An Isotope of Carbon, Mass 13.*

The bands belonging to the Swan spectrum of carbon appear in the vacuum electric furnace at about 2400°C. At temperatures above 2600° they are strong and clear-cut, even the the band at λ6191, difficult to obtain in the carbon arc, being well defined. It has been noted by one of us, during a variety of electric furnace investigations, that plates on which the band at λ4737 is very strong showed a faint band, not to be ascribed to a ghost, about 7.5A to the red of the strong band. The carbon arc shows a scattered structure in this region, which is suppressed in the furnace. It has however thus far failed to give the faint band, which in the furnace spectrum shows a distinct structure, essentially identical with the structure of the main band.

The recent discovery of isotopes of oxygen makes it very probable that other similar elements contain isotopes in small quantities. We have accordingly measured this faint band very carefully, using a first order exposure of a 15 ft. concave grating, the furnace being at about 2800°C. It is now generally agreed that the Swan bands are due to the neutral C_2 molecule, presumably $C^{12}-C^{12}$. We find that the new faint band corresponds quantitatively to that which should be given by an assumed $C^{13}-C^{12}$ molecule. The constants of the Swan band system are known with great precision (Int. Crit. Tables, V, 411, and J. D. Shea, Phys. Rev. 30, 825, 1927), and an accurate comparison with theory is therefore possible. With data of the precision now becoming available for oxygen, as well as in the present case, it is necessary to avoid various approximations which have commonly been used in previous work on isotopes. This will be fully discussed in later publications.

Because of the irradiation due to the strong band, it is to be expected that the measured distance between the two *heads* will be slightly *smaller* than the calculated isotope shift for the head. This is in fact the case, this distance being measured as 2.020 mm (=7.520A= 33.44 cm^{-1}) as compared to a calculated isotope shift of 2.028 mm (33.58 cm^{-1}). Fortunately, however, it is possible to distinguish six individual lines in the very faint isotope band. These have been identified as the unresolved triplets P_{26} to P_{31} (Shea's nomenclature). In the comparator P_{30} and P_{29} could be measured with reasonable accuracy, P_{28} and P_{27} less reliably, P_{26} very poorly, and P_{31} not at all. The corresponding triplets in the main band, also unresolved, could be measured with great precision. The observed isotope shifts in mm for P_{30} to P_{26}, with the calculated in parenthesis in each case are 2.059 (2.0515), 2.049 (2.0473), 2.037 (2.0429), 2.033 (2.0395), and 2.044 (2.0373) respectively. Multiplication by 16.58 gives the shift in cm^{-1}. The two good lines (P_{30} and P_{29}) give an average measured shift 0.082 cm^{-1} too large. Although with the present available data the fact may have no significance, it is interesting to note that this small discrepancy may be cancelled by assuming 12.0000 and 13.0026 for the two masses.

This 1–0 band (λ4737) is especially favorable for showing the faint isotope molecule, when one considers photographic intensity, position with respect to other bands (particularly CN) and size of the shift. We shall endeavor to get better plates, showing the isotope effect in other bands, and also showing more detailed structure. The present evidence seems however fully sufficient to establish the existence of an isotope of carbon, of mass 13. We cannot at this time make any statement as to its relative abundance, except to say that the isotope band is hundreds of times as faint as the strong band.

Arthur S. King
Raymond T. Birge

Mount Wilson Observatory,
Carnegie Institute of Washington,
and
Phycial Laboratory,
University of California,
June 24, 1929.

*See later communication, page 379.

The Raman Effect of Ketones

A study of the Raman effect in three ketones, dimethyl (acetone), methylethyl, and diethyl, has been made in the manner described by Wood (Phil. Mag. October 1928). The spectrograph was a Hilger constant deviation instrument which gave a spectrum about 30 mm long from 3900A to 4900A. Eastman process plates were found to be the most satisfactory as they brought out the faintest lines in exposure-times of from twenty