Ar = 50.9415 Vanadium (V)

 $\Delta_t H^{\circ} = 0 \text{ kJ·mol}^{-1}$ Δ_tH°(298.15 K) = 0 kJ·mol⁻¹ $\Delta_{\text{los}}H^{\circ} = 22.84 \pm 6.28 \text{ kJ} \cdot \text{mol}^{-1}$

CRYSTAL

Vanadium (V)

 $S^{\circ}(298.15 \text{ K}) = 28.936 \pm 0.42 \text{ J·K}^{-1} \cdot \text{mol}^{-1}$ T_{frs} = 2190 ± 20 K

Enthalpy of Formation Zero by definition,

Heat Capacity and Entropy

The heat capacity values for temperatures below 10 K are those chosen by Hultgren et al. A graphical integration yeilds \$^(10 K) = 0.0253 cal·K -1 mol -1 and H^(10 K)-H^(0 K) = 0.147 cal·mol -1. The adopted heat capacity values for 10 \(\le \tau \) \(\le \tau \) 320 K are obtained graphically, based on the following three work

	Purity of Vanadium	reported ≥ 99.5% 99.5%; remainder oxygen 99.8%; metallic immuries <0.08%.
	T/K	54-297 10-274 25-340
	Year	1936 1960 1961
unce works.	Source	~ ~ *

due to the oxygen impurity in the variadium sample used by Clusius et al.³ In order to effect a smooth joining of the C_{ss} values, a graphical representation of C_s (lattice) T^3 versus T for the Hultgren et al.¹ data and the Clusius et al.³ data was used to derive adjusted C_s values. The three data sets²⁻⁴ are in reasonably good agreement; two sets²⁻⁴ lie predominantly above the adopted values while the remaining set ³ lies below. Above 100 K, the three data sets differ from the adopted C_s values by roughly 1%, with the difference decreasing as T increases. The low temperature (T < 50 K) results of Clusius et al. 3 do not join smoothly with the values adopted for T < 10 K. This mismatch is in part

For the region 320 $\leq T \leq 2190$, there are four works upon which the adopted C° values are based.

Purity of Vandadium	99.74% reported as "purest" 0.1%C, 0.07, 0.03%N 0.06% total impurities
TK	320-1800 565-1928 488-1486 1989-2284
Method	G; drop drop levitation
Year	1965 1934 1962 1971
Source	N 40 F 40

950-1300 K; and 7% lower above 1600 K. The results of Golutvin and Kozlowskaya's show considerable scatter and lie roughly 2-10% above the tabulated enthalpy values. The enthalpy data of Jacger and Veenstra's do not join smoothly with that of Berezin et al.'s In the region to 308 cal-mol⁻¹ or from 1.0% to 2.6%. The enthalpy at 2190 K (T_m) is very close to that which is obtained from a linear fit of the Berezin et al. 8 data. Whereas the two sets of data ^{6,8} separately indicate a C_p value near T_m to be at least 11 cal·K⁻¹-mol⁻¹, the compromise yields The heat capacity values reported by Kohlhaas et al. ⁵ are 1-2% lower than the adopted values below 950 K; 0.3% higher in the region 1500-2000 K the adopted enthalpy values are a compromise between the latter two sets of data. Below roughly 1100 K the adopted enthalpy and that reported by Jæger and Veenstra's differ at most by ±15 cal·mol⁻¹. From 1300-1800 K the difference increases from 70 cal·mol⁻¹ 10.5 cal·K-1·mol-1

Fusion Data

Refer to the liquid for details.

Tansition Data

The literature indicates differences in opinion as to the possibility of a transition in the region 175-325 K and near 1825 K. Although there are no detailed enthalpy measurements in the 1825 K region, Barnes' used field-electron emission techniques to show that an allotropic trasformation does not occur in vanadium in this region if the samples are of high purity. Earlier work concerning a possible transition in this regilon was referenced by Barnes.

Documentation exists in the literature as to the observation of anomalies in the temperature dependence of some physical properties of vanadium in the range 175-325 K. Although the anomaly was attributed by different workers to an antiferromagnetic transition, a small distortion of the body-centered cubic crystal structure, and impurities, Kinkel' et al. 10 recently ascribed the anomaly to a second order phase transition at 230 K. Using low temperature x-ray diffraction techniques in the study of a single crystal of vanadium, Kinkel' et al. 10 observed a decrease in crystal lattice symmetry form body-centered cubic (T > 230 K) to tetragonal (T < 230 K). Nevertheless, Crangle and Smith 11 measured the specific heat of polycrystalline vanadium and confirmed the results of Clusius et al. that no appreciable anomaly in C, exists In vanadium between 175 and 265 K. We do not adopt a AC, or A,H value in the two previously mentioned regions.

T.K. ⁻¹ mod ⁻¹ W1mod ⁻¹ H1mod ⁻¹							_			_	_		_		_			_				_		-		_		-					_			_	-		 	 -	-
H*-H*(T;) -4.151 -4.151 -4.151 -2.1151 -1.171 0. 0.046 1.312 2.511 3.932 1.576	log K,	log K,	log K,	ć	; e	.	o c	3	oʻ	•	3 0	.	o	oʻ	oʻ	c	ċ	ċ	ic	d	ic	i c	ċc	d c	d C	ic	i c	i d	Ġ	Ö	ď	•	200	-0.05	900	-0.068	4800	-0.102			
H*-H*(T;) -4.151 -4.151 -4.151 -2.1151 -1.171 0. 0.046 1.312 2.511 3.932 1.576	₽ Q•	Φ_{G}	₽G•	c	ď	.	o c	j	ó	c	s c	.	6	oʻ	oʻ	ď	c	c	Ċ	ic	٠ .	d c	d c	d c	đ	; c	ic	ó	Ö	ó	ď	į		151	201	3.236	4750	525			
H*-H'(T,) -4.151 -4.151 -4.151 -1.171 0.0 0.046 1.312 2.511 2.511 2.521 1.552 1.556 2.223 2.566 3.560	J.C.mol⁻¹ A.H.*	$\Delta_t H^{\bullet}$	$\Delta_i H^{\bullet}$	c	si c	.	o c	;	oʻ	c	; c	.	o' o	o'	oʻ	o	Ö	c	Ö	ó		ic	i c	ć	ď	c	ó	o'	0	ď	oʻ	CRYSTAI	÷	-22.954	-22.853	-22.559	-22 073	-21.395			
New Year	H*-H*(T.)	$H^{\bullet}-H^{\bullet}(T_{\bullet})$	$H^*-H^*(T_i)$	-4640	15.1	-2 215	- 25	:	oʻ	0.046	1313	777	7,011	3.932	5271	7.993	10,768	13,602	16.504	19.476	22 523	25.656	28.882	32.210	35.640	39.173	42,817	46.577	50.464	54.485	58.652	62.547	62.991	67.520	77.242	77.156	82.263	87.561			
1. K ⁻¹ mol ⁻¹ 2 [G ² 3. 7 [G ² 3. 7. 1. 185 3. 7. 1. 185 3. 7. 1. 185 3. 7. 1. 185 3. 7. 1. 185 3. 7. 1. 185 3. 7. 1. 185 5. 5. 185 5. 5.	-H*(T,)]/T	-H*(T,)]/T	T((,T)'H-	INFINITE	\$ 60.	31 133	29.340	2000	28.936	28.936	20 243	20023	20.62	20.033	31.830	34 032	35.247	38.411	40.493	42.485	44,389	46.210	47.955	49,630	51.244	52.800	\$4,306	55.765	57.182	58.562	59.908	61.093	61.223	62.512	63.77	65.021	66.247	67.456			
0.0 1.119 1.170 1.17				ó	7.185	19.558	24.655	2000	28,936	29.090	32,992	35,450	20.47	176	45737	47.353	\$1.630	55.413	58.830	19619	64.864	67.590	20.172	72,638	75,004	77.283	79.492	81.641	83.742	85,805	87.837	89.653	89.856	91.869	93.878	95.884	97.886	99.886			
10 und a addaga nagas www.www. www.w. 4 4 4448 22	្រ	೮	3	ö	13,119	21.876	23.703	34006	24.890	24.928	25.681	26.234	26610	26046	70747	27.489	28.033	28.660	29.372	30.083	30.878	31.798	32.740	33.807	34.811	35.857	37.028	38,200	39.539	40.920	42.468	44.141	44.329	46.254	48.179	50.103	52.028	53.932			
7.K 0 100 200 200 200 450 450 650 650 650 650 650 650 650 6	7.K	X.	4	0	8	202	82	300	298.15	8	350	604	Ş	\$	3	8	8	8	8	8	1100	1200	1300	1400	1500	1600	200	0 2 3	8	2000	2100	2190,000	2200	2300	2400	2500	2600	2200			

PREVIOUS:

Vanadium (V)

V₁(cr)

CURRENT: June 1973

Continued on page 1924

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 $S^{\circ}(298.15 \text{ K}) = [36.136] \text{ J·K}^{-1} \cdot \text{mol}^{-1}$ r_{bs} = 2190 ± 20 K

LIQUID

Vanadium (V)

Enthalpy of Formation

 $H^{\circ}(2190)$ + $H^{\circ}(2298.15 \text{ K})$, between the crystal and liquid. Refer to V(g) table for an additional $\Delta_t H^{\circ}(298.15 \text{ K})$ value as derived frefusion–mass spectrometric work. The enthalpy of formation of V(I) at 298.15 K is calculated from that of the crystal by adding \$\Delta_{tos}H^2\$ and the difference in entha

Heat Capacity and Entropy

Enthalpy data in the liquid phase have been reported by Treverton and Margrave¹ and Berezin et al. Using levitation calorimetry. Trever and Margrave¹ determined the enthalpy of V(I) in the range 2205-2638 K. They reported a least squares analysis of the enthalpy data in form H°(T)-H°(298.15 K) = 11.6527T - 5837.7 where T is in Kelvins and the enthalpy difference is in cal mol-1 The standard deviation measured enthalpies in the region 1990–2325 K. For the liquid region their data were represented by H*(T)-H*(298.15 K) = 11.043T - 37 with a standard deviation of ±90 cal·mol⁻¹. These two works agree remarkably well for the C, value of V(I). In the measured enthalpy regine Treverton and Margrave data! Its lower than the Berezin et al. data² by roughly 600–700 cal·mol⁻¹. The two linear representations of data intersect at 3380 K. We adopt the enthalpy values of Berezin et al. 2 since this work contains enthalpy data surrounding the melting po the experimental points from the calculated values was ± 167 cal mol-1 Berezin et al. 2 also used a form of levitation calorimetry and a T_{lus} value which is our adopted value.

Fusion Data

The adopted value of the enthalpy of fusion, $\Delta_{los}H^\circ = 5.46 \pm 1.50 \, \mathrm{kcal \cdot mol}^{-1}$ is based on the work by Berezin et al.² The actual value calculated by taking the difference in the adopted value of H°(2190) -H°(298 15 K) for V(I) and V(cr). Refer to the heat capacity discussi in the tables for V(cr) and V(l).

Preliminary results of experiments by Berezin et al.² indicated that T_{bs} for 99 96% pure vanadium was close to 2190 K. Representati values of T_{irs} reported in the literature are tabulated below.

We adopt $T_{tat} = 2190 \pm 20$ K principally since it is consistent with the work upon which $\Delta_{tas}H^o$ is based. The adopted T_{tas} value is all suggested by Charlesworth in his compilation of elemental melting points.

Vaporization Data

The vaporization of V(I) was studied by Farber and Srivastava. ORefer to V(g) table for details. Kant and Lin, using a combination effusion and mass-spectrometric techniques, reported the ratio of observed ion intensities relating to V4g) and V(g) and corresponding contribution of V₂(g) in the vapor phase may be neglected. Linearly extrapolating these data to T₁₄₀, the V₂ partial pressure is of the ord the vaporization of vanadium in the range 2060-2316 K. This ratio is of the order of 10° which suggests that at least in this region of 105 smaller than the V partial pressure.

 Γ_{np} is calculated as the temperature at which the Gibbs energy change for the reaction V(1) o V(g) is zero. The difference between $\Delta_H^0(g)$ g) and $\Delta_H^0(V, I)$ at T_{vap} is $\Delta_{vap}H^0$. The uncertainty in T_{vap} is probably of the order of ± 50 K.

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 M. Farber and R. D. Srivastava, J. Chem. Soc., Faraday Trans. 169, 390 (1973).

$\Delta_t H^{\circ}(298.15 \text{ K}) = [17.288] \text{ kJ} \cdot \text{mol}^{-1}$	Enthalpy Re	ference To	emperature =	Enthalpy Reference Temperature = T, = 298.15 K		Standard Stat	Standard State Pressure = p = 0.1 MPa	- 0.1 MPa
Δ _{fus} H ^o = 22.84 ± 6.28 kJ·mol ⁻¹	7/K	1 8		mol-1	H*-H*T	_ki.mol ⁻¹	;	7 2
		\$	2	10(41) 11-	(r) u- u	Ş	ş	
Δ _{1ω} H and the difference in enthalpy H°(298.15 K) value as derived from	,588 8							
	298.15	24.896	36.136	36.136	ď	17.288	15.141	-2.653
Isino levitation calorimetry. Treverton	8 S	24.928 25.681	36.290 40.192	36.137 36.443	0.046	17.288	15.128	-2.634 -2.204
es analysis of the enthalpy data in the	2 2	26.234 26.610	43.659	37.132 38.033	3.932	17.288	14.408	-1.881
n cal mol-1 The standard deviation of	92	26.945	49.592	39.050	5.271	17.288	13.688	-1.430
a form of levitation calorimetry and	88	27 489 28.033	54.553 58.830	41.232 43.447	7.993 10.768	17.288	12.968	-1.129
(1) –H $(298.13 K) = 11.043I = 3776$, V(I) In the measured enthalm; region	000	28.660	62.613	45.611	13.602	17.288	11.528	-0.753
The two linear representations of the	88	30.083	69.161	49.685	19.476	17.288	10.808 10.088	-0.527
lpy data surrounding the melting point	200	30.878	72.064	51.589	22.523	17.288	9.368	-0.445
	1400	32.740	77.372	55.155	32.210	17.288	7.928	-0319
by Berezin et al. ² The actual value is	1450,000	34,304 46,204	81.033 81.033	57.645 57.645	33.913	~	V	
. Refer to the heat capacity discussion	1500	46.204	82.599	58.451	36.223	17.871	6.478	-0.226
4 7 0010 00 0010 0000	95 95 95	46.204 46.204	85.581 88.382	60.054	40.844	18.959	5.682	-0.185
was trose to 2150 h. nepresentative	00 08 12 13 13 13 13 13 13 13 13 13 13 13 13 13	46.204 46.204	91.023	63.199 64.729	50.084 54.705	20.795	3.907 2.948	-0.113
	2002	46.204	95.891	66.229	59.325	22.128	1.954	-0.051
	2190,000	46204	100.085	68.987	88.104	CRYSTAL	U.SS4	270.0- 10 CI
	2200	46.204	100.295	69.129	68.566	o		
	252 252 268 268 268 268 268 268 268 268 268 26	4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	104.315	71.896	73.186	ರರಂ	ರರಂ	ರ ರ ರ
	2600	46.204	108.014	74.534	87.048	ံ ဝံ	i ဝ	် ဝံ
	2800 2800	46.204 46.204	109.757	75.806 77.049	91.668 96.288	ರ ರ	ರರ	o o
	3000 3000	46.204 46.204	113.059	78.263 79.449	105.529	ರ ರ	00	00
based. The adopted $T_{\rm fix}$ value is also	3100	46.204	116.141	80.608	110.150	0.0	0'0	6,0
	3300	46.204	119.029	82.850	119.390	ರ ರ	ಶ ರ	ಶ ರ
	350	46.204 46.204	120.409	83.935 84.996	124.011	ರ ರ	ರ ರ	0 0
ant and Lin, using a combination of	3600	46.204	123 049	86.035	133.251		ö	ő
Vz(g) and V(g) and corresponding to	3690.080	46.204	124.191	86.953	ı	FUG/	FUGACITY - 1 bar	
ggests that at least m this region the	3808	46.204	125.548	88.050		-446.807 -445.120	13286	-0.017
ue v2 partial pressure is of the order	\$ \$	46.204	126.748	89.027 89.984	147.113 151.733	-443.485 -441.901	25.328 37.329	-0.339
zero. The difference between $\Delta_i H^{\circ}(V)$,	4100 4200	46.204 46.204	129.058 130.172	90.923 91.845	156.353	-440.370 -438.894	49.290	-0.628
	4 4 9 9 9	46.204	131,259	92.749		-437.472	73.106	-0.888
	4500	46.204	133,360	94.507		-434.795	96.792	-1.124
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Vanadium (V)

V ₁ (cr,l)	

AG* 16 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	:		J·K 'mol'	J·K-'mol-'		Ki-mol-1		
0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0	<i>T.</i> K	೮		H'(T,))T	$H^{\bullet-}H^{\bullet}(T_{\bullet})$	$\Delta_i H^{\bullet}$	Φ_G	log Kr
13.119	0	ö	0	INFINITE	-4.640	o'	o'	o'
21,773 24,655 29,340 -1,171 0 0 24,886 28,956 0 0 0 0 24,886 29,243 1312 0 0 0 25,681 39,571 31,829 29,243 1312 0 0 26,610 39,571 31,829 29,243 1312 0 0 26,610 39,571 31,829 29,243 2,811 0 0 26,620 39,571 31,829 29,271 0 0 0 28,033 41,329 25,271 0 0 0 0 28,033 41,349 13,240 0 0 0 0 29,372 41,441 11,078 0 0 0 0 29,372 41,441 11,078 0 0 0 0 31,287 41,439 21,241 11,078 0 0 0 31,781 44,389	88	13.119	19.558	31.133	-4.151 -2.315	0 0	င် င	ာ် ဝ
24.85 28.95 0.0 0.0 24.85 28.95 0.046 0.0 24.928 28.95 0.046 0.0 26.234 32.49 32.97 0.046 0.0 26.24 36.49 32.92 2.211 0.0 0.0 26.24 36.49 31.87 3.271 0.0 0.0 26.24 36.49 31.87 3.271 0.0 0.0 26.24 31.87 3.271 0.0 0.0 0.0 28.26 40.431 31.87 0.0 0.0 0.0 28.26 40.431 11.867 0.0 0.0 0.0 30.083 46.210 12.873 0.0 0.0 0.0 0.0 31.77 46.210 12.873 0.0<	250	23.703	24.655	29.340	-1.17	0	o	oʻ
14,253 12,900 12,6214 12,6214 12,6214 12,6215	298.15	24.896	28.936	28.936	Ö	o	ó	o
26.204 3.25.2 1.25.2 1.51.1 0.0 0.0 26.6010 39.571 30.833 2.511 0.0 0.0 26.6010 39.571 31.850 5.271 0.0 26.6010 39.571 31.850 5.271 0.0 28.600 35.471 31.850 5.271 0.0 28.600 35.471 31.850 5.271 0.0 28.600 35.471 31.850 0.0 28.600 35.471 38.411 13.602 0.0 29.577 38.820 40.433 10.504 0.0 29.577 38.820 40.433 10.504 0.0 29.577 30.820 0.0 20.602 31.702 31.800 39.173 0.0 20.602 31.702 31.800 39.173 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 31.800 31.800 0.0 20.602 31.800 0.0 20.602 31.800 31.800 0.0 20.602 31.8	8	24.928	29,090	28.936	0.046	o' c	oʻ oʻ	o' o
2.6.610 39.571 30.813 3.932 0. 1.6.945 47.372 31.830 5.771 0. 0. 2.8.033 51.630 36.247 10.788 0. 0. 0. 2.8.033 51.630 36.247 10.788 0. 0. 0. 0. 2.9.377 58.820 40.483 16.504 0. </td <td>900</td> <td>26.234</td> <td>36.459</td> <td>29.932</td> <td>2611</td> <td>ď</td> <td>o d</td> <td>ó</td>	900	26.234	36.459	29.932	2611	ď	o d	ó
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318.07 31	200	31.798	67.590	46.210	25.656	oʻ c	o c	0 0
34811 75004 51244 35640 0. 0. 35877 77283 22800 42817 0. 0. 39200 81541 53765 42817 0. 0. 40200 81542 53765 42817 0. 0. 42468 87877 5908 38.652 0. 0. 42468 87837 5908 38.652 0. 0. 42468 87837 5908 38.652 0. 0. 42468 87837 5908 38.537 0. 0. 42204 100085 61.033 85.347 RANNSTRON 0. 46204 100295 61.271 88.884 0. 0. 46204 100295 61.271 88.884 0. 0. 46204 100295 61.271 88.884 0. 0. 46204 100295 61.271 88.884 0. 0. 46204 100295	8	33.807	77.638	49.630	32.210	jo	ö	်ငံ
13.557 77.28 2.280 39.173 0. 0. 0. 39.273 81.7038 77.282 2.3436 40.577 0. 0. 0. 39.239 81.742 5.376 40.577 0. 0. 0. 39.239 81.742 5.37182 0.0464 0. 0. 0. 4.2468 87.837 59.908 58.543 0. 0. 0. 4.2468 87.837 59.908 58.547 0. 0. 0. 0. 44.141 86.563 61.993 62.547 0. 0. 0. 0. 46.204 10.0085 61.293 62.547 0. 0. 0. 0. 46.204 10.0085 61.271 85.834 0. 0. 0. 0. 46.204 10.0085 61.271 85.834 0. 0. 0. 0. 46.204 10.0085 61.271 85.834 0. 0. 0. 0. 46.204 10.0075 61.271 85.834 0. 0. 0. 0. 46.204 11.0097 65.316 99.715 0. 0. 0. 0. 46.204 11.0097 75.302 11.81.77 0. 0. 0. 0. 46.204 11.0097 77.802 11.81.77 0. 0. 0. 0. 46.204 11.0097 77.802 11.81.77 0. 0. 0. 0. 46.204 11.0097 77.823 11.81.77 0. 0. 0. 0. 46.204 11.0097 77.823 11.81.77 0. 0. 0. 0. 46.204 11.209 77.823 11.825 0. 0. 0. 0. 46.204 11.209 81.233 15.0539 0. 0. 0. 46.204 11.201 82.380 15.51.80 -445.120 12.201 44.204 12.313 82.300 159.780 -445.120 12.201 44.204 12.313 82.300 159.780 -445.120 13.238 45.204 13.326 86.204 13.340 90.666 192.123 -434.795 95.772 13.216 45.204 13.326 90.666 192.123 -434.795 95.772 13.216 45.204 13.326 90.666 192.123 -434.795 95.772	1500	34.811	75.004	51.244	35.640	ó	o	ó
38.200	1600	35.857	77.283	52.800	39.173	oʻ.	Ö	0,0
1,0,539 1,1,11	88	37.028	79.492 81.641	\$4,306 \$5,768	42.817	o' c	o c	ರ ರ
40320 85.855 35.62 54.485 0. 0 44.14 18268 87.837 59.908 85.852 0. 0 44.14 1 100.085 61.093 85.392	8	39.539	83.742	57.182	50.464	ö	o o	Ö
42.468 87.837 59.908 38.652 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	2000	40.920	\$5.80\$	58.562	54.485	ó	o	ö
4,141 86,653 61,093 62,547 — CRYSTAL <> LIQUID 46,204 100.0085 61,993 65,347 — CRYSTAL <> LIQUID 46,204 100.0085 61,993 65,357 — CRYSTRON 46,204 104,315 64,693 95,095 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	2100		87.837	59.908	58.652		oʻ	ď
46.204 100.295 61.271 85.854 0 0 0 0 0 0 0 0 0	2190.000		89.653	61.093	62.547 85.392	CRYST I	AL <> LIC	ago.
46.204 102.349 65.012 90.474 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	2200		100,295	61.271	85.854		o	oʻ
46.204 106.201 66.316 59.0715 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	2300	46.204	102.349	63.012	90.474	o' o	o o	oʻ c
46,204 108,014 67,885 104,335 0. 0. 46,204 103,757 66,403 108,356 0. 0. 46,204 113,059 72,302 113,576 0. 0. 46,204 113,059 72,302 113,747 0. 0. 46,204 116,161 75,032 127,437 0. 0. 46,204 116,167 76,339 137,538 0. 0. 46,204 119,029 77,612 136,578 0. 0. 46,204 120,499 78,239 141,239 0. 0. 46,204 121,049 81,233 150,539 0. 0. 46,204 124,191 82,268 153,701	2500	46.204 40.204	106.202	66.336 316	55.05 517.85	ာ် ဝ	.	.
46.204 105.757 65.443 108.955 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.	2600	46.204	108.014	67.885	104,335	o	0	oʻ
46.204 11.348 70.3515 11.3716 0 0 0 0 0 0 0 0 0	2700	46.204	109.757	69.403	108.956	o	0	oʻ c
46.204 114.625 73.687 122.817 0 0 0 0 0 0 0 0 0	2800	46.204	113.059	72.302	118.197	o c	ó	ö
45.204 16.14 75.032 127.437 0. 0. 0. 45.204 16.14 75.032 127.637 0. 0. 0. 45.204 19.029 77.612 136.578 0. 0. 0. 45.204 120.409 78.815 141.299 0. 0. 0. 0. 45.204 121.748 80.037 145.919 0. 0. 0. 0. 45.204 121.748 80.037 145.919 0. 0. 0. 0. 45.204 124.315 82.380 153.400 -445.120 123.84 45.204 125.48 83.503 153.80 -445.120 132.84 45.204 127.918 83.503 177.641 -441.901 37.328 45.204 133.340 83.728 178.242 -440.370 49.291 -440.370 46.204 133.340 90.666 192.123 -434.795 96.792 -46.204 133.340 90.666 192.123 -434.795 96.792 -434.795 96.792 -44.204 133.340 90.666 192.123 -434.795 96.792 -43	3000	46.204	114.626	73.687	122.817	o'	o	o
46.204 11.359 76.339 15.2038 0. 0. 46.204 12.049 77.612 136.678 0. 0. 46.204 120.409 77.612 136.678 0. 0. 46.204 120.409 77.612 145.219 0. 0. 0. 46.204 121.049 81.233 150.539 0. 0. 46.204 123.049 81.233 150.539 0. 0. 46.204 125.348 81.350 153.160 -44.68.07 1201 46.204 125.348 84.594 164.401 -443.487 123.86 46.204 125.058 85.602 169.021 -441.901 37.329 46.204 130.172 87.729 173.641 -440.370 440.370	3100	46.204	116.141	75.032	127.437	o'	o'	Ö
46.204 121.748 8.0057 141.299 0. 0. 0. 46.204 121.748 8.0057 141.299 0. 0. 0. 46.204 121.748 8.0057 141.299 0. 0. 0. 46.204 124.191 82.268 154.701 FUGACITY = 1 bar - 46.204 124.191 82.268 154.701 FUGACITY = 1 bar - 46.204 125.348 83.500 159.780 -446.807 1201 46.204 125.348 83.500 159.780 -446.807 1201 46.204 129.038 86.707 173.641 -443.482 25.338 46.204 130.729 86.707 173.641 -443.894 61.216 46.204 131.259 88.778 182.882 -437.477 73.106 46.204 133.360 90.666 192.123 -434.795 96.792	3200	46.204	10.00	77.533	132.058	ರ	o o	ું લ
46.204 121.748 60.057 145.919 0 0 0 46.204 123.049 81.233 150.539 0 0 0 46.204 124.191 82.268 154.701 FUGACITY = 1 bar - 46.204 124.315 82.380 155.160 -446.807 1201 46.204 125.348 83.580 159.780 -445.120 13.286 46.204 127.918 85.562 169.021 -441.381 25.338 46.204 129.058 86.707 173.641 -440.370 49.291 46.204 131.259 88.728 182.82 -431.472 73.106 46.204 131.259 88.728 182.82 -431.472 73.106 46.204 133.360 90.666 192.123 -434.795 96.792	98	46.204	120.409	78.850	141.299	o c	ó	ď
46.204 12.049 81.233 150.539 0	3500	46.204	121.748	80.057	145.919	ö	o'	ď
46.204 124.191 82.268 154.701 FUGACITY = 1 bar- 46.204 124.315 82.380 155.160 -44.807 1.201 46.204 125.48 84.594 164.401 -443.485 25.328 46.204 127.518 85.562 169.021 -441.901 371.329 46.204 13.5038 86.707 173.641 -440.370 49.291 46.204 131.259 88.7728 182.882 -437.472 73.105 46.204 131.359 88.772 187.503 -436.105 84.564 46.204 133.360 90.666 192.123 -434.795 96.792	3600	46.204	123.049	81.233	150.539	oʻ	ó	oʻ
46.204 124.315 87.380 1551.60 -446.807 1.201 46.204 125.38 87.380 159.780 -445.120 13.286 46.204 125.038 86.459 169.021 -443.487 25.338 46.204 125.038 86.707 173.641 -440.370 49.291 46.204 13.129 88.728 182.832 -437.472 73.105 46.204 133.360 90.666 192.123 -434.795 96.792	3690.080	46.204	124.191	82.268	154.701	FUC		18
46,204 125,348 84,394 164,401 -444,170 13,286 46,204 126,748 84,594 164,401 -441,343 25,328 46,204 129,038 86,707 173,641 -440,370 49,291 46,204 131,219 87,729 182,822 -437,477 73,106 46,204 131,229 88,728 182,832 -437,477 73,106 46,204 131,329 89,707 187,503 -436,109 46,204 133,340 50,666 192,123 -434,795 96,792	3700	46.204	124315	82.380	155.160	-446.807	1201	-0.017
46.204 127.918 85.662 169.021 -441.901 77.329 46.204 129.038 86.707 173.641 -440.370 49.291 46.204 131.239 88.737 173.641 -440.370 49.291 46.204 131.239 88.738 182.882 -437.477 73.106 46.204 133.340 90.666 192.123 -434.795 96.792	3800	46.204	125.248	83.500	159.780	-445.120	13.286	-0.185
46.204 129.058 86.707 173.641 -440.370 49.291 46.204 130.172 87.729 178.262 -438.894 61.216 46.204 131.259 88.728 182.882 -437.472 73.106 46.204 133.340 90.666 192.123 -434.795 96.792	869	46204	127.918	85.662	169.021	-441901	37,329	-0.487
46.204 130.172 87.729 178.262 -438.894 61.216 46.204 131.259 88.728 182.882 -437.472 73.106 46.204 133.340 90.666 192.123 -434.795 96.792	4100	46.204	129,058	86.707	173,641	-440.370	49.291	-0.628
46.204 131.259 88.728 182.882 -437.472 73.106 46.204 133.340 90.666 192.123 -434.795 96.792	4200	46.204	130.172	87.729	178.262	-438.894	61.216	-0.761
46.204 133.360 90.666 192.123 -434.795 96.792	4300	46.204	131,259	88.728	182.882	-437.472	73.106	-0.888
	\$ 1 8	46.204	133,360	90.66 90.666	192.123	-434.795	25.35 4.257	-1.124

25

Ar = 50.9415 Vanadium (V)

CRYSTAL-LIQUID

Refer to the individual tables for details.

to 2190 K crystal 2190 K liquid

Vanadium (V)

J. Phys. Chem. Ref. Data, Monograph 9

-2.721 -2.333 -2.052 -1.754

135.426 122.669 109.990 97.384 84.849

468.154 466.048 463.967 461.912 459.888

34.878 37.337 37.337 37.337 37.337 37.337 57.021 57.021 57.021 57.021 57.021 57.021 57.037 57

-1.220 -0.979 -0.754 -0.543 -0.159

457.898 455.944 454.029 452.156 450.326 448.543

59.975

214.055 215.689 216.469 217.227 217.227 217.363 219.381 220.063 220.730 221.382 221.382

FUGACITY - 1 ba

86.210 86.498 92.417 95.453

29.042 9.090 30.105

222.021 222.646 223.260 223.862

245.399 246.181 246.956 247.725

83.613

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98.543 101.687 104.885 108.139 111.449

224.453 225.034 225.606

248.488 249.246 249.998 250.746 251.490

32.260 32.817 33.379 33.946 35.093 35.672 35.672

14.815

27.270

22230

00000 00000 00000 00000

28.853

252.966 253.699 254.428 255.155

255.878 256.600 257.318 258.035 258.749

6.843 7.435 8.031 38.632 39.238

888

259.462 260.172 260.881 261.589 261.295

June 1973 (1 atm)

PREVIOUS:

10.931

-5.011 -4.447 -3.956 -3.508 -3.098

201.450 187.310 174.203 161.189 148.265

501.498 476.745 472.423 470.280

209.440 210.434 211.389 212.309 213.197

Standard State Pressure = p = 0.1 MPa

trature = T, = 298.15 K $-[G^{\bullet}-H^{\bullet}(T_{i})]T$

K-mol A.H.

H*-H*(T,)

-261,001 -126,603 -99,689 -82.297

NFINE

IDEAL GAS

 $IP(V, g) = 54360 \pm 16 \text{ cm}^{-1}$ $S^{*}(298.15 \text{ K}) = 182.30 \pm 0.8 \text{ J·K}^{-1} \cdot \text{mol}^{-1}$

Vanadium (V)

CURRENT

+1	Enthalpy Ro	eference T	Enthalpy Reference Temperature
$\Delta_{\rm r}H^{\circ}(298.15 \text{ K}) = 515.5 \pm 8 \text{ kJ} \cdot \text{mol}^{-1}$			L'K''mol'
	7,8	ប	S[G
	0	ó	ó
	8	28.040	151.831
	85	27.960	171.498
	298.15	26.012	182.298
	300	25.978	187 459
	320	25 19	186.402
	400	24.647	189.727
	\$ \$	24 38	192,610
	909	24.283	199.579
	92	24.582	203.343
	88	24.890	206.647
	88	25.237	212.246
	1100	25,262	214.653
	02: 12:00	25.214	216.849
1 and by Farber and Srivastava using	38	12.5	218364
reaction (A) refers to the sublimation	2005	24.864	222.441
	009	24.739	224.042
	200	24.630	225.538
l-mol-1 Drift	206	24.487	228 269
3rd law cal·K ⁻¹ ·mol ⁻¹	2000	24 460	229.524
122.05 0.72 + 0.55	2100	24.467	230.717
1 100	2300	24.588	232.948
19.18 2.65 +	2400	24.702	233.996
	865	26,633	255.008
	2700	25.25	236.935
5 K), is a median of the two sublimation	2800	25.517	237.858
Isen vapor pressure study in the range	3008	26.127	239.639
	3100	26.477	240,501
crature ranges studied above.	3200	26.855	241.348
	000	250	242.180
	3500	28.136	243.809
els are listed above. All levels reported	3600	28.605	244.608
hose adopted by Hultgren et al., being	3690.080	29.042	245.321
s which have not been observed and/or	3700	29.090	245.399
***************************************		2	

-30.473 -25.675 -21.946 -18.965

408.372 408.372 393.225 378.125 363.073

187.198 189.242 191.215 193.097

-36.875

469.460 461.790 454.122 446.464

\$15.430 \$15.332 \$15.205 514.905

182.299 182.612 182.298

169 744

-16.528 -14.500 -12.786 -11.319 -10.050

512.837 512.227 511.518 510.696 509.758

24.931 27.437 29.930

19.890

-8.942

348.069 333.116 318.218 303.379 288.603 273.893 259.252 244.685 230.193

508.706 507.530 506.229 504.793 503.219

203.785 205.021 206.201 207.327 208.406

-6.328

3

Electronic Levels and Quantum Weights 9 ∞ 0 ٠ ك 54251.26 323.42 553.02 £,cm 54360 , H1122 State F32 F_{S2} 8

Enthalpy of Formation

The vispor pressure over vanadium was measured by Edwards et al.¹ using the Knudsen method and by Farber and Sr effusion-mass spectrometric techniques. Our 2nd and 3rd law analysis is tabulated below, where reaction (A) refers to the content of t V(cr) = V(g) and reaction (B), the vaporization V(l) = V(g).

		Data		Δ,H°(298.15 K), kcal·mol ⁻¹	cal·mol-1	Drift
Source	Reaction	Points	7/K	2nd law	3rd law	cal·K ⁻¹ ·mol ⁻¹
_	٧	12+	1666-1882	121.67 ± 0.99	122.95	0.72 ± 0.55
9	∢	7	1900-2155	121.60 ± 1.48	123.45	0.91 ± 0.73
9	æ	9	2198-2412	113.04 ± 5.34	119.18	2.65 ± 2.30
*	A statistical test of	discounted the 1	statistical test discounted the 1766 K data point.			

We adopt $\Delta H^{\circ}(298.15 \text{ K}) = 123.2 \text{ kcal·mol}^{-1}$ for V(g). This value, which is identical to $\Delta_{acb}H^{\circ}(298.15 \text{ K})$, is a median of the two sublimation studies. Hultgren et al.2 reported a 3rd law value of 123.089 ± 0.250 kcal·mol⁻¹ based on a Knudsen vapor pressure study in the range 1771–1880 K by Saxer.³ This result is consistent with our adopted value.

The results of Kant and Lin3 indicated that the partial pressure of V₂(g) is negligible in the temperature ranges studied above.

Heat Capacity and Entropy

The electronic energy levels and quantum weights are obtained from Moore. Only a few of the levels are listed above. All levels reported by Moore* are considered in the calculation. The heat capacity and entropy values are very similar to those adopted by Hultgren et al., * being identical at 298.15 K and differing by 0.045 cal.K⁻¹ mol⁻¹ in C* at 3800 K. There are predicted levels which have not been observed and/or classified. It is not expected that 5°(298.15 K) would be affected by the missing states, but that in the range 3000-6000 K, an error of 0.2-0.3 cal·K-1-mol-1 might result.

References

'R. Hutgren, R. L. Orr, and K. K. Kelley, Supplement to Selected Values of Thermodynamic Properties of Metals and Alloys, V table, J. W. Edwards, H. L. Johnston, and P. E. Blackburn, J. Amer. Chem. Soc. 73, 4727 (1951).

(May 1966).

K. Sazer, Ph. D. Thesis, Ohio State University, (1962). E. Moore, U. S. Nat. Bur. Stand., NSRDS-NBS 35, Volume I, 1970 [Reprint of NBS Circular 467, Volume I, 1949].

P. K. Sater, Ph. D. Thesis, Ohio State University, (1200).
C. E. Moore, U. S. Nat. Bur. Stand., NSRDS-NBS 35, Volume I, 1970 [Reprint of E. Moore, U. S. Lin, J. Chem. Phys. 51, 1644 (1969).
M. Farber and R. D. Srivastava, J. Chem. Soc., Faraday Trans. I 69, 390 (1973).

Vanadium (V)

CURRENT: March 1984 (1 bar)

Vanadium, Ion (۷٬)	IDEAL GAS	$M_r = 50.94095$ Vanadium, Ion (V*)	V;(g)
$IP(V^{+} \circ) = 118200 + 200 \text{cm}^{-1}$		***************************************	[

1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
IP(V, g) = 118200 ± 200 cm ⁻¹	$\Delta_i H^0(0 \text{ K}) = 1162.5 \pm 8 \text{ kJ} \cdot \text{mol}^{-1}$ Enthalpy Reference Ter	Enthalpy Reference Tempera
5 (298.15 K) = 183.38 ± 0.8 J·K '-mol"	Δ _t H°(298.15 K) = [1171.947] kJ·mol ⁻¹	

Electronic Levels and Quantum Weights State			Δ _t H°(0 Δ _t H°(298.15
	c Levels and Quantum '	Weights 8.	
	0.00	-	
	36.05	3	
	106.83	\$	
	208.89	7	
	339.21	6	
	2604.82		
		6. cm ⁻¹ 6. cm ⁻¹ 0.00 36.05 106.83 208.89 339.21 2604.82	la l

Enthalpy of Formation

from Sugar and Corliss. The ionization limit is converted from cm⁻¹ to kJ mol⁻¹ using the factor, 1 cm⁻¹ = 0.01196266 kJ·mol⁻¹, which is derived from the 1973 CODATA fundamental constants. Rosenstock et al. and Levin and Lias have summarized additional ionization $\Delta_H^{*}(V^*,g,0\,K)$ is calculated from $\Delta_H^{*}(V,g,0\,K)^{\dagger}$ using the spectroscopic value of $\Pi(V)=54360\pm16\,\mathrm{cm}^{-1}$ (650.290 \pm 0.19 kJ·mol $^{-1}$ and appearance potential data.

 $\Delta H^2(V^*, g, 298.15 \, K)$ is calculated from $\Delta H^2(V, g, 0 \, K)$ by using IP(V) with JANAF¹ enthalpies, $H^0(0 \, K) - H^0(298.15 \, K)$, for V(g), and e [ref). $\Delta H^0(V \to V^* + e^-, 298.15 \, K)$ differs from a room temperature threshold energy due to inclusion of these enthalpies and to threshold effects discussed by Rosenstock et al. $^4\Delta H^0(298.15 \, K)$ should be changed by $-6.197 \, k \text{J} \cdot m \text{ol}^{-1}$ if it is to be used in the ion convention that excludes the enthalpy of the electron.

Heat Capacity and Entropy

of the estimated missing levels (for n = 4, 5), the cut-off procedure, and the inclusion of n = 5 levels up to 6000 K, the Gibbs energy function showing variations of 0.001 J·K⁻¹ mol⁻¹ at this temperature. The reported uncertainty in \$\infty\$(298.15 K) is due to uncertainties in the relative and the ionization potential for V*(g), all levels listed by Sugar and Corliss¹ as well as estimated levels, are used in the calculation. The observed levels are too numerous to list completely. The calculations indicate that for V'(g), the thermodynamic functions are independent The information on electronic energy levels and quantum weights, given by Sugar and Corliss, is incomplete because many theoretically predicted levels have not been observed. Although we have listed only the ground, the first excited state, the highest observed excited state ionic mass, and the fundamental constants. Extension of these calculations above 6000 K may require consideration of the higher excited states (n>5), and use of different fill and cut-off procedures.6

JANAF Thermochemical Tables: V(g), 3-30-73; e-(ref), 3-31-82.

²J. Sugar and C. Corliss, J. Phys. Chem. Ref. Data 7, 1194 (1978).

³E. R. Cohen and B. N. Taylor, J. Phys. Chem. Ref. Data 2, 663 (1973).

⁴H. M. Rosenstock, K. Draxl et al., J. Phys. Chem. Ref. Data 6, Supp. 1, 783 pp. (1977).

⁵R. D. Levin and S. G. Lias, U. S. Natl. Bur. Stand. NSRDS-NBS-71, 634 pp. (1982).

R. Downey, Jr., The Dow Chemical Company, AFOSR-TR-78-0960, Contract No. F44620-75-1-0048, (1978).

7 7	Enthalpy R	teference T	emperature J·K ⁻¹ mol ⁻¹	Enthalpy Reference Temperature = T, = 298.15 K		Standard State Pressure		- p - 0.1 MPa	
-	7/K	೮	S• -[G•	-Ir(T,)]/T	$H^{\bullet}-H^{\circ}(T_t)$	Δ,Η.	δ,6	log Kr	_
	288°°	0. 28.792 25.153 23.935	0. 154.942 173.759 179.232	INFINITE 205.447 185.546 183.761	-7.898 -5.051 -2.357 -1.132	1162.492			
	298.15	23.149	183,376	183,376	0	1171.947	1119,646	-196.157	
	88	23.125	183.519	183,376	0.043	1171.982	1119.321	-194.891	_
	\$.5	22.23	190.033	184271	2302	1173.759	1101.494	-143.840	
	88	22004	194.963	185.935	4.514	1175.386	1083.238	-113.165	_
	88	22.179 22.631	198.985	189.637	6.720	1176.949	1064.661	-92.687	
	88	23.221	205.495	191.431	1251	1180.028	1026.767	-67.041	_
	0001	24.400	210.807	194.790	16.016	1183.077	888.098	-51.613	-
_ .	8 13 13 13 13 13 13 13 13 13 13 13 13 13	24.872 25.238	213.155	196.355	18.481 20.987	1184.573	968.527	-41.301	
Ę	864	22.25 27.65 27.65 27.65 27.65	217.367	199.271 200.632	23.525 26.085	1187.415	928.998	-37.328 -33.918	
	0091	35.824	YCU:177	201.934	28.638	1189.946	889.052	-30,960	
豆	888	282	224,272	204.376	33.824	1192.093	848.791	-28.368	
_	86	25.834	27.14	206.624	38.993	1192.9%	828.570 808.302	-24.044	_
	2000	25.823	228.471	207.684	41.575	1194.412	187.997	-20.580	
	2200	25.833	230.933	209.687	44 IS/ 46.740	1172,365	767.563	-19,095	
	7300 7400 7400	25.862 25.915	232.082	210.636 211.553	49.325 51.914	1172.408	728.098	-16.536	
_	2500	25.988	234.243	212.439	54.509	1172.508	689.458	-14,405	_
2 2	2200	26.084 26.201	235.264	213.298 214.130	57.112 59.726	572.711 117.642	670.135	-13.463	
_	2800 2800 2800 2800	26.339	237.206	214.937	62.353	727.2711	631.480	-11.780	
٥	3000	26.672	239.034	216.483	67.653	1172,944	592.813	-11.026	
	3200 3200	26.864	239.911	217.224	70.329	1173.078	573.473	-9.663	
	3300	27.288	241.604	218.651	75.744	1173.409	534.779	-8.465	
	3200	22.72	242.422	220.009	81.247	1173.608	515.423 496.062	-7.919 -7.403	
_	3600	28.239	244.008	220.665	84.034	1174.075	476.693	-6.917	
	3800	28.486	245.535	221.934	89 682	729.518	45122	-6.202	
	000	28.981	247,008	23.151	95.429	733.401	436.473	-5.700	_
	4 4 5	29.226 29.467	248.434	224.321	98.340 101.274	735,300	429.027 421.534	-5.466 -5.243	
	64 4 00 5	29.932	249.130 249.816 250.491	225.449 225.449	107214	740.815	413.997	-5.029 -4.825	
	4600	30,372	251.156	226.538	113.245	744.327	391.139	-4.442	
	6 8 8 8 8	30.580 30.780	251.812	227.068	116.293	746 030	383.442	-4261	
	\$ \$ \$	30.972 31.156	253.094	228.105	122.449	749.324	367.943	-3922	
	2100	31,331	254.340	229.109	128.680	752.461	352.313	-3.608	
	2300	31.657	254.950 255.552	229.600 230.084	131.821	753.968	344.452	-3.460	
	\$400 \$500	31.808	256.145 256.730	230.561	138.152	756.850	328.646	-3.179	
	\$600 \$700	32.090	257.307	231.496	144.542	759.550	312.737	-2917	
	288	32.347	28.438	22.40	150.986	762.058	296.734	-2.793	
	800	32.585	259.538	23223	154.227	764.367	288.701 280.649	-2556	
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-4224 -3.962 -3.721 -3.500 -3.297

354.896 350.279 345.662 341.044 336.426

231.182 231.912 232.618

229.639

210.256 204.780 199.476 194.337 189.336 179.853 175.320 170.927

-3.109 -2.936 -2.775 -2.626 -2.487

331.808 327.190 322.572 317.953

210.989 211.694 212.377 213.038 213.679 214.905 215.606 216.620 217.161 217.689 217.689 217.689 217.689 217.689 217.689 217.689

233.300 233.961 234.601 235.222 235.825

-238 -236 -236 -2361

162.545 159.749 167.963 176.254 184.623

308.716 -142.709 -145.642 -148.625 -151.660

236.411 236.981 237.536 238.076 238.603

48.490 \$5.572 \$5.573 \$5

2.553 2.553 2.553 2.553 2.553

201.590 210.186 218.858 227.604

-154.749 -157.891 -161.088 -164.341 -167.650

239.116

-2.685 -2.726 -2.767 -2.807 -2.846

-174.437 -177.917 -181.454 -185.049 -171.015

90.099 92.179 94.258 96.338

243.243

219.67 220.146 220.146 221.053 221.493 221.523 222.334 222.757 223.163 223.163

240.107 240.585 241.052

-2884 -2922 -2959 -2995 -3030

281.627 290.885 300.215

-188.703

00.497 02.576 04.655 06.735

223.950 224.333 224.709 225.078 225.078

-6004 -5.173 -4.826 -4.816

241.382 234.008 227.777 221.747 215.909

38.076 40.160 42.243 44.325 46.408

207.059 207.906 208.720 209.503 210.259

225.191 226.160 227.086 227.972 228.822

CURRENT: March 1984 (1 bar)

-3.134 -3.167 -3.200

328.636 338.252 347.938 357.696 367.525

-3.065

Standard State Pressure = $p^* = 0.1 \text{ MPa}$

nperature = 7, = 298.15 K -[G*-H*(T,)]JT

.K-'mol-'

log Kr

Š

Ψ

4.-H.(T.)

461,547

83,436

83.436

-73.368 -72.873 -61.481 -52.959 -41.076 -33.200 -27.607 -23.439 -17.657

187.813 189.633

198.861

202.153 204.982 207.467 209.683 211.683

192,652

-15.576 -13.855 -12.408 -11.178 -10.120

348,342 338,030 328,017 318,283 308,814 299,595 299,595

458.546 456.153 456.153 456.153 450.954 450.954 460.95

8.764 8.764 10.882 115.092 115.092 119.290 119.200 119

196.052 197.432 198.734 199.965 201.131 202.239 204.298 205.259 205.259

-9202 -8399 -7691 -7064 -6505

281.871 273.348 265.043 256.949 249.064

M_r = 50.94205 Vanadium, Ion (V⁻)

IDEAL GAS

Vanadium, Ion (V⁻)

Vanadium, Ion (V⁻)

PREVIOUS

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Jeference		ប	o, è	25.030	23.049	23.02	121	21.65	21.399	21.13	21.00	20.970	20.918	20.88	20.873	20.855	20.836	20.832	22,22	20.819	20.814 20.812 20.811	20.80	20.808	20.80	20.803	20.80	20.800	25 25 26 26 26 26 26 26 26 26 26 26 26 26 26	20.79	20.25	20.7%	20.79	20.79	20.794	20.793	20.00	20.79
Enthalpy Reference Tem		ΤÆ	٥٤	885	298.15	85	88	38	88	88	88	28	0.05	1500	98	000 000 000 000 000 000 000 000 000 00	2100	2300	7 4 00 7 2 00 7 2 00	2600	8888	3100	388	3200	356 370 80 80 80 80 80 80 80 80 80 80 80 80 80	3800	900	4300 4300 4300	8 8 8 8 8 8	00 0	4800 4800 6900	800	250	\$500 \$200 \$200	2600	8808	0009
EA(V, g) = 0.525 \pm 0.012 eV Δ_{eff} = 461.547 \pm 2.5 k1·······1	02 J·K ⁻¹ ·mol ⁻¹		Electonic Levels and Quantum Weights	State e, cm 1 8,	0 ;	સ દ				Enthalpy of Formation	$AH^{\dagger}(V, g, 0K)$ is calculated from $AH^{\dagger}(V, g, 0K)$ using the adopted electron affinity of EA(V) = 0.525 ± 0.012 eV (50.654 ± 1.158)	in this yater, recommended by moop and Lineberger, is based on a laser photodetachment electron spectrometry study. Additional information on V (g) may be obtained in the critical discussions of Hoton and Lineberger 2.4 Researcher 2.20 May 2.20 M	ΔH ⁰ (V, g, 298.15 K) is obtained from ΔH ⁰ (V, g, 0 K) by using EA(V) with JANAF enthalpies, H ⁰ (0 K)-H ⁰ (298.15 K), for V ⁻ (g), V(g),	threshold effects discussed by Recenters, 15 A 19708 15 Y. Junia 4 E. Commission of these entitleties and to	convention that excludes the enthalpy of the electron.	Heat Capacity and Entropy	The ground state electronic configuration for V (g) is given by Hotop and Lineberger, 24 Rosenstock et al., 3 and Massey, 5 The fine structure	separation has been calculated by an isoelectronic extrapolation of ratios of fine structure separations, and is that recommended by Hotop and Lineberger	References	JANAF Themochemical Tables: V(g), 6-30-73; e (ref), 3-31-82	² H. Hotop and W. C. Lineberger, J. Phys. Chem. Ref. Data, 14(3), 731 (1985). ³ C. S. Feigerle, R. R. Corderman, S. V. Bobaskev and W. C. Lineberger, J. Chem. Phys. 74, 1580 (1981).	"H. Hotop and W. C. Lineberger, J. Phys. Chem. Ref. Data 4, 539 (1975). H. M. Rosenstock R. Drawl 4, at 1 Phys. Chem. Buf. Data 6, Sum. 1, 202 m., 1,072.	th. S. W. Massey, "Negative Ions," 3rd ed., Cambridge University Press, Cambridge, 741 pp. (1976).														

Enthalpy of Formation

References

Vanadium

Continued from Page 1918 Sublimation Data

Refer to the ideal gas table for details.

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Refer to the individual tables for details.

0 to 3680 K crystal 3680 to 6000 K liquid

 $T_{\rm eq}(1 \, {\rm bar}) \sim 5924 \, {\rm K}$ (not included in the reference state)

NEW Property New	Enthalpy Reference	leference T	l tit	- T, - 298.15 K		Standard Sta	State Pressure = 1	p = 0.1 MPa
Coloniary Colo	¥.	ប		-H'(T,)]/T	H*-H*(T,)	•H.4	•9∀	log Kr
11.56 21.51 0.0 0.0 0.0 14.15 15.66 21.51 0.0 0.0 0.0 14.15 14.56 14.56 14.56 0.0 0.0 0.0 14.15 14.56 14.56 14.56 14.56 0.0 0.0 0.0 14.15 14.57 14.56 14.57 14.56 0.0 0.0 0.0 0.0 14.15 14.56 14.57 14.56 14.57 0.0	°88	0. 16.033	9.612	INFINITE 52.820	-4373	ರರ	ರರಂ	ರರ
74.75) 7.1269 1.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	ន្ត	23.686	28.431	33,056	-1.156	.	်ဝံ	jo
11.244 35.83 12.97 12.98 0 0 22.329 54.53 12.97 12.99 0 0 22.339 54.53 13.53 12.99 0 0 22.329 50.13 13.53 12.99 0 0 26.229 57.17 13.53 10.90 0 0 26.229 57.17 41.57 12.81 0 0 0 27.16 60.57 11.21 12.29 0 0 0 0 27.17 41.57 11.21 12.21 0	C1.967	64.45	37,000	32,000	0.0	ဝံဇ	ರ (o' (
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