LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

General Form of the Equation of State for a Monoatomic Ideal Gas

The April first issue of the *Physical Review* contains, on page 552, an article by Uehling and Uhlenbeck in which a general expression, valid for all statistics, of the equation of state for a monoatomic ideal gas is used (Eq. (16), p. 555). In a letter that the authors wrote to the Editor of this *Journal*[1] which I did not notice before, they say that, as far as they knew, the above equation did not appear in the literature. It may be worth while to remember that I reached the same result in 1928[2]: precisely $pv = NkT\varphi(Tv^{2/3})$, where φ is an arbitrary function of its argument $Tv^{2/3}$. I could also prove that, for all statistics, to the adiabatic invariants $pv^{5/3}$, $Tv^{2/3}$ correspond the other $Jv^{1/3}$, where J is the mean value of the absolute values of the molecular momenta. The equation of state can be written: $pv = NkT\cdot f(Jv^{1/3})$, where f is an arbitrary function of its argument $Jv^{1/3}$.

Observing that the physical dimensions of $Jv^{1/3}$ are those of an action, one is led to introduce a universal constant with the same physical dimensions of an action. This may be avoided by making the supposition $f=1$; but in this case we obtain the particular equation of Boyle and Gay-Lussac.

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May 29, 1933.

[1] Uehling and Uhlenbeck, Phys. Rev. **39**, 1014 (1932).
[2] Polvani, Nuovo Cimento **5**, 331 (1928).

The Equivalence of Mass and Energy

An experimental test of the relationship $\Delta E = C^2\Delta m$ is possible for two modes of nuclear disintegration when the results of recent mass-spectrograph measurements of the masses of the lithium isotopes[1] are considered in conjunction with the disintegration experiments of Cockcroft and Walton[2] and of Lewis, Livingston and Lawrence.[3]

The experiments of Cockcroft and Walton with lithium show that the lithium isotope of mass number seven under bombardment by high energy protons may capture a proton and that the resulting nucleus may disintegrate into two α-particles. The α-particles of range 8.4 cm which appear for protons of 270 kilo-volts energy have an energy of $8.6_2\times10^6$ electron-volts. The gain in energy in the reaction is $16.9_7\times10^6$ e-volts, an energy equivalent to 0.0182 mass units on the O^{16} scale if $\Delta E = C^2\Delta m$. Taking Aston's values[4] for the mass of helium and hydrogen and the author's value, 7.0146 ± 0.0006 for Li^7, the mass change is $0.018_1\pm0.0006$ in the reaction which may be represented as $Li^7+p\rightarrow2\alpha$. Within the probable error of the measurements the equivalence of mass and energy is satisfied.

Recently Lewis, Livingston and Lawrence have reported some remarkable disintegration experiments wherein the H^2 nucleus was the bombarding particle. In the case of lithium, α-particles of two ranges, 8.2 and 14.8 centimeters, were observed as the products of disintegration. The bombarding particles were H^2 nuclei of 1.33×10^6 e-volts energy. Extrapolation of the range-energy data for α-particles secured by Rutherford, Ward and W. B. Lewis[5] yields 12.5×10^6 e-volts for the energy of the α-particles of greatest range. Under the assumption that it is the Li^6 isotope which captures an H^2 nucleus and disintegrates into two α-particles, the process may be indicated as $Li^6+H^2\rightarrow2\alpha$. If one makes the additional assumption that momentum is conserved, the gain in energy in the reaction is 23.7×10^6 e-volts, equivalent to 0.025_5 mass units on the O^{16} scale is $\Delta m = \Delta E/C^2$.

Taking Aston's value for the mass of helium and the writer's values for H^2 and Li^6, the mass change is $0.023_8\pm0.0004$ unit. This measured mass change does not agree satisfactorily with the mass equivalent of the energy change in the disintegration. A more strict comparison must wait on values which include the probable error in the determination of the ranges of the α-particles.

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June 16, 1933.

[1] K. T. Bainbridge, Phys. Rev. **44**, 56 (1933).
[2] J. D. Cockcroft and E. T. S. Walton, Proc. Roy. Soc. **A137**, 229 (1932).
[3] Gilbert N. Lewis, M. Stanley Livingston and Ernest O. Lawrence, Bull. Am. Phys. Soc. **8**, No. 4, 13 (1933).
[4] F. W. Aston, Proc. Roy. Soc. **A115**, 487 (1927).
[5] E. Rutherford, F. A. B. Ward and W. B. Lewis, Proc. Roy. Soc. **A131**, 684 (1931).