Thermodynamic Properties of Uranium Gas

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ALTHOUGH THE CLASSIFICATION of lines in the very complex optical spectrum of uranium is still far from complete, some 312 energy levels for the neutral uranium atom (UI) based on the ground state assignment $^5L_6$ have been reported by various investigators. These energy levels together with their corresponding j values have been tabulated by Katz and Rabinowitch (*3*). This information is sufficient for the calculation of a complete set of thermodynamic properties for uranium gas. With the aid of modern high-speed computing equipment the calculation is easily made. The potential usefulness of such properties to physical chemists and metallurgists doing high-temperature research involving uranium is clear. One table of thermodynamic properties for uranium gas, published by Stull and Sinke (*5*), is already in widespread use, but it is based on a highly incomplete set of term values. There is also available from the Library of Congress a more recent table by Gordon (*2*) which, although a considerable improvement over that by Stull and Sinke, is based on fewer energy levels than given by Katz and Rabinowitch.

There is still some doubt that the ground state for UI has been correctly assigned, and various arguments concerning this point are summarized by Katz and Rabinowitch. Until the ground state is established with certainty the values given in Table I must be considered tentative.

ANALYSIS AND RESULTS

The scheme for calculating thermodynamic properties from spectroscopic term values may be found in several textbooks, such as that by Rossini (*4*). The energy levels for UI listed by Katz and Rabinowitch were processed by an IBM 704 computer which had been programmed to calculate and print out the desired thermodynamic properties as they appear in Table I. The constants used are based on the chemical scale of atomic weights and are consistent with the set suggested by Cohen, DuMond, Layton, and Rollet (*1*). In this system

Gas constant, R = 1.98726 cal. deg.$^{-1}$ mole^{-1}
$\alpha = hc/k = 1.43880$ cm. deg.
Avogadro's No., $N = 6.02322 \times 10^{23}$ molecules mole^{-1}
Sackur-tetrode constant = −2.31538 cal. deg.$^{-1}$ mole^{-1}

LITERATURE CITED

(1) Cohen, E.R., DuMond, J., Layton, T.W., Rollet, J.S., *Rev. Mod. Phys.* **27**, 263 (1955).
(2) Gordon, J.S., "Thermodynamic Functions for Eighteen Elements as Ideal Monatomic Gases," Library of Congress Doc. No. **6930**, 1961.
(3) Katz, J.J., Rabinowitch, E., "The Chemistry of Uranium," McGraw-Hill, New York, 1951.
(4) Rossini, F.D., "Chemical Thermodynamics," pp. 156–189, Wiley, New York, 1950.
(5) Stull, D.R., Sinke, G.C., Advan. Chem. Ser. No. **18**, p. 215, Am. Chem. Soc., Washington, D. C., 1956.

Table I. Thermodynamic Properties of Uranium Gas

Atomic weight = 238.07 gram mole^{-1}
$H^0_{298.15} - H^0_0 = 1553.4$ cal. mole^{-1}
$S^0_{298.15} = 47.726$ cal. deg.$^{-1}$ mole^{-1}

		Cal. Deg.$^{-1}$ Mole^{-1}		
T, ° K.	$H^0_T - H^0_{298.15}$, Cal. Mole^{-1}	C^0_p	S^0_T $S^0_{298.15}$	$-\frac{F^0_T - H^0_{298.15}}{T}$
298.15	0.0	5.663	0.000	47.726
300	10.5	5.666	0.035	47.726
400	581.6	5.724	1.678	47.949
500	1151.5	5.665	2.950	48.372
600	1714.3	5.593	3.976	48.845
700	2271.5	5.571	4.835	49.316
800	2827.9	5.579	5.578	49.769
900	3389.2	5.657	6.239	50.199
1000	3961.0	5.785	6.841	50.606
1100	4547.7	5.954	7.400	50.992
1200	5152.8	6.152	7.927	51.358
1300	5778.7	6.369	8.428	51.708
1400	6426.8	6.593	8.908	52.043
1500	7097.3	6.817	9.370	52.364
1600	7789.9	7.032	9.817	52.674
1700	8503.3	7.234	10.250	52.973
1800	9236.2	7.420	10.668	53.263
1900	9986.6	7.586	11.074	53.544
2000	10752.6	7.732	11.467	53.816
2100	11532.3	7.859	11.847	54.082
2200	12323.7	7.967	12.215	54.340
2300	13125.2	8.060	12.572	54.591
2400	13935.2	8.138	12.916	54.836
2500	14752.5	8.206	13.250	55.075
2600	15576.1	8.264	13.573	55.308
2700	16405.2	8.317	13.886	55.536
2800	17239.4	8.366	14.189	55.758
2900	18078.3	8.413	14.484	55.976
3000	18922.0	8.460	14.770	56.188
3100	19770.5	8.510	15.048	56.396
3200	20624.1	8.563	15.319	56.600
3300	21483.2	8.620	15.583	56.799
3400	22348.3	8.683	15.842	56.994
3500	23220.0	8.752	16.094	57.186
3600	24098.9	8.826	16.342	57.374
3700	24985.5	8.907	16.585	57.558
3800	25880.5	8.994	16.823	57.739
3900	26784.5	9.087	17.058	57.916
4000	27698.0	9.184	17.290	58.091
4100	28621.5	9.287	17.518	58.263
4200	29555.4	9.393	17.743	58.431
4300	30500.2	9.502	17.965	58.598
4400	31455.9	9.614	18.185	58.761
4500	32423.0	9.727	18.402	58.923
4600	33401.3	9.840	18.617	59.082
4700	34391.0	9.953	18.830	59.238
4800	35391.8	10.064	19.041	59.393
4900	36403.7	10.173	19.249	59.546
5000	37426.3	10.279	19.456	59.696

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