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, \( \text{H} \alpha \), \( \text{H} \beta \), \( \text{H} \gamma \) and \( \text{H} \delta \), 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:

\[
\nu = \frac{1}{n^2} - \frac{1}{4} \quad \text{Rydberg constant.}
\]

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 spins 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 \( \nu \) of the Balmer series are plotted as a function of \( 1/n^2 \), with the \( \text{H} \alpha \) line assigned to \( n = 3 \), the \( \text{H} \beta \) 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.