As a matter of fact there are appreciable differences (almost 3 kcal.) even in 0.01 *M* solutions as the figure shows.

The existence of and therewith the necessity for considering these Q^* terms which Eastman introduced is thus established. It is also evident that the differences of partial molar entropies can not be determined by employing Peltier heats and thermo-electric forces alone [*cf.*, on the contrary, Bruzs, *Z. physik. Chem.*, **A161,** 83 (1932)].

A more detailed presentation of this material will be published shortly in a German journal.

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RECEIVED JANUARY 6, 1933 PUBLISHED FEBRUARY 9, 1933

THE THERMAL INTERCONVERSION OF MIXED BENZOINS

Sir:

Julian and Passler [THIS JOURNAL, **54,** 4756 (1932)] record another case of the transformation of the mixed benzoin not formed by the cyanide condensation (anisbenzoin) into the isomer formed by the cyanide method (benzanisoin). The reverse transformation, which is the object of our work, has not hitherto been recorded. The present writers have found that pure benzanisoin (cyanide condensation), after heating for three hours at 125–130° and fractionation from cold dilute alcohol, gives appreciable amounts of anisbenzoin, m. p. 89°, identical with Asahina and Terasaka's compound. Evidently, above the melting point, an equilibrium lying far over to the side of benzanisoin exists. The amount of pure anisbenzoin isolated, after heating, from 20 g. of benzanisoin was 0.10 g. but considerably more was present.

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RECEIVED JANUARY 9, 1933 PUBLISHED FEBRUARY 9, 1933

THE NEUTRON, THE ATOMIC NUCLEUS AND MASS DEFECTS

Sir:

Two general theories of the constitution of atomic nuclei have been proposed: (1) that the nucleus is built up largely from α-particles (Harkins and Wilson[1]) and (2) that the Harkins–Masson[2] nuclear formula $(p_2e)_z(pe)_I$ (a), $(np)_zn_I$ (b) or $(\alpha/2)_zn_I$ (c), represents the constitution of any nucleus

(1) (a) Harkins and Wilson, *Proc. Nat. Acad. Sci.*, **1,** 276 (1915); (b) THIS JOURNAL, **37,** 1368, 1383 (1915).

(2) (a) Harkins, THIS JOURNAL, **42,** 1956 (1920); *Phil. Mag.*, **42,** 305 (1921). See also Ref. 1(b) and Durrant, THIS JOURNAL, **39,** 621–7 (1917). (b) Masson, *Phil. Mag.*

(Heisenberg.[3] See also the earlier paper of Iwenko[4]). Here p represents a neutron; e, an electron; n, a neutron; α, an α-particle, and z and I, the atomic and isotopic numbers. Form (b) of the formula expresses the Heisenberg theory best, though he does not deny the existence of α-particles in the nucleus. Obviously the total number of neutrons is

$$N = Z + I$$

in which Z gives the number of neutrons combined with protons, and I the number of "extra" neutrons.

The energy of binding of (a) a proton and electron to give a neutron is one million electron volts, of (b) a neutron and proton to give H^2 is also one, while that of two H^2 atoms to give one helium atom is 23 million electron volts (Table I). The values for (a) and (b) are uncertain, but the sum is $1.91 \cdot 10^6$.

Thus the pairing of the neutrons and extra protons in the helium nucleus involves a binding energy twelve times as great as the sum of the binding energies of (1) a proton and an electron, and (2) of a neutron and a proton.

Thus if a neutron enters into an α-particle it is subjected to such ex-

TABLE I

BINDING ENERGY OF ATOMS IN 10^6 ELECTRON VOLTS

$$\left.\begin{array}{lll} p + e \longrightarrow n_2 & 1.(?) \\ n + p \longrightarrow H^2 & 1.\ (?) \end{array}\right\} \text{Sum} = 1.91$$

$$2p + e \longrightarrow H^2 \quad 1.91$$

	Proton Odd	Proton Even	Neutron Odd	Neutron Even	H^2 Odd	H^2 Even
$2H^2 \longrightarrow He$						23.2
$He + H^2 \longrightarrow Li^6$					3.42	
$Li^6 + n \longrightarrow Li^7$			6.2			
$Li^7 + H \longrightarrow 2He$		14.0				
$B^{10} + n \longrightarrow B^{11}$			6.3			
$B^{10} + H^2 \longrightarrow C^{12}$						21.0
$B^{11} + H \longrightarrow C^{12}$		14.1				
$C^{12} + n \longrightarrow C^{13}$			5.7			
$C^{12} + H^2 \longrightarrow N^{14}$					8.5	
$C^{13} + H \longrightarrow N^{14}$		(4.0)[a]				
$N^{14} + H^2 \longrightarrow O^{16}$						20.0
$O^{16} + n \longrightarrow O^{17}$			3.2			
$O^{16} + 2H^2 \longrightarrow Ne^{20}$						(12.4 av.)
$F^{19} + H' \longrightarrow Ne^{20}$		6.8				
$Ne^{20} + 2n \longrightarrow Ne^{22}$				(4.2 av.)		
$Ne^{22} + H \longrightarrow Na^{23}$	9.3					
$A^{36} + 4n \longrightarrow A^{40}$				(7.4 av.)		

[a] This value is not directly comparable with the others in this column, since it relates to the formation of a nucleus which does not contain a whole number of α-groups.

(3) Heisenberg, *Z. Physik*, **77**, 1 (1932); **78**, 156 (1932).

(4) Iwenko, *Nature*, **129**, 798 (1932).

tremely powerful forces of polarization that if it does not entirely lose its individuality it becomes very different from a neutron not thus combined.

Table I also gives the approximate binding energy for the union of any atom listed in column 1 with a proton, neutron, or H^2 nucleus. Column 6 shows that the binding energy for the union of an $\alpha/2$ group is much larger (value about 20 million volts) if the final number of such groups in the nucleus is even, than if this number is odd (from 3 to 9 million volts). If the final number is even, then the last p_2e group presumably forms an α-particle with the odd p_2e group already present. Relatively high values are also found for the completion of an α-particle, by a proton (column 3, about 14 million volts for Li^7 and B^{11}, though only 6.8 for F^{19}). No data are available for the calculation of the binding energy for a single neutron in any case in which the final nucleus presumably consists of α-particles alone.

TABLE II

MASS DEFECT OR BINDING ENERGY PER α-PARTICLE

$m' = \frac{-\Delta m}{N_\alpha} \times 10^4$		$\frac{-\Delta m'}{N_\alpha} \times 10^4$
C^{12}	10	12
O^{16}	22	0
Ne^{20}	22	
...	..	
A^{36}	48	3
A^{40}	51	4
Cr^{52}	62	−0.3
Zn^{64}	61	−0.5
Kr^{80}	59	−1.0
Sn^{112}	51	−2.6
Xe	43	

Table II is of interest since it shows that the mass defect per α-particle rises rapidly with the number of α-particles contrary to the assumption of Gamow's formula,[5] up to mass 52 (assumed number of α-particles = 13) and then decreases slowly with the mass number. There is no apparent discontinuity in the values where, between A^{36} and A^{40} according to theory (1) the first pair of cementing or "free" electrons enters, or theory (2) the first set of "free" neutrons (4 in number) come into the nucleus.

In a later paper the two theories will be compared on the basis of the above and other relations. In this connection, the mass numbers for magnesium, silicon, sulfur and calcium are badly needed, but are not at present available.

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RECEIVED JANUARY 14, 1933 PUBLISHED FEBRUARY 9, 1933

(5) Gamow, "Constitution of Atomic Nuclei and Radioactivity," Oxford, 1931.