available for our ten liquids. The calculated and the observed values of K are given in columns 6 and 7 of Table III. The calculated values are consistently too small by 25 to 33 percent (if H_2O is excluded). This suggests a systematic error as in the case of the heat of vaporization. However, the discrepancy is hardly larger than one would expect with the special form of potential adopted if it is taken into account that the coefficients involved (Table II, Part I) have been determined from measurements at the ordinary boiling point.

If we want to summarize the results we should distinguish between the general theory and the deductions based on the special form of potential (7.01). The general theory seems satisfactory in the following regards: It reestablishes a random distribution of the molecules and gives the liquid a shape determined by surface tension. Furthermore, it proves the possibility of coexistence of vapor and liquid within certain limits of temperature and it leads automatically to kinetic expressions for the vapor pressure and for the surface tension.

As to the special form of the potential (7.01) it has been shown that it represents the behavior of liquids of widely variable character in a general way. In the one case of mercury the representation covers the thermal and elastic behavior as well as the surface tension. In all other cases the potential has to be modified for larger molecular distances if it is to include surface tension quantitatively. Furthermore, there remain discrepancies of a systematic nature in the determination of the heat of vaporization and in the critical data. It has not been investigated how far association in one or both phases may be responsible for these deviations. However, even with these deficiencies, it seems satisfactory that the simplified assumption of extensionless mass points, with the very special form of potential (7.01), gives our model practically all properties of real liquids with an almost quantitative agreement.

APPENDIX I

It has to be shown that, for sufficiently high values of the temperature, the equations of state for the two phases admit of only one solution for the molecular density n. The proof proceeds in two steps. First surface terms are neglected. In the limiting case $\varphi/kt\rightarrow 0$ the parameter σ becomes independent of T and assumes the geometrical value $\sigma=(1/2\pi n)^{\frac{1}{3}}$ of Hertz (p. 470, Part I). From this fact, and from the assumed form of $\varphi(r)$ (p. 464, Part I), it follows that p, as determined from (6.04), increases monotonically with decreasing V. This proves the point in the absence of surface terms. To complete the proof we call the unique solution which exists for sufficiently high values of T, in the absence of surface terms n_0 and investigate whether two solutions of the form $n_1=n_0+\nu_1 S/V_1$ and $n_2=n_0+\nu_2 S/V_2$ can be obtained. If these expressions are introduced into the formulae for the pressure[8] it follows that $n_1=n_2$ *to all orders of approximation*. Hence there is only one solution and no surface of separation can exist. As it has been proved previously (Appendix I, Part I) that there are at least two solutions for sufficiently low temperatures there must be an upper limit of temperature (eventually depending on surface terms) for which more than one solution can be obtained.

In Appendix I, Part I we have given two forms for the conditional equations, either Eqs. (a) and (c) or Eqs. (d) and (e). As surface terms were not considered in Appendix I, Part I, it should be mentioned that both sets yield only a zero approximation for a procedure of successive approximations. Furthermore, it should be pointed out that the two sets are *not* equivalent. Eqs. (d) and (e) are a necessary consequence of Eqs. (a) and (c) but not vice versa. The reason for this situation is that the transition from (a) and (c) to (d) and (e) involves a differentiation. For the calculation of the exact critical data the set (d) and (e) represents a much more adequate zero solution than (a) and (c) since (a) makes the pressure zero.

Letters to the Editor

Nuclear Energy Levels in Fe^{56} from the Decay of Mn^{56} and Co^{56}

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March 25, 1943

THE radiations accompanying the radioactive decay of Mn^{56} have been studied by a number of authors.[1] However, no consistent energy level scheme could be con-

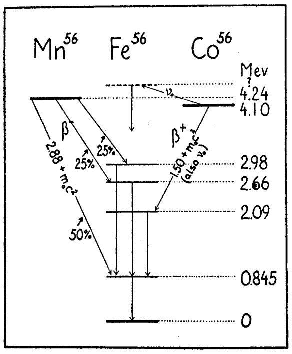

FIG. 1. Nuclear energy levels of Fe^{56} from radioactive disintegrations.

structed to agree with the beta-ray, gamma-ray, and coincidence measurements. We have therefore studied the *photoelectrons* produced in lead by these gamma-rays using our magnetic lens spectrometer, with considerably improved resolution. This study has revealed, in addition to two gamma-rays of 0.845±0.015 and 2.13 ±0.05-Mev energy,[1] the emission of a 1.81 ±0.04-Mev gamma-ray, about as abundant as the 2.13-Mev radiation. It had escaped detection in previous experiments because of the inadequate resolution of the Compton recoil method. All of the experiments may now be represented consistently by the disintegration scheme shown in the left half of Fig. 1.

The gamma-ray energies from a mixture of Co^{56}, Co^{57}, and Co^{58} have been previously reported by us.[2] A study of the decay of these gamma-rays, and a separate investigation of Co^{58},[3] allows us to assign to Co^{56} gamma-rays of energies 0.845±0.015, 1.24±0.04, 3.4±0.2 Mev, and others of as yet undetermined energy between 1.5 and 3 Mev and of lower abundance. The energy of the 0.845-Mev gamma-ray is identical with that from Mn^{56} to within 5 kev. The 15-kev probable error given above refers to the absolute energy values; the relative energies are known much more accurately. The maximum energy of the positrons was found in the beta-ray spectrometer to be 1.50 ±0.05 Mev. Abundant K x-rays and the relatively low intensity of the annihilation radiation indicate the occurrence of orbital electron capture.

The number of positron-gamma-ray coincidences per positron counted in the spectrometer was found to be independent of positron energy (above 0.2 Mev), in agreement with the results of Cook and McDaniel.[4] The efficiency of the gamma-ray counter for gamma-rays of 0.8- and 1.3-Mev energy was determined by coincidence measurements on Mn^{54}, Mn^{56}, Fe^{59}, Co^{58}, Co^{60}. The latter three disintegration schemes have been previously reported by us. With the aid of this calibration it was deduced from the observed coincidence rate in Co^{56} that each positron is accompanied by a 1.24-Mev and a 0.845-Mev gamma-ray in cascade as shown in the right half of Fig. 1. The dependence of the coincidence rate on the amount of lead absorber between source and gamma-ray counter was found to be consistent with this scheme. Further studies of the gamma-rays accompanying orbital electron capture in Co^{56} are in progress and a complete report on these experiments will be published soon.

Taking the mass of the neutral Fe^{56} atom to be 55.9572, we deduce 55.9612 for that of Mn^{56} and 55.9621 for Co^{56}. The threshold for a (p,n) reaction on Fe^{56} should be 5.5 Mev.

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[1] E.g.: Townsend, Proc. Roy. Soc. **177**, 357 (1941); Langer, Mitchell, and McDaniel, Phys. Rev. **56**, 427 (1939); Deutsch and Roberts, Phys. Rev. **60**, 362 (1941); and others.

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[3] Am. Phys. Soc. Bull. **18**, 1 (1943).

[4] C. S. Cook and P. W. McDaniel, Phys. Rev. **62**, 412 (1942).

The Carbon Arc in Oxygen for the Spectrochemical Determination of Potassium

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March 29, 1943

It is well known that the analytical measurement of very small amounts of potassium by the intensity of its spectrum line 4044.14A in the carbon arc is limited by the high background and the lines of the cyanogen bands. The N_2 of the air responsible for this effect may be replaced to a certain extent by O_2 without impairing the strength of the potassium line, as is the case when CO_2 is used. Johnson and Norman[1] recently have used a CO_2 atmosphere for removing the CN bands in their successful measurement of Cl and Br by means of the high voltage spark method of excitation.

The following technique for measuring potassium has proved very useful when employed with the rotating sector method of measuring line intensities. The lower cathode spectrographic carbon is arranged coaxially in a brass tube 3 cm in diameter which is open at the top and closed at the bottom except for a gas inlet. The top is about 5 mm above the crater tip and has a small rectangular notch on the side facing the spectrograph. The gas supplied to the arc from a commercial oxygen tank is controlled by a pressure reducing valve and the pressure in the line is measured by means of a water manometer. Best results are obtained with an arc current of 8 amp., a gas pressure of 2 cm H_2O, a slit width of about 10 microns, and a high contrast emulsion (35-mm high contrast positive film). Purified National 0.25-inch diameter regular graphite electrodes are used. The cathode is focused on the collimator lens of a Bausch and Lomb medium quartz spectrograph. No other gases have been tried.

With this improvement for determining potassium, the spectrochemical method described by the author[2] for sodium in biological materials has been extended to include other elements so that blood serum is now routinely analyzed for Na, K, Ca, Mg, and P all at once. The use of O_2 does not materially influence the measurement of the elements other than K. To the cathode is added 0.01 ml of serum, which amount in the human normally contains 33.0 percent Na, 2.0 percent K, 1.0 percent Ca, 0.27 percent Mg, and 1.3 percent P. Also, 2.5 percent Rb is added as the internal standard for K and 100 percent Cd as the internal standard for all the other elements. The spectrum lines measured are Na 2680.3A, K 4044.1A, Ca 3006.9A, Mg 2783.0A, P 2535.6A, Rb 4201.8A, and Cd 2677.6A.

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