specific heat associated with electronic transitions in crystals. For our particular example, we determined the heat capacities of $Sm_2(SO_4)_3 \cdot 8H_2O$ at temperatures from 17 to 295°K., and the data are reported here. These are compared with the heat capacities of $Gd_2(SO_4)_3 \cdot 8H_2O$ over the same temperature range.[15] The quantitative agreement between the observed and computed electronic specific heats is found satisfactory.[28] The statistical weights for the levels in the basic multiplet were found to be equal to each other.

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(28) The computations employed the energy intervals derived from the absorption spectra of $Sm_2(SO_4)_3 \cdot 8H_2O$ by Dr. F. H. Spedding and Dr. Richard Bear. The intervals were kindly furnished us before publication.

BERKELEY, CALIF. RECEIVED NOVEMBER 16, 1934

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF CALIFORNIA]

The Heat Capacity of $Gd_2(SO_4)_3 \cdot 8H_2O$ from 16 to 300° Absolute

BY J. ELSTON AHLBERG AND CHESTER W. CLARK

In the treatment of the electronic specific heat of samarium ion Sm^{+++} considered in the preceding article[1] it was necessary to use the differences in the heat capacities of $Sm_2(SO_4)_3 \cdot 8H_2O$ and $Gd_2(SO_4)_3 \cdot 8H_2O$. The heat capacity of $Gd_2(SO_4)_3 \cdot 8H_2O$ has been determined previously in this Laboratory by Giauque and Clark.[2] Giauque and Clark suggested that for purposes other than those with which they were immediately concerned, it would be advisable to make a redetermination of the heat capacity of this salt. For reasons which Giauque and Clark[2] have already pointed out, the particular calorimeter employed by them was unsatisfactory and was discarded after having been used only for their measurements on $Gd_2(SO_4)_3 \cdot 8H_2O$. For the purpose of comparison accuracy is gained by the measurement of the heat capacity of the two salts under as nearly identical conditions as possible.

Material.—The same sample of $Gd_2(SO_4)_3 \cdot 8H_2O$ as used by Giauque and Clark was employed for this series of measurements. Analysis furnished by Welsbach Company, Gloucester, New Jersey, showed this sample to be Gd 98.5%, Sm 0.5%, Tb 1.0%. The presence of these impurities, since they are so very similar in many respects to gadolinium, will introduce errors which are negligible compared to the inaccuracy of the measurements. Determination of the water content of the sample gave 19.25% H_2O compared to 19.29% H_2O theoretical; 180.21 g. was used in the measurements.

Heat Capacity Measurements.—The calorimeter used also was employed for the measurements on $Sm_2(SO_4)_3 \cdot 8H_2O$, Series B, reported in the preceding article.[1] The wires on this calorimeter as already noted[1] gave rise to only very small temperature heads during energy input. The uncertainties involved in applying the heat exchange corrections for this effect largely determine the accuracy of the results obtained. We believe that a smooth curve drawn through

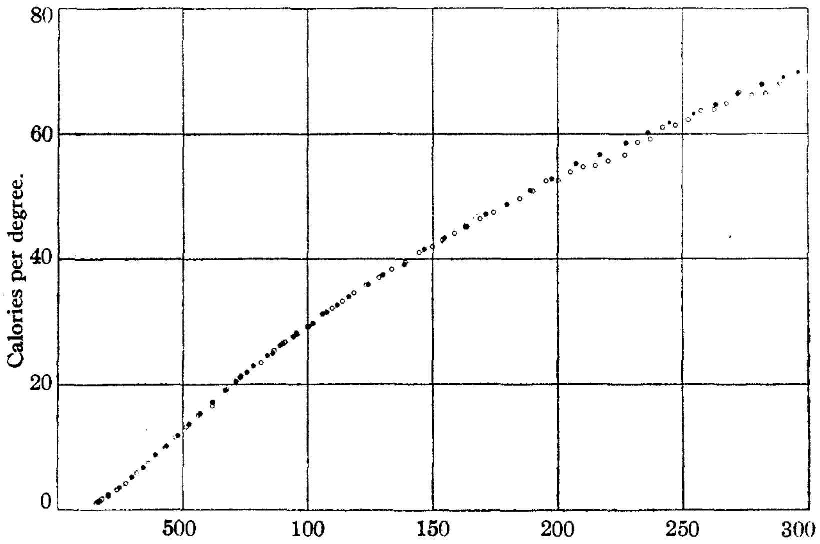

Fig. 1.—Heat capacity of 373.42 g. (1/2 mole) of $Gd_2(SO_4)_3 \cdot 8H_2O$.

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(1) Ahlberg and Freed, THIS JOURNAL, 57, 431 (1935).

(2) Giauque and Clark, *ibid.*, 54, 3135 (1932).

TABLE I

HEAT CAPACITY OF 373.42 G. (1/2 MOLE) OF $Gd_2(SO_4)_3 \cdot 8H_2O$

Value of calorie taken equals 4.185 absolute joules

$T_{av.}$, °K.	ΔT	C_p/1/2 mole in cal./deg.	$T_{av.}$, °K.	ΔT	C_p/1/2 mole in cal./deg.
16.06	3.675	1.301	105.82	6.026	31.21
20.21	3.189	2.208	107.52	4.290	31.53
24.81	5.070	3.577	111.72	5.567	32.68
29.65	4.142	5.213	116.20	5.732	33.98
34.02	4.255	6.747	124.20	4.749	35.90
38.86	4.500	8.713	130.08	7.600	37.50
43.41	4.432	10.19	138.65	7.636	39.23
47.98	4.598	11.91	146.55	7.550	41.56
52.54	4.314	13.76	154.55	7.803	43.37
56.98	4.501	15.43	163.03	7.970	45.21
61.94	5.703	17.23	171.26	8.095	47.15
67.01	4.238	19.10	180.12	8.821	48.97
67.65	5.346	19.36	189.13	8.204	51.02
71.32	4.210	20.54	197.81	8.557	52.93
73.01	5.132	21.07	207.46	7.924	55.33
75.58	4.187	21.93	217.09	8.236	56.81
78.42	5.446	22.92	227.17	7.743	58.64
80.21	4.976	23.46	236.06	8.005	60,27
83.64	4.910	24.53	244.77	8.105	61.96
85.14	4.506	24.94	254.45	7.691	63.30
88.67	4.900	26.23	263.22	7.328	64.77
89.68	4.547	26.45	272.13	8.381	66.44
94.01	5.581	27.60	281.58	8.024	67.87
95.48	4.531	28.01	290.16	6.395	69.09
99.88	5.598	29.23	296.50	6.837	69.86
101.86	4.208	29.76			

the points represents the heat capacity from 30 to 300°K. to within a few tenths of a per cent. From 16 to 30°K. the points are probably accurate to no more than a few per cent, due to the falling off of the temperature coefficient of gold resistance thermometers. In Fig. 1 the values of Giauque and Clark are indicated by circles and those of this research by solid black dots. It is evident that the results of Giauque and Clark show excellent agreement with this research from 16 to 200°K. Divergence does occur between 200 and 300°K. where the heat exchange corrections mentioned above become appreciable. The results of this research are given in Table I.

The experimental work reported here was performed in the Chemical Laboratory of the University of California. The calculations involved were in great part completed at The Johns Hopkins University.

Summary

The specific heat of $Gd_2(SO_4)_3 \cdot 8H_2O$ has been determined from 16 to 300° Absolute.

BALTIMORE, MARYLAND
LEIDEN, HOLLAND

RECEIVED NOVEMBER 22, 1934

[CONTRIBUTION FROM THE KENT CHEMICAL LABORATORY, UNIVERSITY OF CHICAGO]

The Identity of Fermi's Reactions of Element 93 with Element 91

BY A. V. GROSSE AND M. S. AGRUSS

Introduction

The interesting experiments recently performed by E. Fermi and his collaborators,[1] on the bombardment of uranium with neutrons, have led him to conclude that elements with an atomic number above 92 are formed. He specifically assumes that his product, with a period of thirteen minutes, which is precipitated from a highly oxidizing and acid solution together with manganese, is the highest homolog of the latter or element 93; furthermore, in a later paper[1b] he assumes that his product with a period of ninety to one hundred minutes, which is partially (50–60%) precipitated with rhenium sulfide from a highly acid solution, is isotopic with the thirteen minute product.

However, since we have to expect, according to the *periodic law*, other properties[2] for the highest homolog of manganese, we have repeated Fermi's chemical experiments, using protactinium, the longest lived isotope of element 91, as an indicator and obtained results described below.

Materials and Procedure

Materials.—The following solutions were prepared, using C. P. grade of chemicals in all cases: (1) a water solution of uranyl nitrate containing 2.763 g. of U_3O_8 per 50 cc.; (2) a manganese nitrate solution containing 0.1179 g. of MnO_2 per 10 cc.; (3) a 15% solution of sodium thiosulfate; (4) a water solution of potassium perrhenate containing 0.1609 g. of $KReO_4$ per 25 cc.; (5) a 4% sulfuric acid solution of protactinium pentoxide, equivalent to 900 U_3O_8 units of pure protactinium[3] per 5 cc., and containing also 5 mg. of ferric oxide in 5 cc.

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[1] E. Fermi, (a) *Nature*, **133**, 898 (1934); (b) *Proc. Roy. Soc.* (London), **146A**, 483–495 (1934).

[2] Grosse, THIS JOURNAL, **57**, 440 (1935).

[3] A. V. Grosse and M. S. Agruss, *ibid.*, **56**, 2200 (1934).