REFERENCE STATE

0	to	3258	K crystal
3258	to	5778.070	K liquid
above		5778.070	K ideal monatomic gas

Refer to the individual tables for details.

Enthalpy Reference Temperature = T_r = 298.15 K Standard State Pressure = p° = 0.1 MPa

T/K	C_p°	S°	$-[G^\circ-H^\circ(T_r)]/T$	$H^\circ-H^\circ(T_r)$	$\Delta_f H^\circ$	$\Delta_f G^\circ$	log K_f
	J·K⁻¹·mol⁻¹			kJ·mol⁻¹			
0	0.	0.	INFINITE	−5.681	0.	0.	0.
100	19.744	16.143	63.003	−4.686	0.	0.	0.
200	24.085	31.586	43.756	−2.434	0.	0.	0.
250	24.861	37.049	41.886	−1.209	0.	0.	0.
298.15	25.295	41.471	41.471	0.	0.	0.	0.
300	25.307	41.628	41.472	0.047	0.	0.	0.
350	25.598	45.552	41.781	1.320	0.	0.	0.
400	25.840	48.986	42.471	2.606	0.	0.	0.
450	26.088	52.044	43.368	3.904	0.	0.	0.
500	26.349	54.806	44.376	5.215	0.	0.	0.
600	26.843	59.655	46.530	7.875	0.	0.	0.
700	27.214	63.822	48.709	10.579	0.	0.	0.
800	27.459	67.473	50.831	13.313	0.	0.	0.
900	27.668	70.718	52.864	16.069	0.	0.	0.
1000	27.933	73.647	54.798	18.848	0.	0.	0.
1100	28.281	76.325	56.635	21.659	0.	0.	0.
1200	28.662	78.802	58.380	24.507	0.	0.	0.
1300	28.989	81.110	60.041	27.390	0.	0.	0.
1400	29.202	83.267	61.624	30.301	0.	0.	0.
1500	29.319	85.286	63.135	33.227	0.	0.	0.
1600	29.439	87.182	64.579	36.164	0.	0.	0.
1700	29.688	88.973	65.962	39.119	0.	0.	0.
1800	30.124	90.682	67.288	42.108	0.	0.	0.
1900	30.665	92.325	68.563	45.148	0.	0.	0.
2000	31.191	93.911	69.791	48.240	0.	0.	0.
2100	31.713	95.445	70.976	51.386	0.	0.	0.
2200	32.252	96.933	72.122	54.584	0.	0.	0.
2300	32.828	98.379	73.233	57.837	0.	0.	0.
2400	33.459	99.789	74.310	61.151	0.	0.	0.
2500	34.167	101.169	75.357	64.532	0.	0.	0.
2600	34.970	102.525	76.376	67.988	0.	0.	0.
2700	35.890	103.861	77.369	71.530	0.	0.	0.
2800	36.946	105.185	78.339	75.170	0.	0.	0.
2900	38.158	106.502	79.287	78.924	0.	0.	0.
3000	39.546	107.819	80.216	82.808	0.	0.	0.
3100	41.130	109.141	81.128	86.840	0.	0.	0.
3200	42.930	110.474	82.024	91.041	0.	0.	0.
3258.000	44.080	111.256	82.538	93.564	CRYSTAL <--> LIQUID		
3258.000	41.840	122.480	82.538	130.132	TRANSITION		
3300	41.840	123.016	83.049	131.889	0.	0.	0.
3400	41.840	124.265	84.243	136.073	0.	0.	0.
3500	41.840	125.478	85.404	140.257	0.	0.	0.
3600	41.840	126.656	86.534	144.441	0.	0.	0.
3700	41.840	127.803	87.634	148.625	0.	0.	0.
3800	41.840	128.919	88.706	152.809	0.	0.	0.
3900	41.840	130.005	89.751	156.993	0.	0.	0.
4000	41.840	131.065	90.770	161.177	0.	0.	0.
4100	41.840	132.098	91.766	165.361	0.	0.	0.
4200	41.840	133.106	92.738	169.545	0.	0.	0.
4300	41.840	134.091	93.688	173.729	0.	0.	0.
4400	41.840	135.052	94.618	177.913	0.	0.	0.
4500	41.840	135.993	95.527	182.097	0.	0.	0.
4600	41.840	136.912	96.416	186.281	0.	0.	0.
4700	41.840	137.812	97.288	190.465	0.	0.	0.
4800	41.840	138.693	98.141	194.649	0.	0.	0.
4900	41.840	139.556	98.978	198.833	0.	0.	0.
5000	41.840	140.401	99.798	203.017	0.	0.	0.
5200	41.840	142.042	101.391	211.385	0.	0.	0.
5400	41.840	143.621	102.926	219.753	0.	0.	0.
5600	41.840	145.143	104.407	228.121	0.	0.	0.
5778.070	41.840	146.452	105.682	235.572	LIQUID <--> IDEAL GAS		
5778.070	43.671	274.300	105.682	974.285	FUGACITY = 1 bar		
5800	43.762	274.465	106.320	975.244	0.	0.	0.
6000	44.636	275.963	111.950	984.082	0.	0.	0.

PREVIOUS: December 1972 (1 atm) CURRENT: December 1972 (1 bar)

$S°(298.15\ K) = 41.47 \pm 0.21\ J·K^{-1}·mol^{-1}$
$T_{fus} = 3258 \pm 10\ K$

$\Delta_f H°(0\ K) = 0\ kJ·mol^{-1}$
$\Delta_f H°(298.15\ K) = 0\ kJ·mol^{-1}$
$\Delta_{fus} H° = 36.57 \pm 4.2\ kJ·mol^{-1}$

Enthalpy of Formation

Zero by definition.

Heat Capacity and Entropy

The heat capacity values for $T \leq 10$ K are chosen to be the same as those adopted by Hultgren *et al.*[1] A graphical integration of these $C_p°$ data yields $S°(10\ K) = 0.025\ cal·K^{-1}mol^{-1}$. The adopted $C_p°$ values for the range $10 \leq T \leq T_{fus}$ are based on the following experimental data.

Source	T/K	Method
[2]	53– 295	$C_p°$
[3]	10– 273	$C_p°$
[4]	12– 550	$C_p°$
[5]	300–1554	drop, enthalpy
[6]	533–1383	drop, enthalpy
[7]	1900–3200	$C_p°$, pulse heating

The data of Cezairliyan,[7] reported as smoothed $C_p°$ values and represented by a third-order polynomial, yields $C_p°$ values from 3200 K to T_{fus} by extrapolation. These smooth $C_p°$ values, as reported by Cezirliyan,[7] are adopted for the range 1900–3200 K. Using a polynomial fit for each enthalpy data set,[5, 6] $C_p°$ values are obtained which define the region 298–1500 K A polynomial, constrained at 10 K, is used to produce smoothed $C_p°$ values in the range 10–298 K based on the three low temperature studies.[3-5]

For $T < 100$ K, the tabulated values do not agree well with the experimental data. In this region the deviations from the tabulated values are ± 5% for Clusius and Losa,[3] −0.3 to +1.9% for Kelley,[2] and −1.7 to 2.8% for Sterrett and Wallace.[4] The deviations are due in part to experimental scatter[3] and a poor match of experimental data at 10 K.

Many other experimental studies have been referenced by Gmelin[8] and Hultgren *et al.*[1] In addition, Cezairliyan[7] has compared graphically many of the investigations. The $C_p°$ data and enthalpy data are all in generally good agreement. The importance of the recent Cezairliyan study[7] is that it gives added evidence to the deviation from a linear C_p–T relationship above 1000 K.

Fusion Data

The melting point of Ta is chosen as 3258 ± 10 K based on the subsecond pulse heating technique of Cezairliyan.[7] This choice is made so as to have a T_{fus} consistent with $C_p°$ data at temperatures near T_{fus} (see heat capacity discussion). Other T_{fus} values covering the range 3053–3273 K are referenced by Charlesworth;[9] while additional references are found in Gmelin.[8] Hultgren *et al.*[1] recommends a T_{fus} value of 3287 K.

The enthalpy of fusion, $\Delta_{fus}H°$, for Ta has been measured by Lebedev *et al.*[10] They reported a $\Delta_{fus}H°$ value of 8.74 ± 0.5 kcal·mol^{-1} based on measurements made during electrical explosion in thin wires. We adopt this value for $\Delta_{fus}H°$ Based on $\Delta_{fus}H° = 8.74\ kcal·mol^{-1}$ and $T_{fus} = 3258$ K, the entropy of melting, $\Delta_{fus}S°$, is calculated to be $2.68\ cal·K^{-1}·mol^{-1}$. This compares with $\Delta_{fus}S° = 2.33\ cal·K^{-1}·mol^{-1}$ for Nb, as reported in these tables.

References

[1] R. Hultgren, R. L. Orr, and K. K. Kelley, Supplement to Selected Values of Thermodynamic Properties of Metals and Alloys, Ta table, (August 1971).
[2] K. K. Kelley, J. Chem. Phys. 8, 316 (1940).
[3] K Clusius and C. G. Losa, Z. Naturforsch. 10A, 939 (1955).
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[6] F. L. Oetting and J. D. Navratil, J. Chem. Eng. Data 17, 230 (1972).
[7] A. Cezairliyan, U. S. Natl. Bur. Stands. Rept. 10326, 211 pp. (July 1970), Ch. 7, Ch. 8.
[8] "Gmelins Handbuch der Anorganishen Chemie," 8th Edition, Tantal, Vol. 50, Pt. A, No. 2, Verlag Chemie, Weinheim (1969).
[9] J. H. Charlesworth, Melting Points of Metallic Elements and Selected Compounds, AFML-TR-70-137, (October 1970).
[10] S. V. Lebedev, A. I. Savvatimskii, and Yu. B. Smirnov, High Temperature USSR 9, 635 (1971).

Enthalpy Reference Temperature = T_r = 298.15 K Standard State Pressure = $p°$ = 0.1 MPa

T/K	$C_p°$ (J·K^{-1}mol^{-1})	$S°$ (J·K^{-1}mol^{-1})	$-[G°-H°(T_r)]/T$ (J·K^{-1}mol^{-1})	$H°-H°(T_r)$ (kJ·mol^{-1})	$\Delta_f H°$ (kJ·mol^{-1})	$\Delta_f G°$ (kJ·mol^{-1})	log K_f
0	0.	0.	INFINITE	−5.681	0.	0.	
100	19.744	16.143	63.003	−4.686	0.	0.	0.
200	24.085	31.586	43.756	−2.434	0.	0.	0.
250	24.861	37.049	41.886	−1.209	0.	0.	0.
298.15	25.295	41.471	41.471	0.	0.	0.	0.
300	25.307	41.628	41.472	0.047	0.	0.	0.
350	25.598	45.552	41.781	1.320	0.	0.	0.
400	25.840	48.986	42.471	2.606	0.	0.	0.
450	26.088	52.044	43.368	3.904	0.	0.	0.
500	26.349	54.806	44.376	5.215	0.	0.	0.
600	26.843	59.655	46.530	7.875	0.	0.	0.
700	27.214	63.822	48.709	10.579	0.	0.	0.
800	27.459	67.473	50.831	13.313	0.	0.	0.
900	27.668	70.718	52.864	16.069	0.	0.	0.
1000	27.933	73.647	54.798	18.848	0.	0.	0.
1100	28.281	76.325	56.635	21.659	0.	0.	0.
1200	28.662	78.802	58.380	24.507	0.	0.	0.
1300	28.989	81.110	60.041	27.390	0.	0.	0.
1400	29.202	83.267	61.624	30.301	0.	0.	0.
1500	29.319	85.286	63.135	33.227	0.	0.	0.
1600	29.439	87.182	64.579	36.164	0.	0.	0.
1700	29.688	88.973	65.962	39.119	0.	0.	0.
1800	30.124	90.682	67.288	42.108	0.	0.	0.
1900	30.665	92.325	68.563	45.148	0.	0.	0.
2000	31.191	93 911	69.791	48.240	0.	0.	0.
2100	31.713	95.445	70.976	51.386	0.	0.	0.
2200	32.252	96.933	72.122	54.584	0.	0.	0.
2300	32.828	98.379	73.233	57.837	0.	0.	0.
2400	33.459	99.789	74.310	61.151	0.	0.	0.
2500	34.167	101.169	75.357	64.532	0.	0.	0.
2600	34.970	102.525	76.376	67.988	0.	0.	0.
2700	35.890	103.861	77.369	71.530	0.	0.	0.
2800	36.946	105.185	78.339	75.170	0.	0.	0.
2900	38.158	106.502	79.287	78.924	0.	0.	0.
3000	39.546	107.819	80.216	82.808	0.	0.	0.
3100	41.130	109.141	81.128	86.840	0.	0.	0.
3200	42.930	110.474	82.024	91.041	0	0.	0.
3258.000	44.080	111.256	82.538	93.564	--- CRYSTAL <---> LIQUID ---		
3300	44.965	111.826	82.907	95.433	−36.456	0.471	−0.007
3400	47.256	113.202	83.778	100.042	−36.031	1.584	−0.024
3500	49.823	114.608	84.638	104.894	−35.363	2.681	−0.040
3600	52.685	116.051	85.491	110.017	−34.424	3.756	−0.054
3700	55.864	117.537	86.337	115.441	−33.184	4.800	−0.068
3800	59.377	119.073	87.178	121.201	−31.609	5.806	−0.080

PREVIOUS: CURRENT: December 1972

$S°(298.15\ K)$ = [50.366] $J·K^{-1}·mol^{-1}$
T_{fus} = 3258 ± 10 K

$\Delta_f H°(298.15\ K)$ = [30.795] $kJ·mol^{-1}$
$\Delta_{fus}H°$ = 36.57 ± 4.2 $kJ·mol^{-1}$

Enthalpy of Formation

The enthalpy of formation of Ta(l) at 298.15 K is calculated from that of the crystal by adding $\Delta_{fus}H°$ and the difference in enthalpy, $H°(3258\ K)-H°(298.15\ K)$, between the crystal and liquid.

Heat Capacity and Entropy

The heat capacity for Ta(l) is estimated as 10.0 $cal·K^{-1}·mol^{-1}$ by analogy with other monatomic metals. The same value was adopted by Hultgren *et al.*[1] and Stull and Sinke.[2] A glass transition is assumed at 2150 K. Below this temperature, the heat capacity values used are those of Ta(cr). The entropy at 298.15 K is calculated in a manner similar to that used for the enthalpy of formation.

Fusion Data

Refer to the crystal table for details.

Vaporization Data

T_{vap} is the temperature at which the Gibbs energy change for the reaction Ta(l) → Ta(g) is zero. The difference between $\Delta_f H°$(Ta, g) and $\Delta_f H°$(Ta, l) at T_{vap} is $\Delta_{vap}H°$. The uncertainty in the boiling point is probably of the order of ±200 K.

References

[1]R. Hultgren, R. L. Orr, and K. K. Kelley, Supplement to Selected Values of Thermodynamic Properties of Metals and Alloys, Ta table, (August 1971).
[2]D. R. Stull and G. C. Sinke, "Thermodynamic Properties of the Elements," American Chemical Society, Washington, D C., (1956).

Enthalpy Reference Temperature = T_r = 298.15 K Standard State Pressure = $p°$ = 0.1 MPa

T/K	$C_p°$	$S°$	$-[G°-H°(T_r)]/T$	$H°-H°(T_r)$	$\Delta_f H°$	$\Delta_f G°$	log K_f
		J·K⁻¹·mol⁻¹			kJ·mol⁻¹		
0							
100							
200							
250							
298.15	25.295	50.366	50.366	0.	30.795	28.143	−4.931
300	25.307	50.522	50.366	0.047	30.795	28.127	−4.897
350	25.598	54.447	50.676	1.320	30.795	27.682	−4.131
400	25.840	57.881	51.366	2.606	30.795	27.237	−3.557
450	26.088	60.938	52.263	3.904	30.795	26.793	−3.110
500	26.349	63.701	53.271	5.215	30.795	26.348	−2.753
600	26.843	68.550	55.424	7.875	30.795	25.458	−2.216
700	27.214	72.717	57.604	10.579	30.795	24.569	−1.833
800	27.459	76.367	59.726	13.313	30.795	23.680	−1.546
900	27.668	79.613	61.758	16.069	30.795	22.790	−1.323
1000	27.933	82.541	63.693	18.848	30.795	21.901	−1 144
1100	28.281	85.220	65.530	21.659	30.795	21.011	−0.998
1200	28.662	87.697	67.275	24.507	30.795	20 122	−0.876
1300	28.989	90.005	68.936	27.390	30.795	19.232	−0.773
1400	29.202	92.162	70.518	30.301	30.795	18.343	−0.684
1500	29.319	94.181	72.029	33.227	30.795	17.453	−0.608
1600	29.439	96.076	73.474	36.164	30.795	16.564	−0.541
1700	29.688	97.868	74.856	39.119	30.795	15.674	−0.482
1800	30.124	99.576	76.183	42.108	30.795	14.785	−0.429
1900	30.665	101.219	77.457	45.148	30.795	13.896	−0.382
2000	31.191	102.806	78.685	48.240	30 795	13.006	−0.340
2100	31.713	104.340	79.871	51.386	30.795	12.117	−0.301
2150.000	31.980	105.089	80.448	52.978	GLASS <--> LIQUID		
2150.000	41.840	105.089	80.448	52.978	TRANSITION		
2200	41.840	106.051	81.019	55.070	31.281	11.222	−0.266
2300	41.840	107.911	82.148	59.254	32.212	10.289	−0.234
2400	41.840	109.692	83.259	63.438	33.082	9.317	−0.203
2500	41.840	111.400	84.351	67.622	33.885	8.310	−0.174
2600	41.840	113.041	85.423	71.806	34.613	7.272	−0.146
2700	41.840	114.620	86.475	75.990	35.256	6.208	−0.120
2800	41.840	116.141	87.508	80.174	35.799	5.122	−0.096
2900	41.840	117.610	88.521	84.358	36.229	4.018	−0.072
3000	41.840	119.028	89.514	88.542	36.529	2.902	−0.051
3100	41.840	120.400	90.488	92.726	36.681	1.778	−0.030
3200	41.840	121.728	91.444	96.910	36.664	0.652	−0.011
3258.000	41.840	122.480	91.990	99.337	--- CRYSTAL <--> LIQUID ---		
3300	41.840	123.016	92.381	101.094	0.	0.	0.
3400	41.840	124.265	93.301	105.278	0.	0.	0.
3500	41.840	125.478	94.203	109.462	0.	0.	0.
3600	41.840	126.656	95.088	113.646	0.	0.	0.
3700	41.840	127.803	95.957	117.830	0.	0.	0.
3800	41.840	128.919	96.810	122.014	0.	0.	0.
3900	41.840	130.005	97.647	126.198	0.	0.	0.
4000	41.840	131.065	98.469	130.382	0.	0.	0.
4100	41.840	132.098	99.277	134.566	0.	0.	0.
4200	41.840	133.106	100.070	138.750	0.	0.	0.
4300	41.840	134.091	100.850	142.934	0.	0.	0.
4400	41.840	135.052	101.617	147.118	0.	0.	0.
4500	41.840	135.993	102.370	151.302	0.	0.	0.
4600	41.840	136.912	103.111	155.486	0.	0.	0.
4700	41.840	137.812	103.840	159.670	0.	0.	0.
4800	41.840	138.693	104.557	163.854	0.	0.	0.
4900	41.840	139.556	105.262	168.038	0.	0.	0.
5000	41.840	140.401	105.957	172.222	0.	0.	0.
5200	41.840	142.042	107.313	180.590	0.	0.	0.
5400	41.840	143.621	108.629	188.958	0.	0.	0.
5600	41.840	145.143	109.906	197.326	0.	0.	0.
5778.070	41.840	146.452	111.012	204.776	----- FUGACITY = 1 bar -----		
5800	41.840	146.611	111.146	205.694	−738.755	2.801	−0.025
6000	41.840	148.029	112.352	214.062	−739.225	28.380	−0.247

PREVIOUS: CURRENT: December 1972

CRYSTAL-LIQUID

0	to	3258	K crystal
above		3258	K liquid

Refer to the individual tables for details.

Enthalpy Reference Temperature = T_r = 298.15 K Standard State Pressure = p° = 0.1 MPa

	J·K⁻¹·mol⁻¹			kJ·mol⁻¹			
T/K	C_p°	S°	$-[G^\circ-H^\circ(T_r)]/T$	$H^\circ-H^\circ(T_r)$	$\Delta_f H^\circ$	$\Delta_f G^\circ$	log K_f
0	0.	0.	INFINITE	−5.681	0.	0.	0.
100	19.744	16.143	63.003	−4.686	0.	0.	0.
200	24.085	31.586	43.756	−2.434	0.	0.	0.
250	24.861	37.049	41.886	−1.209	0.	0.	0.
298.15	25.295	41.471	41.471	0.	0.	0.	0.
300	25.307	41.628	41.472	0.047	0.	0.	0.
350	25.598	45.552	41.781	1.320	0.	0.	0.
400	25.840	48.986	42.471	2.606	0.	0.	0.
450	26.088	52.044	43.368	3.904	0.	0.	0.
500	26.349	54.806	44.376	5.215	0.	0.	0.
600	26.843	59.655	46.530	7.875	0.	0.	0.
700	27.214	63.822	48.709	10.579	0.	0.	0.
800	27.459	67.473	50.831	13.313	0.	0.	0.
900	27.668	70.718	52.864	16.069	0.	0.	0.
1000	27.933	73.647	54.798	18.848	0.	0.	0.
1100	28.281	76.325	56.635	21.659	0.	0.	0.
1200	28.662	78.802	58.380	24.507	0.	0.	0.
1300	28.989	81.110	60.041	27.390	0.	0.	0.
1400	29.202	83.267	61.624	30.301	0.	0.	0.
1500	29.319	85.286	63.135	33.227	0.	0.	0.
1600	29.439	87.182	64.579	36.164	0.	0.	0.
1700	29.688	88.973	65.962	39.119	0.	0.	0.
1800	30.124	90.682	67.288	42.108	0.	0.	0.
1900	30.665	92.325	68.563	45.148	0.	0.	0.
2000	31.191	93.911	69.791	48.240	0.	0.	0.
2100	31.713	95.445	70.976	51.386	0.	0.	0.
2200	32.252	96.933	72.122	54.584	0.	0.	0.
2300	32.828	98.379	73.233	57.837	0.	0.	0.
2400	33.459	99.789	74.310	61.151	0.	0.	0.
2500	34.167	101.169	75.357	64.532	0.	0.	0.
2600	34.970	102.525	76.376	67.988	0.	0.	0.
2700	35.890	103.861	77.369	71.530	0.	0.	0.
2800	36.946	105.185	78.339	75.170	0.	0.	0.
2900	38.158	106.502	79.287	78.924	0.	0.	0.
3000	39.546	107.819	80.216	82.808	0.	0.	0.
3100	41.130	109.141	81.128	86.840	0.	0.	0.
3200	42.930	110.474	82.024	91.041	0.	0.	0.
3258.000	44.080	111.256	82.538	93.564	CRYSTAL <--> LIQUID TRANSITION		
3258.000	41.840	122.480	82.538	130.132			
3300	41.840	123.016	83.049	131.889	0.	0.	0.
3400	41.840	124.265	84.243	136.073	0.	0.	0.
3500	41.840	125.478	85.404	140.257	0.	0.	0.
3600	41.840	126.656	86.534	144.441	0.	0.	0.
3700	41.840	127.803	87.634	148.625	0.	0.	0.
3800	41.840	128.919	88.706	152.809	0.	0.	0.
3900	41.840	130.005	89.751	156.993	0.	0.	0.
4000	41.840	131.065	90.770	161.177	0.	0.	0.
4100	41.840	132.098	91.766	165.361	0.	0.	0.
4200	41.840	133.106	92.738	169.545	0.	0.	0.
4300	41.840	134.091	93.688	173.729	0.	0.	0.
4400	41.840	135.052	94.618	177.913	0.	0.	0.
4500	41.840	135.993	95.527	182.097	0.	0.	0.
4600	41.840	136.912	96.416	186.281	0.	0.	0.
4700	41.840	137.812	97.288	190.465	0.	0.	0.
4800	41.840	138.693	98.141	194.649	0.	0.	0.
4900	41.840	139.556	98.978	198.833	0.	0.	0.
5000	41.840	140.401	99.798	203.017	0.	0.	0.
5200	41.840	142.042	101.391	211.385	0.	0.	0.
5400	41.840	143.621	102.926	219.753	0.	0.	0.
5600	41.840	145.143	104.407	228.121	0.	0.	0.
5778.070	41.840	146.452	105.682	235.572	----- FUGACITY = 1 bar -----		
5800	41.840	146.611	105.837	236.489	−738.755	2.801	−0.025
6000	41.840	148.029	107.220	244.857	−739.225	28.380	−0.247

PREVIOUS: CURRENT. December 1972

IP(Br, g) = 63600 ± 100 cm^{-1}
$S°(298.15\ K)$ = 185.22 $J·K^{-1}·mol^{-1}$

$\Delta_f H°(0\ K)$ = 781.47 $kJ·mol^{-1}$
$\Delta_f H°(298.15\ K)$ = 781.99 $kJ·mol^{-1}$

Electronic Levels and Quantum Weights		
State	ϵ_i, cm^{-1}	g_i
$^4F_{3/2}$	0.00	4
$^4F_{5/2}$	2010.10	6
$^4F_{7/2}$	3963.92	8
$^4F_{9/2}$	5621.04	10

Enthalpy of Formation

The enthalpy of sublimation of tantalum has been derived from 2nd and 3rd law analysis of the vapor pressure data of several investigators. These four studies are based on the Langmuir method.

Source	T/K	Data Points	$\Delta_{sub}H°(298.15\ K)$, $kcal·mol^{-1}$ 2nd law	3rd law	Drift $cal·K^{-1}·mol^{-1}$
[1]	2628–2952	7	190.0 ± 3.0	186.9	−1.1 ± 1.1
[2]	2004–3269	16*	183.0	186.9	1.5
[3]	2637–2854	7	151.9 ± 10.1	182.6	11.2 ± 3.7
[4]	2904–3155	8**	233.1	190.3	−14.2

*Only smooth data was reported, however, 16 refers to the number of experimental determinations.
**Only smooth data reported.

Babeliowsky[5] reported an enthalpy of sublimation value of 168.4 ± 4.0 $kcal·mol^{-1}$. This value is based on mass spectrometric vaporization studies and is calculated by the 2nd law method. Sasaki *et al.*,[6] also using a mass spectrometer, reported an enthalpy of sublimation value of 185.4 ± 0.3 $kcal·mol^{-1}$ as an average value in the range 2550–2770 K. The value chosen for the enthalpy of sublimation which, in this case, is the enthalpy of formation of Ta(g) is 186.9 ± 0.5 $kcal·mol^{-1}$, based on the work of Edwards *et al.*[1] and Langmuir and Malter.[2]

Heat Capacity and Entropy

The electronic levels and quantum weights are obtained from Moore.[7] Although not all levels are listed, all levels given by Moore are used in the calculation. There are predicted electronic levels which have not been observed.[7] These levels are assumed to lie above 20000 cm^{-1} and thus will not significantly affect the entropy at temperatures below 3000 K. The heat capacity and entropy values are very similar to those adopted by Hultgren *et al.*,[8] being identical at 298.15 K and differing by 0.154 $cal·K^{-1}·mol^{-1}$ in $C_p°$ at 6000 K.

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Enthalpy Reference Temperature = T_r = 298.15 K Standard State Pressure = $p°$ = 0.1 MPa

T/K	$C_p°$	$S°$	$-[G°-H°(T_r)]/T$	$H°-H°(T_r)$	$\Delta_f H°$	$\Delta_f G°$	log K_f
	$J·K^{-1}mol^{-1}$			$kJ·mol^{-1}$			
0	0.	0.	INFINITE	−6.200	781.471	781.471	INFINITE
100	20.786	162.504	203.713	−4.121	782.555	767.919	−401.120
200	20.787	176.912	187.123	−2.042	782.381	753.316	−196.746
250	20.802	181.551	185.562	−1.003	782.196	746.071	−155.883
298.15	20.858	185.219	185.219	0.	781.990	739.131	−129.493
300	20.861	185.348	185.219	0.039	781.981	738.865	−128.648
350	21.006	188.573	185.474	1.085	781.754	731.697	−109.200
400	21.259	191.394	186.041	2.141	781.525	724.562	−94.618
450	21.624	193.918	186.778	3.213	781.298	717.455	−83.280
500	22.082	196.219	187.609	4.305	781.080	710.373	−74.212
600	23.183	200.340	189.395	6.567	780.681	696.270	−60.616
700	24.381	204.003	191.225	8.945	780.355	682.229	−50.909
800	25.562	207.336	193.033	11 442	780.119	668.228	−43.631
900	26.676	210.412	194.796	14.055	779.975	654.251	−37.972
1000	27.701	213.276	196.502	16.774	779.916	640.286	−33.445
1100	28.633	215.961	198.150	19.592	779.923	626.323	−29.742
1200	29.470	218.489	199.741	22.498	779.981	612.357	−26.655
1300	30.212	220.878	201.276	25.483	780.082	598.385	−24.043
1400	30.865	223.141	202.757	28.537	780.226	584.403	−21.804
1500	31 437	225.291	204.189	31.653	780.416	570.409	−19.863
1600	31.937	227.336	205.572	34.822	780.648	556.401	−18.165
1700	32.377	229.286	206.910	38.039	780.909	542.378	−16.665
1800	32.768	231.147	208.205	41.296	781.177	528.339	−15.332
1900	33.119	232.929	209.460	44.591	781.433	514.285	−14.139
2000	33.441	234.636	210.676	47.919	781.668	500.219	−13.064
2100	33.739	236.275	211.856	51.278	781.882	486.141	−12.092
2200	34.021	237.851	213.002	54.666	782.072	472.053	−11.208
2300	34.289	239.369	214.116	58.082	782.234	457.958	−10.401
2400	34.548	240.834	215.199	61.524	782.362	443.856	−9.660
2500	34.799	242.249	216.253	64.991	782.449	429.750	−8.979
2600	35.045	243.619	217.279	68.484	782.486	415.641	−8.350
2700	35.287	244.946	218.279	72.000	782.460	401.532	−7.768
2800	35.525	246.234	219.255	75.541	782.360	387.425	−7.227
2900	35.761	247.484	220.207	79.105	782.171	373.323	−6.724
3000	35.994	248.701	221.136	82.693	781.875	359.229	−6.255
3100	36.226	249.885	222.045	86.304	781.454	345.148	−5.816
3200	36.457	251.039	222.933	89.938	780.887	331.082	−5.404
3300	36.688	252.164	223.802	93.595	743.696	317.507	−5.026
3400	36.918	253.263	224.652	97.276	743.192	304.600	−4.680
3500	37.149	254.336	225.485	100.979	742.712	291.707	−4.353
3600	37.381	255.386	226.301	104.706	742.254	278.828	−4.046
3700	37.614	256.413	227.101	108.455	741.820	265.961	−3.755
3800	37.849	257.419	227.886	112.228	741.409	253.106	−3.479
3900	38.085	258.406	228.656	116.025	741.022	240.261	−3.218
4000	38.324	259.373	229.412	119.846	740.658	227.425	−2.970
4100	38.565	260.322	230.154	123.690	740.319	214.599	−2.734
4200	38.810	261.254	230.883	127.559	740.003	201.780	−2.510
4300	39.057	262.171	231.600	131.452	739.713	188.969	−2.296
4400	39.309	263.071	232.305	135.370	739.447	176.164	−2.091
4500	39.566	263.958	232.999	139.314	739.207	163.365	−1.896
4600	39.827	264.830	233.681	143.284	738.992	150.571	−1.710
4700	40.096	265.689	234.353	147.280	738.804	137.781	−1.531
4800	40.371	266.536	235.015	151.303	738.644	124.995	−1.360
4900	40.655	267.372	235.667	155.354	738.511	112.212	−1.196
5000	40.948	268.196	236.309	159.434	738.407	99.432	−1.039
5100	41.251	269.010	236.942	163.544	738.333	86.653	−0.888
5200	41.566	269.814	237.567	167.685	738.289	73.875	−0.742
5300	41.893	270.609	238.183	171.858	738.278	61.098	−0.602
5400	42.235	271.395	238.791	176.064	738.300	48.321	−0.467
5500	42.592	272.173	239.390	180.305	738.358	35.543	−0.338
5600	42.964	272.944	239.983	184.583	738.451	22.764	−0.212
5700	43.354	273.708	240.568	188.899	738.583	9.983	−0.091
5778.070	43.671	274.300	241.020	192.296	----- FUGACITY = 1 bar -----		
5800	43.762	274.465	241.146	193.254	0.	0.	0.
5900	44.189	275.217	241.717	197.652	0.	0.	0.
6000	44 636	275 963	242.281	202.093	0.	0.	0.

PREVIOUS: December 1972 (1 atm) CURRENT December 1972 (1 bar)

Tantalum, Ion (Ta^+) — IDEAL GAS — $M_r = 180.94735$ — Tantalum, Ion (Ta^+) — $Ta^+(g)$

$IP(Ta^+, g) = [130660 \pm 4000]\ cm^{-1}$

$S°(298.15\ K) = 183.38 \pm 0.2\ J \cdot K^{-1} \cdot mol^{-1}$

$\Delta_f H°(0\ K) = 1542.3 \pm 2\ kJ\ mol^{-1}$

$\Delta_f H°(298.15\ K) = [1549.150]\ kJ\ mol^{-1}$

Electronic Levels and Quantum Weights		
State	ϵ_i, cm^{-1}	g_i
$^5F_1$	0.00	3
$^5F_2$	1031.33	5
$^5F_3$	2642.19	7
$^5F_4$	4415.70	9
$^5F_5$	6186.72	11

Enthalpy of Formation

$\Delta_f H°(Ta^+, g, 0\ K)$ is calculated from $\Delta_f H°(Ta, g, 0\ K)$[1] using the spectroscopic value of $IP(Ta) = 63600 \pm 100\ cm^{-1}$ ($760.825 \pm 1.20\ kJ \cdot mol^{-1}$) from Moore.[2] The ionization limit is converted from cm^{-1} to $kJ \cdot mol^{-1}$ using the factor, $1\ cm^{-1} = 0.01196266\ kJ \cdot mol^{-1}$, which is derived from the 1973 CODATA fundamental constants.[3] Rosenstock *et al.*[4] and Levin and Lias[5] have summarized additional ionization and appearance potential data.

$\Delta_f H°(Ta^+, g, 298.15\ K)$ is calculated from $\Delta_f H°(Ta, g, 0\ K)$ by using IP(Ta) with JANAF[1] enthalpies, $H°(0\ K) - H°(298.15\ K)$, for Ta(g), $Ta^+(g)$, and e^-(ref). $\Delta_r H°(Ta \rightarrow Ta^+ + e^-, 298.15\ K)$ differs from a room temperature threshold energy due to inclusion of these enthalpies and to threshold effects discussed by Rosenstock *et al.*[4] $\Delta_f H°(298.15\ K)$ should be changed by $-6.197\ kJ \cdot mol^{-1}$ if it is to be used in the ion convention that excludes the enthalpy of the electron.

Heat Capacity and Entropy

The information on electronic energy levels and quantum weights, given by Moore,[2] is incomplete because many theoretically predicted levels have not been observed. Although we have only a few of the atomic energy levels for $Ta^+(g)$, all levels listed by Moore[2] as well as estimated levels, are used in the calculation. The observed levels are too numerous to list completely. The calculations indicate that for $Ta^+(g)$, the thermodynamic functions are independent of the estimated missing levels (for n=6), and the cut-off procedure up to 6000 K, the Gibbs energy function showing no significant variations at this temperature. The reported uncertainty is $S°(298.15\ K)$ is due to uncertainties in the relative ionic mass, and the fundamental constants. Extension of these calculations above 6000 K may require consideration of the higher excited states (n>6), and use of different fill and cut-off procedures.[6]

References

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Enthalpy Reference Temperature = T_r = 298.15 K — *Standard State Pressure = $p°$ = 0.1 MPa*

	$J \cdot K^{-1} \cdot mol^{-1}$			$kJ \cdot mol^{-1}$			
T/K	$C_p°$	$S°$	$-[G°-H°(T_r)]/T$	$H°-H°(T_r)$	$\Delta_f H°$	$\Delta_f G°$	log K_f
0	0.	0.	INFINITE	-6.338	1542.296		
100	20.787	160.112	202.703	-4.259			
200	21.242	174.589	185.431	-2.168			
250	22.067	179.411	183.759	-1.087			
298.15	23.109	183.385	183.385	0.	1549.150	1500.584	-262.896
300	23.151	183.528	183.385	0.043	1549.185	1500.283	-261.222
350	24.256	187.181	183.671	1.228	1550.136	1492.057	-222.677
400	25.237	190.485	184.320	2.466	1551.128	1483.693	-193.750
450	26.048	193.506	185.175	3.749	1552.152	1475.203	-171.237
500	26.708	196.286	186.149	5.069	1553.200	1466.597	-153.214
600	27.734	201.251	188.262	7.793	1555.342	1449.076	-126.153
700	28.581	205.591	190.434	10.610	1557.534	1431.192	-106.797
800	29.369	209.459	192.575	13.507	1559.776	1412.991	-92.259
900	30.120	212.962	194.648	16.482	1562.074	1394.506	-80.935
1000	30.818	216.172	196.642	19.530	1564.420	1375.762	-71.862
1100	31.441	219.139	198.554	22.643	1566.802	1356.781	-64.428
1200	31.971	221.899	200.386	25.815	1569.205	1337.582	-58.223
1300	32.399	224.475	202.141	29.034	1571.619	1318.182	-52.965
1400	32.725	226.889	203.824	32.291	1574.044	1298.596	-48.451
1500	32.956	229.155	205.438	35.576	1576.481	1278.836	-44.533
1600	33.103	231.287	206.987	38.880	1578.926	1258.914	-41.099
1700	33.181	233.297	208.476	42.194	1581.365	1238.838	-38.065
1800	33.204	235.194	209.908	45.514	1583.774	1218.620	-35.363
1900	33.188	236.989	211.287	48.834	1586.133	1198.269	-32.943
2000	33.145	238.690	212.615	52.151	1588.435	1177.795	-30.761
2100	33.085	240.306	213.895	55.462	1590.680	1157.208	-28.784
2200	33.017	241.844	215.131	58.767	1592.866	1136.515	-26.984
2300	32.947	243.310	216.325	62.066	1594.989	1115.724	-25.339
2400	32.881	244.710	217.478	65.357	1597.045	1094.842	-23.829
2500	32.821	246.051	218.595	68.642	1599.028	1073.876	-22.437
2600	32.768	247.338	219.676	71.921	1600.930	1052.832	-21.152
2700	32.724	248.574	220.723	75.196	1602.742	1031.716	-19.960
2800	32.689	249.763	221.739	78.467	1604.450	1010.535	-18.852
2900	32.660	250.910	222.725	81.734	1606.042	989.296	-17.819
3000	32.639	252.016	223.683	84.999	1607.502	968.003	-16.854
3100	32.623	253.086	224.615	88.262	1608.812	946.665	-15.951
3200	32.610	254.122	225.521	91.524	1609.951	925.286	-15.104
3300	32.601	255.125	226.403	94.784	1574.442	904.346	-14.315
3400	32.594	256.098	227.262	98.044	1575.596	884.023	-13.581
3500	32.586	257.043	228.099	101.303	1576.750	863.666	-12.890
3600	32.579	257.951	228.916	104.561	1577.903	843.276	-12.236
3700	32.569	258.853	229.713	107.818	1579.055	822.853	-11.617
3800	32.558	259.722	230.492	111.075	1580.206	802.400	-11.030
3900	32.544	260.567	231.252	114.330	1581.355	781.917	-10.473
4000	32.527	261.391	231.995	117.584	1582.504	761.404	-9.943
4100	32.506	262.194	232.722	120.835	1583.650	740.862	-9.439
4200	32.482	262.977	233.433	124.085	1584.794	720.292	-8.958
4300	32.453	263.741	234.129	127.331	1585.935	699.695	-8.500
4400	32.421	264.487	234.811	130.575	1587.074	679.072	-8.062
4500	32.386	265.215	235.478	133.816	1588.209	658.423	-7.643
4600	32.347	265.926	236.132	137.052	1589.340	637.748	-7.242
4700	32.305	266.622	236.774	140.285	1590.467	617.049	-6.858
4800	32.260	267.301	237.403	143.513	1591.590	596.327	-6.489
4900	32.212	267.966	238.020	146.737	1592.708	575.580	-6.136
5000	32.163	268.616	238.625	149.955	1593.821	554.811	-5.796
5100	32.112	269.253	239.219	153.169	1594.930	534.020	-5.469
5200	32.060	269.876	239.803	156.378	1596.033	513.207	-5.155
5300	32.008	270.486	240.376	159.581	1597.131	492.373	-4.853
5400	31.955	271.084	240.939	162.779	1598.224	471.518	-4.561
5500	31.904	271.670	241.493	165.972	1599.311	450.644	-4.280
5600	31.853	272.244	242.037	169.160	1600.394	429.749	-4.009
5700	31.805	272.807	242.572	172.343	1601.471	408.835	-3.747
5800	31.758	273.360	243.098	175.521	863.789	390.703	-3.519
5900	31.715	273.903	243.615	178.695	864.644	382.539	-3.387
6000	31.675	274.435	244.125	181.864	865.451	374.361	-3.259

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EA(Ta, g) = 0.322 ± 0.012 eV
$S°$(298.15 K) = 174.560 ± 0.002 J·K^{-1}·mol^{-1}

$\Delta_f H°$(0 K) = 750.403 ± 1.5 kJ·mol^{-1}
$\Delta_f H°$(298.15 K) = [744.941] kJ·mol^{-1}

Electonic Levels and Quantum Weights		
State	ϵ_i, cm^{-1}	g_i
$^5D_0$	0	1
$^5D_1$	1070	3
$^5D_2$	2240	5

Enthalpy of Formation

$\Delta_f H°(Ta^-, g, 0 K)$ is calculated from $\Delta_f H°(Ta, g, 0 K)$[1] using the adopted electron affinity of EA(Ta) = 0.322 ± 0.012 eV (31.068 ± 1.158 kJ·mol^{-1}). This value, recommended by Hotop and Lineberger,[2] is based on a laser photodetachment electron spectrometry study.[3] Additional information on Ta^-(g) may be obtained in the critical discussions of Hotop and Lineberger,[2,4] Rosenstock *et al.*[5] and Massey.[6]

$\Delta_f H°(Ta^-, g, 298.15 K)$ is obtained from $\Delta_f H°(Ta, g, 0 K)$ by using EA(Ta) with JANAF[1] enthalpies, $H°(0 K)-H°(298.15 K)$, or Ta^-(g), Ta(g), and e^-(ref). $\Delta_r H°(Ta^- \rightarrow Ta + e^-, 298.15 K)$ differs from a room-temperature threshold energy due to inclusion of these enthalpies and to threshold effects discussed by Rosenstock *et al.*[5] $\Delta_f H°(298.15 K)$ should be changed by + 6 197 kJ·mol^{-1} if it is to be used in the ion convention that excludes the enthalpy of the electron.

Heat Capacity and Entropy

The ground state electronic configuration for Ta^-(g) is given by Hotop and Lineberger,[2,4] Rosenstock *et al.*,[5] and Massey.[6] The fine structure separation has been calculated by an isoelectronic extrapolation of ratios of fine structure separations[3] and is that recommended by Hotop and Lineberger.[2]

References

[1]JANAF Thermochemical Tables: Ta(g), 12–31–72; e^-(ref), 3–31–82.
[2]H. Hotop and W. C. Lineberger, J. Phys. Chem. Ref. Data, 14, 731 (1985).
[3]C. S. Feigerle, R. R. Corderman, S. V. Bobashev, and W. C. Lineberger, J. Chem. Phys. 74, 1580 (1981).
[4]H. Hotop and W. C. Lineberger, J. Phys. Chem. Ref. Data 4, 539 (1975).
[5]H. M. Rosenstock, K. Draxl *et al.*, J. Phys. Chem. Ref. Data 6, Supp. 1, 783 pp. (1977).
[6]H. S. W. Massey, "Negative Ions", 3rd ed., Cambridge University Press, Cambridge, 741 pp. (1976).

Enthalpy Reference Temperature = T_r = 298.15 K Standard State Pressure = $p°$ = 0.1 MPa

T/K	$C_p°$ (J·K^{-1}·mol^{-1})	$S°$ (J·K^{-1}·mol^{-1})	$-[G°-H°(T_r)]/T$ (J·K^{-1}·mol^{-1})	$H°-H°(T_r)$ (kJ·mol^{-1})	$\Delta_f H°$ (kJ·mol^{-1})	$\Delta_f G°$ (kJ·mol^{-1})	log K_f
0	0.	0.	INFINITE	−6.416	750.403		
100	20.787	150.978	194.351	−4.337			
200	21.456	165.484	176.691	−2.241			
250	22.780	170.401	174.954	−1.138			
298.15	24.558	174.560	174.560	0.	744.941	711.515	−124.654
300	24.632	174.712	174.561	0 045	744.901	711.308	−123.850
350	26.631	178.660	174.868	1.327	743.870	705.791	−105.334
400	28.486	182.340	175.575	2.706	742.924	700.417	−91.465
450	30.041	185.788	176.520	4.171	742.051	695.157	−80.692
500	31.236	189.018	177.610	5.704	741.234	689.991	−72.083
600	32.583	194.852	180.009	8.906	739.697	679.888	−59.189
700	32.816	199.904	182.499	12.184	738.192	670.038	−49.999
800	32.336	204.261	184.954	15.446	736.642	660.407	−43.120
900	31.479	208.022	187.313	18.638	735.000	650.975	−37.782
1000	30 476	211.288	189.551	21.737	733.240	641.732	−33.521
1100	29 464	214.145	191.660	24.733	731.348	632.672	−30.043
1200	28.511	216.667	193.641	27.631	729.320	623.790	−27.153
1300	27.649	218.914	195.500	30.439	727.165	615.082	−24.714
1400	26.885	220.935	197.246	33.164	724.902	606.545	−22.630
1500	26.216	222.766	198.887	35.819	722.551	598.172	−20.830
1600	25.633	224 439	200.432	38.411	720.127	589.959	−19.260
1700	25 127	225.977	201.890	40.948	717.631	581.900	−17.880
1800	24.688	227.401	203.269	43.438	715.053	573.989	−16.657
1900	24.306	228.725	204.574	45.887	712.384	566.225	−15.567
2000	23.972	229.963	205.813	48.301	709.626	558.603	−14.589
2100	23.680	231.126	206.991	50.683	706.785	551.122	−13.708
2200	23.424	232.221	208.113	53.038	703.863	543.777	−12.911
2300	23.199	233.258	209.184	55.369	700.862	536.568	−12.186
2400	23.000	234.241	210.208	57.679	697.779	529.490	−11.524
2500	22.823	235.176	211.188	59.970	694.611	522.543	−10.918
2600	22.666	236.068	212.128	62.244	691.351	515.724	−10.361
2700	22.525	236.921	213.030	64.504	687.990	509.033	−9.848
2800	22.399	237.737	213.898	66.750	684.517	502.468	−9.374
2900	22.286	238.521	214.734	68.984	680.918	496.029	−8.934
3000	22.184	239.275	215.539	71.207	677.180	489.717	−8.527
3100	22.091	240.001	216.317	73.421	673.283	483.532	−8.147
3200	22.008	240.701	217.068	75.626	669.208	477.476	−7.794
3300	21.931	241.377	217.794	77.823	628.478	472.020	−7.471
3400	21.862	242.031	218.498	80.012	624.405	467.340	−7.180
3500	21.799	242.664	219.179	82.195	620.325	462.780	−6.907
3600	21.740	243.277	219.840	84.372	616.239	458.337	−6.650
3700	21.687	243.872	220.482	86.543	612.148	454.007	−6.409
3800	21.638	244.449	221.105	88.710	608.052	449.787	−6.183
3900	21.593	245.011	221.711	90.871	603.951	445.676	−5.969
4000	21.551	245.557	222.300	93.028	599.845	441.670	−5.768
4100	21.512	246.089	222.874	95.182	595 736	437.766	−5.577
4200	21.476	246.607	223.433	97.331	591.623	433.963	−5.397
4300	21.443	247.112	223.977	99.477	587.506	430.258	−5.227
4400	21 412	247.604	224.509	101.620	583.386	426.649	−5.065
4500	21.383	248.085	225.027	103.759	579.263	423.133	−4.912
4600	21.356	248.555	225.534	105.896	575.138	419.709	−4.766
4700	21.331	249.014	226.029	108.031	571.009	416.375	−4.627
4800	21.307	249.463	226.512	110.163	566.879	413.128	−4.496
4900	21.285	249.902	226.985	112.292	562.746	409.968	−4.370
5000	21.264	250.332	227.448	114.420	558.610	406.892	−4.251
5100	21.245	250.752	227.900	116.545	554.473	403.898	−4.137
5200	21.227	251.165	228.344	118.669	550.334	400.986	−4.028
5300	21.209	251.569	228.778	120.790	546.193	398.154	−3.924
5400	21.193	251 965	229.204	122.911	542.051	395.399	−3.825
5500	21.178	252.354	229.621	125.029	537.907	392.722	−3.730
5600	21.163	252.735	230.031	127.146	533.761	390.120	−3.639
5700	21.149	253.110	230.432	129.262	529.614	387.591	−3.552
5800	21.136	253.478	230.827	131.376	−213.289	387.937	−3.494
5900	21.124	253.839	231.214	133.489	−217.652	398.340	−3.527
6000	21.112	254.194	231.594	135.601	−222.060	408.818	−3.559

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