The Isotope Effect in the Spectrum of Chlorine.

THREE strong bands in the absorption spectrum of chlorine have been analysed and the rotation constants for the normal and excited states of the chlorine molecule determined. These bands have been allocated by Kuhn (*Zeits. f. Phys.*, **39**, 77 ; 1926) to one vibration progression having a common initial level (probably 2) in absorption, the final states being denoted by the arbitrary numbers 5, 6, and 7. The $2 \rightarrow 5$ and $2 \rightarrow 7$ bands consist of single P and R branches from which a set of term differences can be found for each band, some twelve of one set being in good agreement with the corresponding members of the other set. The $2 \rightarrow 6$ band appears to consist of a single series of lines, each of which must, however, be in reality double, since on that assumption a set of term differences can be found which agrees well with the previous ones. These three bands show the phenomenon of alternation of intensity in the lines comprising them, as is to be expected in a symmetrical molecule. The ratio of intensities is approximately 1·4 : 1. There are indications that there may be a progressive diminution in this ratio in going from F_2 through Cl_2 and Br_2 to I_2, and it is hoped that work on Br_2 now in progress in this laboratory (Prof. J. Patkowski) may throw further light on this question.

A fourth weaker band which is displaced about 9·6 cm.$^{-1}$ with respect to the $2 \rightarrow 6$ band has been observed and analysed, and is found to have the same structure as the $2 \rightarrow 6$ band (*i.e.* superposed P and R branches) but slightly different rotation constants; this is ascribed to one of the isotopes of chlorine. Since this element has isotopes 35 and 37 present in the ratio 3·35 : 1, three kinds of molecules, $Cl_{35}Cl_{35}$, $Cl_{35}Cl_{37}$, and $Cl_{37}Cl_{37}$, must exist in the proportions 11·2 : 6·7 : 1 respectively. The three strong bands must be due to absorption by the most abundant molecule $Cl_{35}Cl_{35}$, and the weaker companion of the $2 \rightarrow 6$ band due to $Cl_{35}Cl_{37}$. Similar companions in the case of the $2 \rightarrow 5$ and $2 \rightarrow 7$ bands have been observed, but not yet fully analysed on account of the complexity of the spectrum in these regions. Hitherto the isotopic band due to $Cl_{37}Cl_{37}$, which must be very weak, has not been observed.

The nuclear separations of the $(2 \rightarrow 6)_{35\text{-}35}$ and $(2 \rightarrow 6)_{35\text{-}37}$ bands have been calculated and are found to agree closely both in the normal and excited states (see table of constants), although the values of the rotation constants differ appreciably in the two cases.

The most interesting feature of the $(2 \rightarrow 6)_{35\text{-}37}$ band is that, unlike the other bands, no alternation of intensity in its lines can be observed. This result provides direct confirmation of the theoretical conclusion that alternating intensities arise from equality of the nuclei, since the nuclear masses in $Cl_{35}Cl_{37}$ are unequal, whilst in every other respect this molecule is identical with the symmetrical molecule $Cl_{35}Cl_{35}$. Photometric measurements made on the least confused lines in the $(2 \rightarrow 6)_{35\text{-}35}$ and $(2 \rightarrow 6)_{35\text{-}37}$ bands indicate that the ratio of the intensity of the $(2 \rightarrow 6)_{35\text{-}37}$ band to the mean intensity of the $(2 \rightarrow 6)_{35\text{-}35}$ band is approximately that to be expected from the relative numbers in which the molecules exist, namely, 1 : 1·7.

The absolute values of the upper vibration quantum numbers have been calculated from the isotope effect and are found to be 17, 18, and 19 for the bands in which this number has been previously denoted by 5, 6, and 7 respectively. The available vibrational data are not sufficiently exact to decide whether half-integral vibration quantum numbers should be used, as is predicted by the wave mechanics.

CONSTANTS.

Band.	B''.	B'.	I''.	I'.	r''.	r'.
$(2 \rightarrow 17)_{35\text{-}35}$	·2412 cm.$^{-1}$	·1254 cm.$^{-1}$	114×10^{-40} gm. cm.^{2}	220×10^{-40} gm. cm.^{2}	$·991 \times 10^{-8}$ cm.	$1·38 \times 10^{-8}$ cm.
$(2 \rightarrow 18)_{35\text{-}35}$	·2412 ,,	·1209 ,,	114 ,,	228 ,,	·991 ,,	1·40 ,,
$(2 \rightarrow 18)_{35\text{-}37}$	·2337 ,,	·1164 ,,	118 ,,	237 ,,	·993 ,,	1·41 ,,
$(2 \rightarrow 19)_{35\text{-}35}$	·2412 ,,	·1166 ,,	114 ,,	237 ,,	·991 ,,	1·43 ,,

In the above table, r is half the internuclear distance. The constants in the upper and lower electronic states are denoted as usual by $'$ and $''$ respectively, and the absolute values of the upper vibrational quantum number are used in place of the arbitrary ones.

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Cosmic Radiation and Radioactive Disintegration.

A THEORY of radioactivity has been proposed by Perrin, who suggested that the disintegration of the radioactive elements may be due to their absorption of cosmic radiations. Former efforts to verify this theory have resulted in unsuccessful attempts to alter the rate of disintegration by subjecting radio-elements to intense gamma radiation and also by shielding them from external radiations.

However, to test the hypothesis further, the activity of a source of polonium has been actually measured by me at 1150 feet below the surface of the earth, at the bottom of the New Jersey Zinc Company's mine, Franklin, N.J. At this depth, it is thought that enough of the cosmic radiation would be absorbed to insure a change in the radioactivity of the specimen if that activity were a phenomenon produced by this radiation. The apparatus used comprised an ionisation chamber arranged to deliver a saturation current into a single-fibre electrometer of sensitivity 15 divisions per volt. The current was compensated by a measured current supplied by altering the potential of the external member of a standard condenser the internal member of which was connected to the electrometer. The results of the measurements showed that the activity did not change by more than about one per cent (which was the limit of accuracy of the experiment) when the polonium was taken from the surface of the earth to the bottom of the mine. The activity of the rocks of the mine was found to be small in comparison with the activity of the polonium, and therefore did not produce appreciable errors in the measurements.

We thus conclude that if Perrin's theory is to account for radioactive disintegration, the cosmic radiation responsible for the disintegration must be of such a penetrating power that it remains practically unabsorbed in going about eleven hundred feet through the earth and must yet have the property that it can be appreciably absorbed by relatively small amounts of radioactive elements.

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