H_α, H_β, H_γ and H_δ, in the visible region. The spectrum continues into the ultra-violet region to form a complete series of spectral lines. In 1885 *J. J. Balmer* discovered that the frequencies of this series fit an empirical formula:

(1) $$\nu = R \cdot \left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

n = 3, 4, 5, 6 …

R = 3290 THz: Rydberg constant.

Later, with the aid of the Bohr model of the atom, it was shown that the frequency series could be explained simply in terms of the energy released by an electron when it undergoes downward transitions from higher shells to the second shell of a hydrogen atom.

The line spectrum of a helium atom, which contains only one more electron than hydrogen, is already much more complex, because the spin of the two electrons can be oriented in parallel or anti-parallel, so that they occupy completely different energy levels in the helium atom.

The complexity increases further for all other chemical elements. However, in every case the line spectrum is uniquely characteristic of the element.

EVALUATION

When the frequencies ν of the Balmer series are plotted as a function of $1/n^2$, with the H_α line assigned to n = 3, the H_β line to n = 4, and so on, the points lie on a straight line (see Fig. 1).

The gradient of the line corresponds to the Rydberg constant R. The intercept where the curve crosses the x-axis is at about 0.25, as a consequence of the fact that the transitions of the Balmer series go down to the n = 2 energy level.

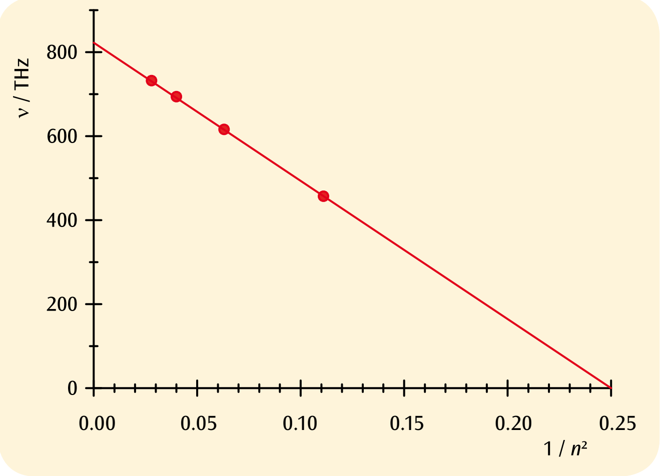

Fig. 1: Transition frequencies of the Balmer series as a function of $1/n^2$

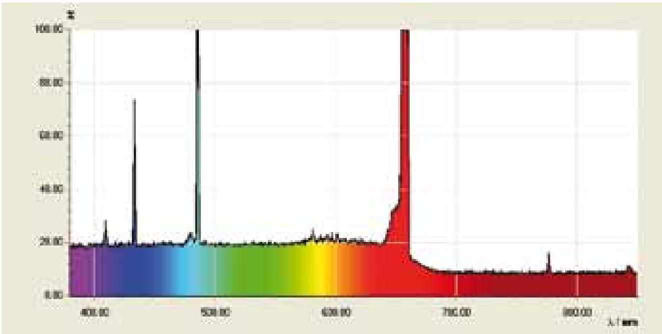

Fig. 2: Line spectrum of hydrogen atoms

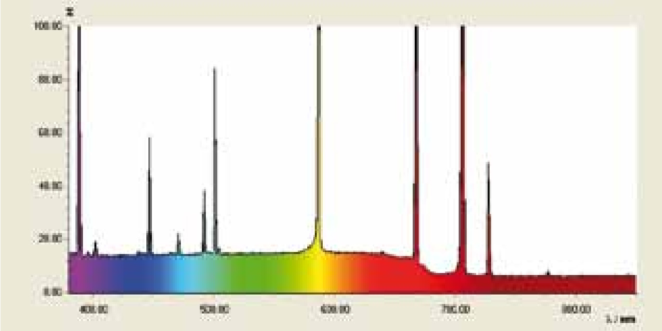

Fig. 3: Line spectrum of helium

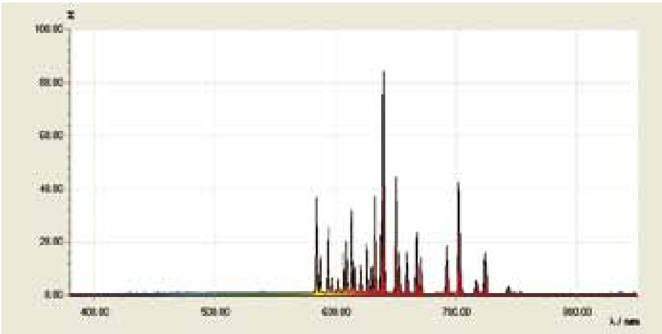

Fig. 4: Line spectrum of neon

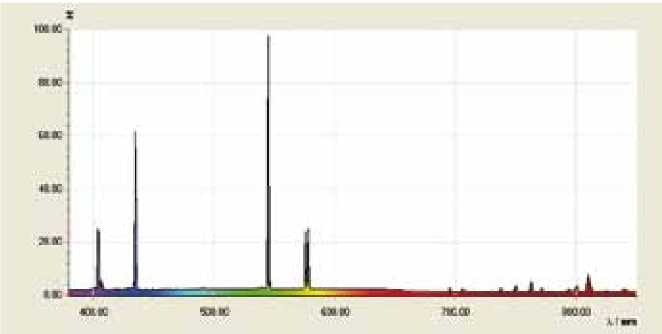

Fig. 5: Line spectrum of mercury vapour