NBS TECHNICAL NOTE

270-2

Selected Values of Chemical Thermodynamic Properties

Part 2.

Tables for the Elements Twenty-Three Through Thirty-Two in the Standard Order of Arrangement

D. D. WAGMAN, W. H. EVANS, I. HALOW, V. B. PARKER,
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U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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PREFACE

Technical Note 270-2 is the second of a series of publications containing material prepared as a revision of the tables of Series I of National Bureau of Standards Circular 500, Selected Values of Chemical Thermodynamic Properties. This Note contains revised Tables 24 to 32, covering the elements silicon, germanium, tin, lead, boron, aluminum, gallium, indium, and thallium, and compounds of these elements following the Standard Order of Arrangement.

Tables for the first twenty-three elements and their compounds, and a discussion of the symbols, conventions, units of energy, and conversion factors used in this series are given in National Bureau of Standards Technical Note 270-1.

Donald D. Wagman, Chief,
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Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Si		c	28.086	0	0	0	0.769	4.50	4.78
		amorp			1.0				
		g		107.86	108.9	98.3	1.805	40.12	5.318
Si^+		g		295.83	298.35				
Si^{2+}		g		672.71	676.71				
Si^{3+}		g		1444.50	1449.98				
Si^{4+}		g		2485.50	2492.46				
Si^{5+}		g		6331.3	6339.8				
Si^{6+}		g		11062.6	11072.6				
Si^{7+}		g		16747.	16758.				
Si^{8+}		g		23756.	23769.				
Si^{9+}		g		31871.	31886.				
Si^{10+}		g		41127.	41143.				
Si^{11+}		g		52108.	52125.				
Si^{12+}		g		64178.	64196.				
Si_2		g	56.172	141.32	142.	128.	2.22	54.92	8.22
Si_3		g	84.258	146.4	147.		2.9		12.9
SiO		g	44.0854	-24.08	-23.8	-30.2	2.082	50.55	7.15
SiO_2	α, quartz	c	60.0848		-217.72	-204.75	1.657	10.00	10.62
	α, cristobalite	c			-217.37	-204.56	1.671	10.20	10.56

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(2) — SILICON — July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
SiO_2	α, tridymite	c			-217.27	-204.42	1.693	10.4	10.66
		amorp			-215.94	-203.33		11.2	10.6
		g			-77.				
		aq			-214.4				
SiH		g	29.0940	86.	86.28		2.069		
SiH_4		g	32.1179	10.30	8.2	13.6	2.517	48.88	10.24
Si_2H_6		g	62.2198	23.04	19.2	30.4	3.768	65.14	19.31
Si_3H_8		liq	92.3218		22.1				
		g			28.9				
H_2SiO_3		c	78.1001		-284.1	-261.1		32.	
	un-ionized; std. state, m = 1	aq			-282.7	-258.0		26.	
H_4SiO_4		c	96.1155		-354.0	-318.6		46.	
	un-ionized; std. state, m = 1	aq			-351.0	-314.7		43.	
$HSi(OH)_6^-$	un-ionized; std. state, m = 1	aq	131.1382			-414.6			
$H_2[Si(OH)_6]$	un-ionized; std. state, m = 1	aq	132.1462		-487.6	-428.1		77.	
$H_2Si_2O_5$		c	138.1849		-499.2	-464.5		46.	
$H_6Si_2O_7$		c	174.2156		-638.0	-579.8		79.	
SiF		g	47.0844	1.	1.7	-5.8	2.260	53.94	7.80
SiF_2		g	66.0828	-147.75	-148.	-150.	2.630	60.38	10.49

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(3) — SILICON — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SiF_4	g	104.0796	-384.66	-385.98	-375.88	3.663	67.49	17.60
std. state, m = 1	aq				-384.2			
SiF_6^{2-} std. state, m = 1	aq	142.0764		-571.0	-525.7		29.2	
SiH_3F	g	50.1083				2.617	56.95	11.33
$SiHF_3$	g	86.0892				2.867	64.96	14.47
H_2SiF_6	aq	144.0923						
in 41 HF + 175 H_2O	aq			-568.0				
160 HF + 720 H_2O	aq			-573.2				
363 HF + 1785 H_2O	aq			-568.7				
762 HF + 3385 H_2O	aq			-567.8				
SiCl	g	63.539	45.	45.39		2.267		8.81
$SiCl_2$	g	98.992	-39.61	-39.59	-42.35	2.98	67.0	12.16
$SiCl_4$	liq	169.898		-164.2	-148.16		57.3	34.73
	g		-156.508	-157.03	-147.47	4.633	79.02	21.57
SiH_3Cl	g	66.5629				2.733	59.88	12.20
SiH_2Cl_2	g	101.0079				3.144	68.26	14.45
$SiCl_3H$	liq	135.4530		-128.9	-115.34		54.4	
	g		-121.40	-122.6	-115.2	3.872	74.99	18.12

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(4) — SILICON — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
SiBr	g	107.995	51.30	50.		2.40		9.23
$SiBr_4$	liq	347.722		-109.3	-106.1		66.4	
	g			-99.3	-103.2	5.317	90.29	23.21
SiH_3Br	g	111.0189				2.812	62.69	12.63
SiH_2Br_2	g	189.9199				3.411	74.0	15.66
$SiHBr_3$	liq	268.8210		-85.0	-80.4		59.3	
	g			-75.9	-78.5	4.282	83.28	19.30
$SiCl_3Br$	g	214.354				4.662	83.64	21.72
$SiCl_2Br_2$	g	258.810				4.955	88.2	22.40
$SiClBr_3$	g	303.266				5.121	90.1	22.79
SiI_4	c	535.7036		-45.3				
SiH_3I	g	158.0143				2.886	64.73	13.00
SiS	g	60.150	26.6	26.88	14.56	2.135	53.43	7.71
SiS_2	c	92.214		-49.5				
SiSe	g	107.046	23.	23.78		2.18		8.04
$SiSe_2$	c	186.006		-7.				
SiTe	g	155.686	31.	30.99		2.22		8.31
SiN	g	42.0927	116.	116.28	109.01	2.087	51.78	7.21

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(5) — SILICON — July 1965

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Si_3N_4 α	c	140.2848		-177.7	-153.6		24.2	
$NH_4HSi(OH)_6$ std. state, m = 1	aq	149.1768			-433.6			
$SiF_4 \cdot 2NH_3$	c	138.1408		-463.				
$(NH_4)_2SiF_6$ hexagonal	c	178.1536	-633.79	-640.94	-565.38	10.116	66.98	54.52
cubic	c		-633.908	-640.67	-565.40	10.498	67.99	59.25
ionized; std. state, m = 1	aq			-634.3	-563.6		83.4	
in 555 H_2O	aq			-633.605				
795 H_2O	aq			-633.465				
1,500 H_2O	aq			-633.200				
2,775 H_2O	aq			-632.714				
SiC β, cubic	c	40.0972	-15.36	-15.6	-15.0	0.781	3.97	6.42
α, hexagonal	c			-15.0	-14.4		3.94	6.38
	g		175.6	177.		2.4		
SiC_2	g	52.1083	145.7	147.		2.5		
Si_2C	g	68.1832	131.1	132.		2.7		
Si_2C_2	g	80.1943	167.					
Si_2C_3	g	92.2054	176.					
Si_3C	g	96.2692	161.					

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 24(6) — SILICON — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$SiH_3(CH_3)$	methylsilane	g	46.1450				3.266	61.28	15.74
SiH_3CCH	silylacetylene	g	56.1402				3.511	64.35	17.34
SiH_3CHCH_2	vinylsilane	g	58.1561		-2.				
$SiH_2(CH_3)_2$	dimethylsilane	g	60.1721				4.293	71.59	22.00
$SiH_3C_2H_5$	ethylsilane	g	60.1721	-29.					
$SiH(CH_3)_3$	trimethylsilane	g	74.1992				5.324	79.09	28.18
$Si(CH_3)_4$	tetramethylsilane	liq	88.2262		-63.	-24.		66.27	48.78
		g			-57.149	-23.934	6.539	85.78	34.39
$SiH(C_2H_5)_3$	triethylsilane	liq	116.2804		-54.				
$Si(C_2H_5)_4$	tetraethylsilane	liq	144.3346		-68.				
$SiH(OCH_3)_3$	trimethoxysilane,	liq	122.1974		-199.				
$Si(OCH_3)_4$	tetramethoxysilane	liq	152.2238		-302.				
$SiH(OC_2H_5)_3$	triethoxysilane	liq	164.2786		-226.				
$Si(OC_2H_5)_4$	tetraethoxysilane	liq	208.3322		-334.				
$[(CH_3)_3Si]_2O$	hexamethyldisiloxane	liq	162.3818	-188.65	-194.8	-129.5	16.170	103.69	74.42
		g		-174.07	-185.88	-127.81	10.51	127.85	57.00
$SiF_4 \cdot N(CH_3)_3$		c	163.1915		-419.3				
$SiF_4 \cdot 2N(CH_3)_3$		c	222.3034		-439.5				
$(CH_3)_3SiCl$	trimethylchlorosilane	liq	108.6442		-91.5	-58.93		66.5	
		g			-84.32	-58.23		88.2	
$Si(OC_2H_5)_3Cl$	triethoxychlorosilane	liq	198.7236		-294.5				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(1) — GERMANIUM — July 1965

Formula and Description		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Ge		c	72.59	0	0	0	1.105	7.43	5.580
		g		89.34	90.0	80.3	1.768	40.103	7.345
Ge^+		g		271.18	273.32				
Ge^{2+}		g		638.63	642.25				
Ge^{3+}		g		1427.85	1432.95				
Ge^{4+}		g		2482.0	2488.6				
Ge^{5+}		g		4637.	4645.				
Ge_2		g	145.18	113.	113.08	99.5	2.29	60.4	8.5
Ge_3		g	217.77	113.	112.95	99.3	3.27	68.1	13.8
Ge_4		g	290.36	114.	113.98	99.4	4.40	78.8	19.2
GeO	brown	c	88.589		-50.7	-56.7		12.	
	yellow	c				-49.5			
		g		-11.	-11.04	-17.49	2.102	53.58	7.39
GeO_2	hexagonal	c	104.589		-131.7	-118.8		13.21	12.45
		amorp			-128.4				
Ge_2O_2		g	177.179		-112.				
Ge_3O_3		g	265.768		-212.				
GeH_4		g	76.622	19.11	21.7	27.1	2.567	51.87	10.76
GeH_4^+		g		261.	265.1				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(2) — GERMANIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ge_2H_6	liq	151.228		32.82				
	g			38.8				
$Ge_2H_6^+$	g			329.				
Ge_3H_8	liq	225.834		46.3				
	g			54.2				
$Ge_3H_8^+$	g			277.				
H_2GeO_3	aq	122.604		-195.73				
GeF	g	91.588	-8.	-7.97		2.185		8.30
GeF_2	g	110.587	-121.					
GeF_4	g	148.584				4.163	72.36	19.56
GeH_3F	g	94.612				2.731	60.39	12.34
H_2GeF_6	aq	188.596		-481.7				
GeCl	g	108.043	37.09	37.	30.	2.290	58.8	8.81
$GeCl_4$	liq	214.402		-127.1	-110.6		58.7	
	g		-118.06	-118.5	-109.3	5.050	83.08	22.97
GeH_3Cl	g	111.067				2.865	63.00	13.08
$GeHCl_3$	liq	179.957					53.6	
	g					4.192	79.06	19.40

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(3) — GERMANIUM — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
GeBr	g	152.499	58.	56.32		2.355		8.87
$GeBr_2$	g	232.408		-15.0	-25.5		79.1	
$GeBr_4$	liq	392.226		-83.1	-79.2		67.1	
	g		-64.61	-71.7	-76.0	5.736	94.66	24.34
GeH_3Br	g	155.523				2.966	65.66	13.47
GeI_2	c	326.399		-21.	-20.		32.	
	g			11.2	-1.0		76.	
GeI_4	c	580.208		-33.9	-34.5		64.8	
	g		-12.31	-13.6	-25.4	6.12	102.49	24.89
in $HCl \cdot 14.3H_2O$	aq			-35.65				
$GeIH_3$	g	202.518				3.037	67.65	13.75
GeS	c	104.654		-16.5	-17.1		17.	
	g		22.0	22.	10.	2.185	56.	8.05
GeS_2	c	136.718		-45.3				
GeSe	c	151.55		-22.0				
	g		23.	22.84		2.26		8.42
GeTe	c	200.19		-6.				
	g		42.25	42.		2.32		8.59
$GeTe_2$	g	327.79		44.				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 25(4) — GERMANIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Ge_3N_4	c	273.797		-15.1				
GeP	c	103.564		-5.	-4.		15.	
GeC	g	84.601	150.	151.				
GeC^+	g		388.	390.				
GeC_2	g	96.612	142.	143.				
Ge_2C	g	157.191	130.	131.				
Ge_3C	g	229.781	136.	137.				
$Ge(C_2H_5)_4$	liq	188.839		-49.5				
GeSi	g	100.676	126.	127.				
Ge_2Si	g	173.266	123.	124.				
Ge_3Si	g	245.856	121.	122.				
GeSiC	g	112.687	127.	128.				
Ge_2SiC	g	185.277	138.	139.				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(1) — TIN — July 1965

Substance: Formula and Description		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Sn	I, white	c	118.69	0	0	0	1.505	12.32	6.45
	II, gray	c		-0.371	-0.50	0.03	1.376	10.55	6.16
		g		72.18	72.2	63.9	1.485	40.243	5.081
Sn^+		g		241.54	243.04				
Sn^{2+}		g		578.97	581.95				
	in aq HCl	aq			-2.1	-6.5		-4.	
Sn^{3+}		g		1282.9	1287.4				
Sn^{4+}		g		2222.3	2228.3				
	in aq HCl	aq			7.3	0.6		-28.	
Sn^{5+}		g		3889.	3896.				
SnO		c	134.689		-68.3	-61.4		13.5	10.59
		g					2.117	55.45	7.55
SnO_2		c	150.689		-138.8	-124.2		12.5	12.57
SnH_4		g	122.722	41.78	38.9	45.0	2.669	54.39	11.70
SnH_4^+		g		254.	252.6				
$SnOH^+$	std. state, m = 1	aq	135.697		-68.4	-60.9		12.	
$SnO(OH)^+$	std. state, m = 1	aq	151.697			-113.3			
$Sn(OH)_2$	precipitated	c	152.705		-134.1	-117.5		37.	
$Sn(OH)_4$	precipitated	c	186.719		-265.3				
SnF^+	std. state, m = 1	aq	137.688			-80.1			

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(2) — TIN — July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$SnO(OH)F$	std. state, m = 1	aq	188.686			-188.5			
$SnCl^+$	undissoc., in aq HCl;								
	std. state, m = 1	aq	154.143		-39.4	-39.4		23.	
$SnCl_2$		c	189.596		-77.7				
	in aq HCl	aq			-79.3				
	un-ionized, in aq HCl;								
	std. state, m = 1	aq			-78.8	-71.6		41.	
$SnCl_2 \cdot 2H_2O$		c	225.627		-220.2				
$SnCl_3^-$	in aq HCl; std. state, m = 1	aq	225.049		-116.4	-102.8		62.	
$SnCl_4$		liq	260.502		-122.2	-105.2		61.8	39.5
		g		-112.16	-112.7	-103.3	5.355	87.4	23.5
	in aq HCl; std. state, m = 1	aq			-152.5	-124.9		26.	
	$CHOOC_2H_5$				-139.7				
	$CH_3COOC_2H_5$				-139.6				
	$C_3H_7COOC_2H_5$				-138.4				
	$C_6H_5COOC_2H_5$				-130.6				
$SnCl_6^{2-}$		aq	331.408		-231.9				
$SnOHCl$	std. state, m = 1	aq	171.150		-108.4	-93.7		30.	
$SnOHCl \cdot H_2O$		c	189.166			-155.0			

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Table 26(3) — TIN — July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$SnBr^+$	in aq HBr; std. state, m = 1	aq	198.599		-29.8	-32.4		23.	
$SnBr_2$		c	278.508		-58.2				
		aq			-56.8				
	in aq HBr; std. state, m = 1	aq			-58.8	-57.8		45.	
$SnBr_3^-$	in aq HBr; std. state, m = 1	aq	358.417		-89.6	-82.9		60.	
$SnBr_4$		c	438.326		-90.2	-83.7		63.2	
		g			-75.2	-79.2	5.982	98.43	24.71
	in $HCOOC_2H_5$				-100.5				
	$CH_3COOC_2H_5$				-93.7				
	$HCOOC_4H_9$				-100.0				
	$C_3H_7COOC_2H_5$				-92.3				
	$CH_3COOC_4H_9$				-93.6				
$SnBr_4 \cdot 8H_2O$		c	582.449		-661.5				
		liq			-651.3				
SnOHBr	std. state, m = 1	aq	215.606		-97.4	-86.7		35.	
$SnCl_3Br$		g	304.958				5.508	92.8	23.9
$SnClBr_3$		g	393.870				5.770	97.6	24.4
SnI_2		c	372.499		-34.3				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(4) — TIN — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
SnI_2	in aq HCl	aq			-28.5				
SnI_4		c	626.308						20.3
		g					6.360	106.6	25.2
SnS		c	150.754		-24.	-23.5		18.4	11.77
		g			28.5				
SnS_2		c	182.818					20.9	16.76
$SnSO_4^{2+}$	std. state, m = 1	aq	214.752			-173.1			
$Sn(SO_4)_2$		c	310.813		-389.4				
	std. state, m = 1	aq				-354.2			
SnSe		c	197.65		-21.7				
		g			30.8				
SnTe		c	246.29		-14.6				
		g			38.4				
NH_4SnCl_3	std. state, m = 1	aq	243.088		-148.1	-121.8		89.	
$(NH_4)_2SnCl_6$		c	367.485		-295.6				
		aq			-293.9				
$SnCl_2 \cdot 2.5NH_3$		c	232.172		-144.0				
$SnCl_2 \cdot 4NH_3$		c	257.718		-175.7				
$SnCl_2 \cdot 9NH_3$		c	342.871		-273.0				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(5) — TIN — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$SnBr_2 \cdot NH_3$	c	295.539		-87.				
NH_4SnBr_3 std. state, m = 1	aq	376.456		-121.3	-101.9		87.	
$SnBr_2 \cdot 2NH_3$	c	312.569		-112.9				
$(NH_4)_2SnBr_6$	c	314.585					120.2	63.97
$SnBr_2 \cdot 3NH_3$	c	329.600		-137.2				
$SnBr_2 \cdot 5NH_3$	c	363.661		-180.2				
$SnBr_2 \cdot 9NH_3$	c	431.783		-254.1				
$SnI_2 \cdot NH_3$	c	389.529		-61.				
$SnI_2 \cdot 2NH_3$	c	406.560		-85.3				
$SnI_2 \cdot 3NH_3$	c	423.591		-109.1				
$SnI_2 \cdot 5NH_3$	c	457.652		-153.3				
$SnI_2 \cdot 9NH_3$	c	525.774		-230.5				
$SnCl_4 \cdot 1.5PH_3$	c	311.498		-147.8				
$Sn(CH_3)_2H_2$	liq	150.776		14.5				
	g			21.				
$Sn(CH_3)_3H$	liq	164.803		-2.1				
	g			5.				
$Sn(CH_3)_4$	liq	178.830		-12.5				
	g			-4.5				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 26(6) — TIN — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$Sn(C_2H_5)_2H_2$	liq	178.830		2.1				
	g			11.0				
$Sn(CH_3)_3C_2H_5$	liq	192.857		-16.0				
	g			-7.				
$Sn(CHCH_2)_4$	liq	226.875		72.				
$Sn(C_2H_5)_4$	liq	234.939		-22.9				
	g			-10.9				
$Sn_2(CH_3)_6$	liq	327.590		-21.6				
in C_6H_{12}; cyclohexane				-21.1				
$Sn(CH_3)_2Cl_2$	c	219.666		-80.4				
$Sn(CH_3)_3Br$	liq	243.704		-45.2				
$Sn(CH_3)_3I$	liq	290.700		-32.4				
in CCl_4				-31.2				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(1) — LEAD — July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Pb		c	207.19	0	0	0	1.644	15.49	6.32
		g		46.76	46.6	38.7	1.481	41.889	4.968
	in Hg; saturated				0.007	-0.270		16.42	
Pb^{+}		g		217.795	219.116				
Pb^{2+}		g		564.44	567.25				
	std. state, m = 1	aq			-0.4	-5.83		2.5	
Pb^{3+}		g		1300.93	1305.22				
Pb^{4+}		g		2276.9	2282.7				
Pb^{5+}		g		3864.	3871.				
PbO	yellow	c	223.189	-51.766	-51.94	-44.91	2.507	16.42	10.94
	red	c			-52.34	-45.16		15.9	10.95
$PbO \cdot 1/3H_2O$		c	282.640			-63.7			
PbO_2		c	239.189		-66.3	-51.95		16.4	15.45
Pb_2O_3		c	462.378					36.3	25.74
Pb_3O_4		c	685.568		-171.7	-143.7		50.5	35.1
$PbOH^{+}$	undissoc.; std. state, m = 1	aq	224.197			-54.1			
$HPbO_2^{-}$	std. state, m = 1	aq	240.197			-80.90			
$Pb(OH)_2$		c	241.205			-108.1			
	precipitated	c			-123.3				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(2) — LEAD — July 1965

Formula and Description		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
H_2PbO_2	undissoc.; std. stste, m = 1	aq				-95.8			
$Pb(OH)_3^-$	std. stste, m = 1	aq	258.212			-137.6			
$Pb_3(OH)_4^{2+}$	std. state, m = 1	aq	689.599		-248.0	-212.4		56.	
$Pb_4(OH)_4^{4+}$	std. stste, m = 1	aq	896.769		-254.8	-223.8		56.	
$Pb_6(OH)_8^{4+}$	std. state, m = 1	aq	1379.179		-499.5	-430.3		119.	
PbF^+	std. stste, m = 1	aq	226.188			74.18			
PbF_2		c	245.187		-158.7	-147.5		26.4	
	std. state, m = 1	aq			-159.4	-139.11		-4.1	
	undissoc.; std. stste, m = 1	aq				-142.6			
PbF_4		c	283.184		-225.1				
$PbCl^+$	std. stste, m = 1	aq	242.643			-39.39			
$PbCl_2$		c	278.096		-85.90	-75.08		32.5	
	ionized; std. stste, m = 1	aq			-80.3	-68.57		29.5	
	undissoc.; std. state, m = 1	aq				-71.03			
$PbCl_3^-$	std. state, m = 1	aq	313.549			-101.9			
$PbCl_4$		liq	349.002		-78.7				
	in CCl_4				-77.99				
$PbClO_3^+$	std. stste, m = 1	aq	290.641			-6.2			
$Pb(ClO_3)_2$	undissoc.; std. stste, m = 1	aq	374.092			-6.6			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(3) LEAD July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$PbO \cdot PbCl_2$		c	501.285		-144.7				
$2PbO \cdot PbCl_2$		c	724.475		-199.8				
$3PbO \cdot PbCl_2$		c	947.664		-253.4				
PbClOH		c	259.650			-114.8			
$3Pb(OH)_2 \cdot PbCl_2$		c	1001.710			-505.1			
PbFCl		c	261.641		-127.8	-116.7		29.1	
$PbBr^+$	std. state, m = 1	aq	287.099			-32.2			
$PbBr_2$		c	367.008		-66.6	-62.60		38.6	19.15
	ionized; std. state, m = 1	aq			-58.5	-55.53		41.9	
	undissoc.; std. state, m = 1	aq				-57.5			
$PbBr_3^-$	std. state, m = 1	aq	446.917			-82.0			
$PbBrO_3^+$	std. state, m = 1	aq	335.097			-7.9			
$Pb(BrO_3)_2$		c	463.004			-11.95			
	std. state, m = 1	aq			-40.4	-5.0		80.5	
$PbO \cdot PbBr_2$		c	590.197		-122.9				
$2PbO \cdot PbBr_2$		c	813.387		-177.3				
$3PbO \cdot PbBr_2$		c	1036.576		-231.9				
PbBrF		c	306.097			-108.9			

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National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(4) — LEAD — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
PbI^+	std. state, m = 1	aq	334.094			-20.8			
PbI_2		c	460.999	-41.81	-41.94	-41.50	4.666	41.79	18.49
	ionized; std. state, m = 1	aq			-26.8	-30.49		55.7	
	undissoc.; std. state, m = 1	aq				-34.3			
PbI_3^-	std. state, m = 1	aq	587.903			-47.5			
PbI_4^{2-}	std. state, m = 1	aq	714.808			-60.9			
$Pb(IO_3)_2$		c	556.995		-118.4	-84.0		74.8	
$PbI_2 \cdot HI \cdot 5H_2O$		c	678.988		-400.6				
PbS		c	239.254		-24.0	-23.6		21.8	11.83
$PbSO_3$		c	287.252		-160.1				
$PbSO_4$		c	303.252	-217.82	-219.87	-194.36	4.795	35.51	24.667
PbS_2O_3		c	319.316		-161.1				
PbS_2O_6		aq	367.314		-286.8				
$PbS_2O_6 \cdot 4H_2O$		c	439.376		-568.6				
PbS_3O_6		c	399.378		-290.7				
$PbSO_4 \cdot PbO$		c	526.441		-280.0	-246.7		49.4	
$PbSO_4 \cdot 2PbO$		c	749.630		-334.4	-294.0		65.6	
$PbSO_4 \cdot 3PbO$		c	972.820		-388.8	-341.2		81.4	
PbSe		c	286.15		-24.6	-24.3		24.5	12.0

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National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(5) — LEAD — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$PbSeO_3$		c	334.148		-128.5				
$PbSeO_4$		c	350.148		-145.6	-120.7		40.1	
PbTe		c	334.79		-16.9	-16.6		26.3	12.08
$PbTeO_4$		c	398.788		-180.				
$Pb(N_3)_2$	monoclinic	c	291.230		114.3	149.3		35.4	
	orthorhombic	c			113.8	148.7		35.7	
$PbNO_3^+$	std. state, m = 1	aq	269.195			-33.9			
$Pb(NO_3)_2$		c	331.200		-108.0				
	ionized; std. state, m = 1	aq			-99.5	-59.05		72.5	
	in 40 H_2O				-102.9				
	in 100 H_2O				-101.8				
	in 200 H_2O				-101.2				
	in 400 H_2O				-100.7				
	in 10,000 H_2O				-100.0				
$Pb(N_3)_2 \cdot PbO$		c	514.420			79.6			
$Pb(NO_3)_2 \cdot NH_3$			348.230		-132.5				
$Pb(NO_3)_2 \cdot 3NH_3$		c	382.292		-178.1				
$Pb(NO_3)_2 \cdot 6NH_3$		c	433.383		-233.7				
$PbCl_2 \cdot NH_3$		c	295.127		-110.4				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(6) — LEAD — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$PbCl_2 \cdot 3/2NH_3$	c	303.642		-121.6				
$PbCl_2 \cdot 2NH_3$	c	312.157		-132.6				
$PbCl_2 \cdot 13/4NH_3$	c	333.445		-158.0				
$PbCl_2 \cdot 8NH_3$	c	414.341		-248.3				
$2PbCl_2 \cdot NH_4Cl$	c	609.684		-247.25	-201.49		96.0	
$PbBr_2 \cdot NH_3$	c	384.039		-93.3				
$PbBr_2 \cdot 2NH_3$	c	401.069		-115.8				
$PbBr_2 \cdot 3NH_3$	c	418.100		-136.3				
$PbBr_2 \cdot 5.5NH_3$	c	460.676		-186.0				
$PbBr_2 \cdot 8NH_3$	c	503.253		-233.5				
$PbI_2 \cdot 1/2NH_3$	c	469.514		-54.8				
$PbI_2 \cdot NH_3$	c	478.029		-67.0				
$PbI_2 \cdot 2NH_3$	c	495.060		-89.3				
$PbI_2 \cdot 5NH_3$	c	546.152		-151.2				
$PbI_2 \cdot 8NH_3$	c	597.244		-207.0				
$3PbI_2 \cdot 4NH_4I$	c	1962.768		-314.0				
$3PbI_2 \cdot 4NH_4I \cdot 6H_2O$	c	2070.860		-734.0				
$PbSO_4 \cdot 2NH_3$	c	337.313		-262.8	-199.2		47.2	

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(7) LEAD July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$PbSO_4 \cdot 4NH_3$	c	354.343		-302.4	-207.2		80.7	
$Pb(P_2O_7)^{2-}$ std. state, m = 1	aq	381.133			-479.8			
$Pb(P_2O_7)_2^{6-}$	aq	555.077		-1086.6				
$Pb_3(PO_4)_2$	c	811.513					84.4	61.25
$PbHPO_3$	c	287.170		-234.0				
$PbHPO_4$	c	303.169			-287.5			
$3PbI_2 \cdot PI_3$	c	1794.683		-132.0				
$3PbI_2 \cdot PI_3 \cdot 12H_2O$	c	2010.867		-976.9				
$3PbI_2 \cdot AsI_3$	c	1838.631		-111.6				
$3PbI_2 \cdot AsI_3 \cdot 12H_2O$	c	2054.815		-952.1				
$3PbI_2 \cdot SbI_3$	c	1885.460		-128.4				
$3PbI_2 \cdot SbI_3 \cdot 12H_2O$	c	2101.644		-977.3				
$PbCO_3$	c	267.199		-167.1	-149.5		31.3	20.89
PbC_2O_4	c	295.210		-203.5	-179.3		34.9	25.2
	aq						13.4	
$PbO \cdot PbCO_3$	c	490.389		-219.5	-195.2		48.8	

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 27(8) — LEAD — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$Pb(CH_3)_4$		liq	267.330		23.4				
		g			32.48				
$Pb(CHCH_2)_4$		liq	315.375		213.				
$Pb(C_2H_5)_4$		liq	323.439		12.6				
		g			26.19				
$Pb(O_2CH)^+$	formate; std. state, m = 1	aq	252.208			-90.7			
$Pb(O_2CH)_2$	formate	c	297.226		-210.0				
	ionized; std. state, m = 1	aq			-203.8	-173.57		46.	
	undissoc.; std. state, m = 1	aq				-175.4			
$Pb(O_2CCH_3)^+$	acetate; std. state, m = 1	aq	266.235			-97.1			
$Pb(O_2CCH_3)_2$		c	325.280		-230.36				
	ionized; std. state, m = 1	aq			-232.7	-182.41		43.7	
	undissoc.; std. state, m = 1	aq				-186.4			
	in 400 H_2O	aq			-231.76				
$Pb(O_2CCH_3)_2\ 3H_2O$		c	379.326		-442.52				
$PbCl_2 \cdot PbCO_3$		c	545.295			-227.6			
$Pb(CN)_2 \cdot 2PbO \cdot H_2O$		c	723.620		-123.7				

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Table 27(9) — LEAD — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$PbCNS^+$	std. state, m = 1	aq	265.272			15.1			
$Pb(SCN)_2$	thiocyanate	c	323.354			32.1			
	undissoc.; std. state, m = 1	aq				36.9			
	ionized; std. state, m = 1	aq			36.1	38.47		71.5	
$PbSiO_3$		c	283.274		-273.83	-253.86		26.2	21.52
		amorp			-271.9				
Pb_2SiO_4		c	506.464		-325.8	-299.4		44.6	32.78
		amorp			-322.2				
$PbI_2 \cdot SnI_2$		c	833.498		-64.2				
$PbI_2 \cdot SnI_2 \cdot 8H_2O$		c	977.620		-630.9				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(1) — BORON — July 1965

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
B β	c	10.811	0	0	0	0.290	1.40	2.65
	amorp			0.9		0.315	1.56+x	2.86
	g		133.28	134.5	124.0	1.511	36.65	4.971
B^+	g		324.64	327.34				
B^{++}	g		904.74	908.92				
B^{+++}	g		1779.43	1785.09				
B^{++++}	g		7760.6	7767.8				
B^{+++++}	g		15606.2	15614.9				
B_2	g	21.622	197.	198.5	185.0	2.094	48.23	7.30
BO	g	26.8104	5.26	6.	-1.	2.073	48.62	6.98
BO_2	g	42.8098	-71.99	-71.8	-73.1	2.553	54.84	10.28
BO_2^- std. state, m = 1	aq			-184.60	-162.27		-8.9	
B_2O_2	g	53.6208	-109.01	-108.7	-110.5	2.960	57.93	13.69
B_2O_3	c	69.6202	-302.731	-304.20	-285.30	2.223	12.90	15.04
	amorp			-299.84	-282.6		18.6	14.6
	g		-201.4	-201.67	-198.85	3.426	66.85	15.98
$B_4O_7^{--}$ std. state, m = 1	aq	155.2398			-622.6			
BH	g	11.8190	106.7	107.46	100.29	2.065	41.05	6.97
BH_3	g	13.8349		24.				

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Table 28(2) — BORON — July 1965

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
BH_4^- std. state, m = 1	aq	14.8429		11.51	27.31		26.4	
B_2H_6	g	27.6698	12.29	8.5	20.7	2.857	55.45	13.60
in n-C_5H_{12}; std. state, $x_2 = 1$				6.0	23.0		39.4	
B_4H_{10}	g	53.3237		15.8				
B_5H_9	c	63.1267	13.626					
	liq			10.20	41.03	7.131	44.03	36.12
	g		24.40	17.5	41.8	3.662	65.92	23.13
B_5H_{11}	liq	65.1427		17.5				
	g			24.7				
B_6H_{10}	liq	74.9457		13.45				
	g			22.6				
$B_{10}H_{14}$	c	122.2216	-0.496	-10.8	45.9	6.762	42.20	52.09
	g		18.669	7.54	51.66	5.938	84.4	42.94
HBO_2 cubic	c	43.8178		-192.17				
monoclinic	c			-189.83	-172.9		9.	
orthorhombic	c			-188.52	-172.5		12.	
	g		-133.48	-134.3	-131.7	2.554	57.35	10.09
H_2BOH	g	29.8343			-64.			
$HB(OH)_2$	g	45.8337			-125.			

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Table 28(3) — BORON — July 1965

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
H_3BO_3	c	61.8331	-258.312	-261.55	-231.60		21.23	19.45
	g			-237.6				
un-ionized; std. state, m = 1	aq			-256.29	-231.56		38.8	
in 60 H_2O	aq			-256.355				
100 H_2O				-256.338				
200 H_2O				-256.324				
500 H_2O				-256.314				
1,000 H_2O				-256.31				
5,000 H_2O				-256.304				
10,000 H_2O				-256.30				
$B(OH)_4^-$ std. state, m = 1	aq	78.8405		-321.23	-275.65		24.5	
$H_2BO_3 \cdot H_2O_2^-$ std. state, m = 1	aq	94.8399			-252.8			
$H_2BO_3 \cdot H_3BO_3 \cdot 2H_2O_2^-$ std. state, m = 1	aq	190.6877			-516.7			
$(BOH)_3$	g	83.4551		-289.				
$(HBO_2)_3$	g	131.4533		-544.				
$HB_4O_7^-$ std. state, m = 1	aq	156.2478			-641.8			
$H_2B_4O_7$ std. state, m = 1	aq	157.2557			-650.1			

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(4) BORON July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
BF		g	29.8094	-29.93	-29.2	-35.8	2.078	47.89	7.07
BF_3		g	67.8062	-271.082	-271.75	-267.77	2.784	60.71	12.06
	in 50 H_2O	aq			-296.4				
	in nitrobenzene $C_6H_5NO_2$; std. state, $x_2 = 1$				-280.4	-265.9		25.3	
BF_4^-	std. state, m = 1	aq	86.8046		-376.4	-355.4		43.	
B_2F_4		g	97.6156	-343.48	-344.2	-337.1	4.08	75.8	18.90
BOF		g	45.8088		-145.				
$(BOF)_3$		g	137.4264		-568.				
HBF_4	in 14.67 HF + 58.72 H_2O	aq	87.8126		-375.5				
$B(OH)_2F$		g	63.8241		-249.7				
$BOHF_2$		g	65.8152		-260.9				
$BF_2(OH)_2^-$	std. state, m = 1	aq	82.8225			-320.5			
BF_3OH^-	std. state, m = 1	aq	84.8136		-365.0	-338.1		40.	
$B_3O_3FH_2$		g	101.4455		-383.				
$B_3O_3F_2H$		g	119.4360		-476.				
$B_3F_4O_3OH^{2-}$	std. state, m = 1	aq	173.4322		-753.5				
BCl		g	46.264	35.	35.73	28.90	2.118	50.94	7.57

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(5) — BORON — July 1965

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
BCl_3	liq	117.170	-105.40	-102.1	-92.6	6.88	49.3	25.5
	g		-96.28	-96.50	-92.91	3.362	69.31	14.99
in $(CH_3)_2O$				-147.0				
CH_3COCl				-123.5				
$C_6H_5NO_2$				-110.8				
B_2Cl_4	liq	163.434		-125.0	-111.1		62.7	32.9
	g		-117.09	-117.2	-110.1	4.86	85.4	22.80
$BOCl$	g	62.2634		-75.				
$(BOCl)_3$	g	186.7902		-390.4	-370.5		91.	
$(BOCl)_4$	g	249.0536		-502.				
$B_3O_3H_2Cl$	g	117.9001		-314.				
$B_3O_3HCl_2$	g	152.3452		-339.				
$BClF_2$	g	84.2608		-212.8	-209.4		65.	
BCl_2F	g	100.7154		-154.2	-150.9		68.	
BBr	g	90.720	57.97	56.9	46.7	2.147	53.75	7.87
BBr_3	liq	250.538		-57.3	-57.0		54.9	
	g		-43.83	-49.15	-55.56	3.755	77.47	16.20
in $C_6H_5NO_2$				-69.8				

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(6) BORON July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$BBrF_2$	g	128.7168				3.054	68.42	13.49
$BFBr_2$	g	189.6274				3.386	74.06	14.89
BCl_2Br	g	161.626				3.477	74.16	15.39
$BClBr_2$	g	206.082				3.609	76.90	15.78
BI_3	g	391.5242	18.	17.00	4.96	4.024	83.43	16.92
BS	g	42.875	81.	81.74	69.02	2.085	51.65	7.18
BS_2	g	74.939		29.				
B_2S_2	g	85.750		36.				
B_2S_3	c	117.814		-57.5				
	g			16.				
$SF_4 \cdot BF_3$	c	175.8638		-484.				
BN	c	24.8177	-60.10	-60.8	-54.6	0.628	3.54	4.71
	g		154.	154.75	146.87	2.076	50.71	7.04
$(NH_3)_2 \cdot B_2H_6$	c	58.7074		-46.				
$NH_3 \cdot B_3H_7$ β, tetragonal; ammonia triborane	c	56.5194				6.727	39.63	50.
ammonia triborane	g						68.	

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(7) — BORON — July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$B_3N_3H_6$		liq	80.5009		-129.3	-93.88		47.7	
		g		-116.205	-122.31	-93.24	3.944	68.97	23.14
NH_4BO_2	std. state, m = 1	aq	60.8484		-216.27	-181.24		18.2	
	in 220 H_2O	aq			-216.0				
NH_4BO_3		aq	76.8478		-195.4				
$NH_4BO_3 \cdot \frac{1}{2}H_2O$		c	85.8554		-238.3				
$NH_4B_5O_8 \cdot 4H_2O$		c	224.1519				47.365	92.97	85.34
$NH_3 \cdot BF_3$		c	84.8368		-323.6				
$B_3N_3H_3Cl_3$	β, trichloroborazole	c	183.8360		-255.0				
	β, trichloroborazole	g			-237.8				
BP	cubic	c	41.7848		-19.				
$B_{13}P_2$		c	202.4906		-40.				
$2PH_3 \cdot B_2H_6$		c	95.6652		-27.				
PF_3BH_3		g	101.8039		-204.1				
$POCl_3 \cdot BCl_3$		c	270.5022		-256.3	-220.1		74.	
$PH_3 \cdot BCl_3$		c	151.1677		-120.9	-93.6		46.	
BC		g	22.8222	197.					
BC_2		g	34.8333	181.					

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(8) — BORON — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
B_2C		g	33.6332	181.					
B_4C		c	55.2552	-16.93	-17.	-17.	1.343	6.48	12.62
$B(CH_3)_3$		liq	55.9162		-34.2	-7.7		57.1	
		g		-23.38	-29.7	-8.6	3.831	75.2	21.15
	in n-C_7H_{16}				-34.5				
	$C_6H_5NO_2$				-35.79				
$B(C_2H_5)_3$		liq	97.9974	-42.54	-46.5	2.2	13.02	80.47	57.65
		g			-37.69	3.80		104.6	
BH_3CO		g	41.8455	-25.056	-26.58	-22.2	3.090	59.57	14.21
$BH(OCH_3)_2$	dimethoxyborane	liq	73.8879		-144.7	-113.2		57.	
	dimethoxyborane	g			-138.5	-113.2	4.36	77.4	21.01
$B(OCH_3)_3$	trimethoxyborane	liq	103.9144		-223.2	-178.0	11.45	67.8	45.89
	trimethoxyborane	g			-215.0	-177.0		92.	
$B(OC_2H_5)_3$	triethoxyborane	liq	145.9958		-250.8				
	triethoxyborane	g			-240.4				
$(CH_3)_2O \cdot 2B_2H_6$		g	101.4092		-30.	17.		156.	
$(CH_3)_2O \cdot BF_3$		liq	113.8757		-338.9				
		g			-328.5	-297.8		92.	

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Table 28(9) — BORON — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(C_2H_5)_2O \cdot BF_3$	liq	141.9299		-354.3				
	g			-343.8				
$(CH_3O)_2BCl$ dimethoxychloroborane	liq	108.3329		-186.28				
dimethoxychloroborane	g			-178.2				
$B(OC_2H_5)Cl_2$	liq	126.7786		-157.5				
	g			-149.1				
$CH_3COCl \cdot BCl_3$	liq	195.6686		-168.2				
$B(OC_2H_5)_2Cl$	liq	136.3872		-205.6				
	g			-196.0				
$(CH_3)_2S \cdot BH_3$	liq	75.9690		-20.7	8.4		55.	
	g			-10.6	11.5		78.	
$(C_2H_5)_2S \cdot BH_3$	liq	104.0232		-40.8	1.6		75.0	
	g			-30.5	5.5		96.6	
$BH_3NH_2CH_3$	c	44.8928		-32.2				
$(CH_3)_3N \cdot BH_3$	c	72.9468		-34.06	16.85		44.7	
	g		-11.25	-20.3	20.8	5.27	77.6	30.58
$(CH_3)_3B \cdot NH_3$	c			-67.9	-19.0		52.	
	g			-54.1	-14.4		82.	

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Table 28(10) — BORON — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$B(CH_3)_3 \cdot NH_2CH_3$	c	86.9741		-64.3	-10.5		68.	
	g			-52.6	-6.5		94.	
$(CH_3)_4N \cdot BH_4$	c	88.9898		-38.1	32.1		44.0	
std. state, m = 1	aq			-32.6	28.3		75.2	
$(CH_3)_3N \cdot B(CH_3)_3$	c	115.0281		-66.6	6.9		67.	
	g			-52.6	11.1		100.	
$(C_2H_5)_2NH \cdot B(CH_3)_3$	c	129.0552		-79.2				
	g			-62.9				
$(CH_3)_3NB_3H_7$	c	98.6007				8.732	54.60	51.98
$B(OCH_3)_3 \cdot NH_3$	c	120.9452		-254.				
$B(OCH_2CH_2)_3N$ triethanolamine borate	c	156.9784				6.702	43.78	44.75
$(CH_3)_3N \cdot BF_3$	g	126.9181		-304.4				
$(CH_3)_3P \cdot B(CH_3)_3$	c	131.9952		-81.8				
	g			-68.3				
$BF_3 \cdot P(CH_3)_3$	c	143.8852		-327.4				
	g			-312.6				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 28(11) — BORON — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$(CH_3)_3As \cdot B(CH_3)_3$	c	175.9430		-50.				
$(CH_3)_3As \cdot BF_3$	c	187.8330		-292.				
BSi	g	38.897	173.					
BSi_2	g	66.983	175.					
BSiC	g	50.9082	164.					
$PbO \cdot B_2O_3$ glassy	amorp	292.810		-365.6				26.5
$PbO \cdot 2B_2O_3$ glassy	amorp	362.430		-672.4				41.4

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(1) — ALUMINUM — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Al	c	26.9815	0	0	0	1.094	6.77	5.82
	g		77.44	78.0	68.3	1.654	39.30	5.11
Al^+	g		215.476	217.517				
Al^{2+}	g		649.663	653.185				
Al^{3+}	g		1305.70	1310.70				
std. state, m = 1	aq			-127.	-116.		-76.9	
Al^{4+}	g		4072.71	4079.19				
Al^{5+}	g		7619.73	7627.70				
Al^{6+}	g		12012.2	12021.7				
Al^{7+}	g		17592.7	17603.7				
Al^{8+}	g		24169.8	24182.2				
Al^{9+}	g		31785.	31799.				
Al^{10+}	g		40978.	40993.				
Al^{11+}	g		51170.	51187.				
Al_2	g	53.9630	116.	116.14	103.57	2.33	55.7	8.7
AlO	g	42.9809	21.83	21.8	15.6	2.101	52.17	7.38
AlO_2^- std. state, m = 1	aq	58.9803		-219.6	-196.8		-5.	
Al_2O	g	69.9624	-30.55	-31.	-38.	2.776	61.96	10.92
$(AlO)_2$	g	85.9618		-94.				

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Table 29(2) — ALUMINUM — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula	Description			0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
Al_2O_3	α, corundum	c	101.9612	-397.59	-400.5	-378.2	2.394	12.17	18.89
	δ	c			-398.				
		c			-391.				
		c				-397.			
	γ	c			-395.				
		amorp			-390.				
$Al_2O_3 \cdot H_2O$	boehmite	c	119.9765		-472.0	-436.3		23.15	31.37
	diaspore	c			-478.	-440.		16.86	25.22
$Al_2O_3 \cdot 3H_2O$	gibbsite	c	156.0072		-612.5	-546.7		33.51	44.49
	bayerite	c			-610.1				
AlH		g	27.9895	62.	61.96	55.25	2.071	44.88	7.02
AlH_3		c	20.0054		-11.				
$AlOH^{2+}$	std. state, m = 1	aq	43.9889			-165.9			
$Al(OH)_3$		amorp	78.0036		-305.				
$Al(OH)_4^-$	std. state, m = 1	aq	95.0110		-356.2	-310.2		28.	
AlF		g	45.9799	-61.68	-61.7	-67.8	2.126	51.36	7.63
AlF^{2+}	std. state, m = 1	aq				-192.			
AlF_2^+	std. state, m = 1	aq			-266.				
AlF_3		c	83.9767	-358.02	-359.5	-340.6	2.778	15.88	17.95

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Table 29(3) — ALUMINUM — July 1965

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
AlF_3	g		-287.01	-287.9	-284.0	3.37	66.2	14.97
un-ionized; std. state, m = 1	aq			-363.	-338.		-6.	
ionized; std. state, m = 1	aq			-366.	-316.		-86.8	
in 450 H_2O	aq			-365.5				
AlF_6^{3-}	aq	140.9719		-602.9				
Al_2F_6	g	167.9534		-628.				
AlOF	g	61.9793		-141.				
H_3AlF_6 in 800 HF + 8,000 H_2O		143.9958		-595.0				
AlCl	g	62.4345	-11.44	-11.4	-17.7	2.236	54.50	8.36
$AlCl_2$	g	97.8875		-79.				
$AlCl_3$	c	133.3405	-168.02	-168.3	-150.3	4.104	26.45	21.95
	g			-139.4				
std. state, m = 1	aq			-247.	-210.		-36.4	
in 1,000 H_2O	aq			-247.3				
3,000 H_2O	aq			-247.53				
5,000 H_2O	aq			-247.55				
10,000 H_2O	aq			-247.56				
30,000 H_2O	aq			-247.5				
50,000 H_2O	aq			-247.34				
100,000 H_2O	aq			-247.0				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(4) — ALUMINUM — July 1965

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
$AlCl_3$ in 0.04185 $HCl + 230\ H_2O$	aq			-246.57				
2.072 $HCl + 230\ H_2O$	aq			-245.84				
4.144 $HCl + 230\ H_2O$	aq			-245.08				
8.287 $HCl + 230\ H_2O$	aq			-243.57				
12.431 $HCl + 230\ H_2O$	aq			-242.05				
14.505 $HCl + 230\ H_2O$	aq			-241.99				
16.575 $HCl + 230\ H_2O$	aq			-240.52				
18.649 $HCl + 230\ H_2O$	aq			-239.76				
0.1092 $HCl + 600\ H_2O$	aq			-246.88				
5.405 $HCl + 600\ H_2O$	aq			-246.13				
10.810 $HCl + 600\ H_2O$	aq			-245.37				
21.619 $HCl + 600\ H_2O$	aq			-243.85				
32.429 $HCl + 600\ H_2O$	aq			-242.33				
37.834 $HCl + 600\ H_2O$	aq			-241.56				
43.238 $HCl + 600\ H_2O$	aq			-240.80				
48.643 $HCl + 600\ H_2O$	aq			-240.02				
in $SiCl_4$, std. state, $x_2 = 1$				-165.5	-144.0		15.	
$AlCl_3 \cdot 6H_2O$	c	241.4325		-643.3				
Al_2Cl_6	g	266.6810		-308.5	-291.7		117.	

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(5) — ALUMINUM — July 1965

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
AlOCl	c	78.4339		-189.2				
	g			-81.				
AlBr	g	106.8905	0.74	-1.	-10.	2.281	57.22	8.50
$AlBr_3$	c	266.7085		-126.0				24.3
	g			-101.6				
std. state, m = 1	aq			-214.	-191.		-17.8	
in 3,000 H_2O	aq			-214.2				
$HBr \cdot 8.5\ H_2O$	aq			-205.7				
C_2H_5Br				-126.5				
CH_3I				-126.1				
C_2H_5I				-126.9				
C_6H_6; benzene				-124.6				
$C_6H_5CH_3$; toluene				-125.3				
Al_2Br_6	g	533.4170		-232.0				
AlI	g	153.8859	16.	15.66		2.33		8.60
AlI_3	c	407.6947		-75.0	-71.9		38.	23.6
	g			-49.6				
	aq			-165.8				
std. state, m = 1	aq			-167.	-153.		2.9	

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(6) — ALUMINUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
Al_2I_6	g	815.3894		-123.5				
AlS	g	59.0455	48.	48.02	35.88	2.172	55.09	7.98
Al_2S_3	c	150.1550		-173.				
$Al_2(SO_4)_3$	c	342.1478		-822.38	-740.95		57.2	62.00
	aq			-902.2				
std. state, m = 1	aq			-906.	-766.		-139.4	
$Al_2(SO_4)_3 \cdot 6H_2O$	c	450.2398		-1269.53	-1104.82		112.1	117.8
$Al_2(SO_4)_3 \cdot 18H_2O$	c	666.4239		-2122.1				
$AlCl_3 \cdot \frac{1}{2}SO_2$	c	165.3719		-212.9				
$AlCl_3 \cdot SO_2$	c	197.4033		-253.6				
$AlCl_3 \cdot H_2S$	c	167.4204		-182.4				
$AlBr_3 \cdot H_2S$	c	300.7884		-140.6				
$AlI_3 \cdot 2H_2S$	c	475.8546		-103.1				
Al_2Se_3	c	290.843		-135.				
Al_2Te_3	c	436.763		-78.				
AlN	c	40.9882	-74.80	-76.0	-68.6	0.925	4.82	7.20

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(7) — ALUMINUM — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Al(NO_3)_3$ std. state, m = 1 in 361.6 HCl + 4585 H_2O	aq	212.9962		-276. -271.932	-196.		28.1	
$Al(NO_3)_3 \cdot 6H_2O$	c	321.0882		-681.28	-526.74		111.8	103.5
$Al(NO_3)_3 \cdot 9H_2O$	c	375.1343		-897.96				
$AlCl_3 \cdot NH_3$	c	150.3711		-212.6				
$AlCl_3 \cdot NH_4Cl$	c	186.8321		-256.8				
$AlCl_3 \cdot 3NH_3$	c	184.4323		-283.0				
$AlCl_3 \cdot 5NH_3$	c	218.4936		-339.2				
$AlCl_3 \cdot 6NH_3$	c	235.5242		-363.4				94.
$AlCl_3 \cdot 7NH_3$	c	252.5548		-384.6				
$AlCl_3 \cdot NH_4Cl \cdot 6NH_3$	c	289.0157		-445.4				
$AlCl_3 \cdot 14NH_3$	c	371.7690		-516.3				
$AlBr_3 \cdot NH_3$	c	283.7391		-177.6				
$AlBr_3 \cdot 3NH_3$	c	317.8003		-252.7				
$AlBr_3 \cdot 5NH_3$	c	351.8616		-316.2				
$AlBr_3 \cdot 6NH_3$	c	368.8922		-343.0				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(8) — ALUMINUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$AlBr_3 \cdot 7NH_3$	c	385.9228		-364.7				
$AlBr_3 \cdot 9NH_3$	c	419.9840		-403.5				
$AlBr_3 \cdot 14NH_3$	c	505.1370		-497.2				
$AlI_3 \cdot NH_3$	c	424.7253		-119.0				
$AlI_3 \cdot 3NH_3$	c	458.7865		-205.9				
$AlI_3 \cdot 5NH_3$	c	492.8478		-287.9				
$AlI_3 \cdot 6NH_3$	c	509.8784		-312.9				
$AlI_3 \cdot 7NH_3$	c	526.9090		-335.6				
$AlI_3 \cdot 9NH_3$	c	560.9702		-374.9				
$AlI_3 \cdot 13NH_3$	c	629.0926		-450.0				
$AlI_3 \cdot 20NH_3$	c	748.3069		-580.8				
$NH_4Al(SO_4)_2$	c	237.1433		-562.2	-487.2		51.7	54.12
std. state, m = 1	aq			-593.	-491.		-40.2	
in 500 H_2O	aq			-591.24				
1,000 H_2O	aq			-591.64				
1,500 H_2O	aq			-591.82				
2,000 H_2O	aq			-592.02				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(9) — ALUMINUM — July 1965

Substance: Formula and Description	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$NH_4Al(SO_4)_2$								
in 2,500 H_2O	aq			-592.21				
3,000 H_2O	aq			-592.40				
3,500 H_2O	aq			-592.54				
$NH_4Al(SO_4)_2 \cdot 12H_2O$	c	453.3274		-1420.26	-1180.21		166.6	163.3
$(NH_4)_2O \cdot 3Al_2O_3 \cdot 4SO_3 \cdot 6H_2O$	c	786.3010		-2408.7	-2125.3		164.2	185.3
$(NH_4)_2O \cdot 3Al_2O_3 \cdot 5SO_3 \cdot 9H_2O$	c	920.4101		-2759.3				
AlP	c	57.9553		-39.8				
$AlPO_4$ berlinite	c	121.9529	-411.40	-414.4	-382.7	3.528	21.70	22.27
$AlCl_3 \cdot PH_3$	c	167.3382		-176.9				
$AlBr_3 \cdot PH_3$	c	300.7062		-139.0				
$H_6(NH_4)_3Al_5(PO_4)_8 \cdot 18H_2O$ ammonium taranakite	c	1279.1184	-4364.85	-4433.0	-3863.9	57.185	339.9	380.5
AlAs	c	101.9031		-27.8				
Al_2C_2	g	77.9853	122.					
Al_4C_3	c	143.9594	-48.71	-49.9	-46.9	3.936	21.26	27.91
$Al(CH_3)_3$	c	72.0867	-29.76					
	liq			-32.6	-2.4	8.114	50.05	37.19
	g			-17.7				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(10) — ALUMINUM — July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Al_2(CH_3)_6$	g	144.1734		-55.19	-2.34		125.4	
$(CH_3CO_2)_3Al$ aluminum triacetate	c	204.1165		-452.3				
$(CH_3)_2S \cdot Al(CH_3)_3$	liq	134.2208		-55.				
	g			-44.				
$(CH_3)_3N \cdot AlCl_3$	c	192.4524		-210.1				
$(CH_3)_3N \cdot AlBr_3$	c	325.8204		-170.0				
Al_2SiO_5 andalusite	c	162.0460	-651.84	-655.9	-620.8	4.086	22.28	29.33
kyanite	c		-652.09	-656.4	-620.5	3.834	20.03	29.09
sillimanite	c		-658.62	-662.6	-627.6	4.162	22.99	29.30
$Al_2Si_2O_7 \cdot 2H_2O$								
kaolinite	c	258.1615		-979.6	-903.0		48.5	58.62
halloysite	c			-975.1	-898.5		48.6	58.86
	c			-979.3	-902.3		47.1	57.24
$Al_6Si_2O_{13}$ mullite	c	426.0532		-1903.	-1811.		60.8	77.94
$2AlI_3 \cdot PbI_2$	c	2198.386		-234.				
$2AlI_3 \cdot 3PbI_2 \cdot 10H_2O$	c	2378.539		-1122.				
AlB_2	c	48.6035		-36.				

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Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 29(11) — ALUMINUM — July 1965

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
AlB_{12} α	c	156.7135		-63.6				
$Al(BH_4)_3$	liq	71.5101		-3.9	34.6		69.1	46.5
	g			3.	35.		90.6	

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(1) — GALLIUM — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
Ga		c	69.72	0	0	0	1.331	9.77	6.18
		liq			1.33				
		g		66.	66.2	57.1	1.566	40.38	6.06
Ga^+		g		204.32	206.00				
Ga^{2+}		g		677.38	680.54				
	std. state, m = 1	aq				-21.			
Ga^{3+}		g		1385.	1390.				
	std. state, m = 1	aq			-50.6	-38.0		-79.	
Ga^{4+}		g		2865.	2871.				
Ga_2		g	139.44	105.	104.8				
GaO		g	85.719	67.	66.8	60.6	2.127	55.2	7.66
GaO_3^{3-}	std. state, m = 1	aq	117.718			-148.			
Ga_2O		c	155.439		-88.				
		g			-21.				
Ga_2O_3	β, rhombic	c	187.438		-263.72	242.04		20.31	22.00
GaH		g	70.728	53.	52.7	46.3	2.07	46.69	7.00
GaOH		g	86.727	-27.	-27.4				
$Ga(OH)^{2+}$	std. state, m = 1	aq				-90.9			
$HGaO_2^{2-}$	std. state, m = 1	aq	102.727			-164.			

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(2) — GALLIUM — July 1965

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$Ga(OH)_2^+$ std. state, m = 1	aq	103.735			-142.8			
$H_2GaO_3^-$ std. state, m = 1	aq	119.734			-178.			
$Ga(OH)_3$	c	120.742		-230.5	-198.7		24.	
GaF	g	88.718	-60.	-60.2		2.167		7.95
GaF^{2+} std. state, m = 1	aq			-128.3	-111.1		-54.	
GaF_2^+ std. state, m = 1	aq	107.717		-206.3	-182.8		-35.	
GaF_3	c	126.715		-278.	-259.4		20.	
	aq			-288.1				
GaCl	g	105.173	-19.	-19.1	-25.4	2.29	57.4	8.50
$GaCl_3$	c	176.079		-125.4	-108.7		34.	
	g			-107.0				
	aq			-170.4				
$(GaCl_3)_2$	g	352.158		-233.1				
GaBr	g	149.629	-10.	-11.9	-21.5	2.37	60.2	8.70
$GaBr_3$	c	309.447		-92.4	-86.0		43.	
	aq			-137.				
$GaBr_4^-$ std. state, m = 1	aq	389.356		-158.2	-131.5		8.6	
GaI	g	196.624	7.4	6.9		2.41		8.76

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(3) GALLIUM July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
GaI_3	c	450.433		-57.1				
$(GaI_3)_2$	g	900.866		-76.				
$Ga_2(SO_4)_3$	c	427.625						62.4
Ga_2Te_3	c	522.24						41.2
GaN	c	83.727		-28.2				
	g			40.	34.		54.	
$GaCl_3 \cdot NH_3$	c	193.110		-170.8				
	g			-150.1				
$GaCl_3 \cdot 3NH_3$	c	227.171		-230.7				
$GaCl_3 \cdot 5NH_3$	c	261.232		-285.5				
$GaCl_3 \cdot 6NH_3$	c	278.263		-307.9				
$GaCl_3 \cdot 7NH_3$	c	295.293		-328.3				
$GaCl_3 \cdot 14NH_3$	c	414.508		-460.				
$GaBr_3 \cdot NH_3$	c	326.478		-134.9				
$GaBr_3 \cdot 5NH_3$	c	394.600		-255.0				
$GaBr_3 \cdot 6NH_3$	c	411.631		-279.3				
$GaBr_3 \cdot 7NH_3$	c	428.661		-300.7				
$GaBr_3 \cdot 9NH_3$	c	462.724		-339.				
$GaBr_3 \cdot 14NH_3$	c	547.877		-432.				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(4) — GALLIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$GaI_3 \cdot NH_3$	c	467.464		-96.2				
$GaI_3 \cdot 5NH_3$	c	535.586		-215.5				
$GaI_3 \cdot 6NH_3$	c	552.617		-241.7				
$GaI_3 \cdot 7NH_3$	c	569.647		-263.5				
$GaI_3 \cdot 9NH_3$	c	603.709		-302.5				
$GaI_3 \cdot 13NH_3$	c	671.831		-379.				
$GaI_3 \cdot 20NH_3$	c	791.045		-510.				
GaP	c	100.694		-21.				
$GaPO_4$	c	164.691			-310.1			
$GaCl_3 \cdot PCl_3$	c	313.412		-205.2				
$GaCl_3 \cdot POCl_3$	c	329.411		-278.3				
GaAs	c	144.642		-17.	-16.2		15.34	11.05
GaSb	c	191.47		-10.0	-9.3		18.18	11.60
Ga_2C_2	g	163.462		134.				
$Ga(CH_3)_3$	liq	114.825		-20.4				
	g			-12.5				
$GaCl_3 \cdot CH_3Cl$	c	226.567		-151.3				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 30(5) — GALLIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$2GaCl_3 \cdot CH_3Cl$	c	402.646		-277.3				
$2GaCl_3 \cdot C_2H_5Cl$	c	414.873		-286.5				
$GaCl_3 \cdot CH_3COCl$	c	254.578		-194.9				
$GaCl_3 \cdot (CH_3)_2CO$	c	234.160		-200.0				
$GaCl_3 \cdot (C_2H_5)_2O$	c	250.203		-201.4				
$GaCl_3 \cdot 2(C_2H_5)_2O$	c	324.326		-274.2				
$GaBr_3 \cdot CH_3Br$	c	404.391		-107.5				
$2GaBr_3 \cdot CH_3Br$	c	713.838		-199.8				
$GaCH_3I_2$	c	338.564		-50.9				
$Ga(CH_3)_3 \cdot (CH_3)_2S$	liq	176.959		-47.1				
	g			-35.				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 31(1) — INDIUM — July 1965

Substance	State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
In	c	114.82	0	0	0	1.578	13.82	6.39
	g		58.25	58.15	49.89	1.48	41.51	4.98
In^+	g		191.68	193.06				
std. state, m = 1	aq				-2.9			
In^{2+}	g		626.82	629.68				
std. state, m = 1	aq				-12.1			
In^{3+}	g		1273.2	1277.56				
std. state, m = 1	aq			-25.	-23.4		-36.	
In^{4+}	g		2528.	2534.1				
In_2	g	229.64	91.7	91.04		2.50		
InO	g	130.819	92.	92.5	87.1	2.14	56.5	7.78
In_2O_3	c	277.638		-221.27	-198.55		24.9	22.
InH	g	115.828	52.	51.5	45.49	2.075	49.60	7.07
InOH	g	131.827	-18.	-19.				
$In(OH)^{2+}$ std. state, m = 1	aq			-88.5	-74.8		-21.	
$In(OH)_2^+$ std. state, m = 1	aq	148.835		-148.	-125.5		6.	
InF	g	133.818	-48.2	-48.61		2.198		
InCl II	c	150.273		-44.5				
	g			-18.				
$InCl_3$	c	221.179		-128.4				
	g			-89.4				

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 31(2) — INDIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
In_2Cl_3	g	335.999		-103.6				
InBr	c	194.729		-41.9	-40.4		27.	
	g		-11.5	-13.6	-22.54	2.406	61.99	8.76
$InBr_3$	c	354.547		-102.5				
	g			-67.4				
in $HCl \cdot 20H_2O$				-119.8				
InI	c	241.724		-27.8	-28.8		31.	
	g		2.52	1.8	-9.0	2.437	63.87	8.80
InI_3	c	495.533		-57.				
	g			-28.8				
InS	c	146.884		-33.0	-31.5		16.	
	g			90.		57.		
In_2S	g	261.704		15.	3.1		76.	
In_2S_3	c	325.832		-102.	-98.6		39.1	28.20
In_3S_4	c	472.716		-141.3				
In_4S_5	c	619.600		-180.				
$InSO_4^+$ std. state, m = 1	aq	210.882			-206.5			
$In_2(SO_4)_3$	c	517.825		-666.	-583.		65.	67.
InSe	c	193.78		-28.				
In_2Se_3	c	466.52		-82.				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 31(3) — INDIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
InTe	c	242.42		-23.				
In_2Te_3	c	612.44		-47.				
InN	c	128.827		-4.2				
$InCl_3 \cdot NH_3$	c	238.210		-162.6				
$InCl_3 \cdot 2NH_3$	c	255.240		-195.0				
$InCl_3 \cdot 3NH_3$	c	272.271		-226.6				
$InCl_3 \cdot 5NH_3$	c	306.332		-274.5				
$InCl_3 \cdot 7NH_3$	c	340.393		-315.				
$InCl_3 \cdot 15NH_3$	c	476.638		-466.				
$InBr_3 \cdot 3NH_3$	c	405.639		-198.3				
$InBr_3 \cdot 5NH_3$	c	439.700		-251.3				
$InBr_3 \cdot 7NH_3$	c	473.761		-293.2				
$InBr_3 \cdot 15NH_3$	c	610.006		-450.				
$InI_3 \cdot 2NH_3$	c	529.594		-119.0				
$InI_3 \cdot 5NH_3$	c	580.686		-203.8				
$InI_3 \cdot 7NH_3$	c	614.747		-250.7				
$InI_3 \cdot 9NH_3$	c	648.809		-292.1				
$InI_3 \cdot 13NH_3$	c	716.931		-369.				
$InI_3 \cdot 21NH_3$	c	853.176		-520.				
InP	c	145.794		-21.2	-18.4		14.3	10.86

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES - SERIES I

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 31(4) — INDIUM — July 1965

Substance			ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
InAs	c	189.742		-14.0	-12.8		18.1	11.42
InSb	c	236.57		-7.3	-6.1		20.6	11.82
	g			82.3				
$InSb_2$	g	358.32		75.				
$(InC_2O_4)^+$ std. state, m = 1	aq	202.840			-192.3			
$In(C_2O_4)_2^-$ std. state, m = 1	aq	290.860			-368.			
$InCl_3 \cdot 2(CH_3)_2S$	c	345.447		-161.1				
$InBr_3 \cdot 2(CH_3)_2S$	c	478.815		-145.9				
$InI_3 \cdot 2(CH_3)_2S$	c	619.801		-79.				
$InSCN^{2+}$ std. state, m = 1	aq	172.902			14.4			
$In(CNS)_2^+$ std. state, m = 1	aq	230.984			16.1			
$In(CNS)_3$ un-ionized; std. state, m = 1	aq	289.066			39.4			

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(1) — THALLIUM — July 1965

Substance	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description			0°K	298.15°K (25°C)				
			kcal/mol				cal/deg mol	
Tl	c	204.37	0	0	0	1.632	15.34	6.29
	g		43.701	43.55	35.24	1.481	43.225	4.968
in Hg	liq			0.076	-0.062		15.80	
Tl^+	g		184.553	185.883				
std. state, m = 1	aq			1.28	-7.74		30.0	
Tl^{2+}	g		655.636	658.447				
Tl^{3+}	g		1343.5	1347.8				
std. state, m = 1	aq			47.0	51.3		-46.	
Tl^{4+}	g		2513.	2519.				
Tl_2O	c	424.7394		-42.7	-35.2		30.	
Tl_2O_3	c	456.7382			-74.5			
Tl_2O_4	c	472.7376			-83.0			
TlOH	c	221.3774		-57.1	-46.8		21.	
in 350 H_2O	aq			-54.12				
500 H_2O	aq			-54.18				
750 H_2O	aq			-54.26				
1,000 H_2O	aq			-54.33				
1,500 H_2O	aq			-54.42				
2,000 H_2O	aq			-54.48				
∞ H_2O	aq			-53.69				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(2) THALLIUM July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
TlOH	std. state, m = 1	aq			-53.69	-45.33		27.4	
	undissoc.; std. state, m = 1	aq				-46.4			
$TlOH^{2+}$	std. state, m = 1	aq				-3.8			
$Tl(OH)_2^+$	std. state, m = 1	aq	238.3848			-58.5			
$Tl(OH)_3$		c	255.3922			-121.2			
TlF		c	223.3684		-77.6				
		g			-43.6				
	std. state, m = 1	aq			-78.22	-74.38		26.7	
	undissoc.; std. state, m = 1	aq				-74.5			
	in 800 H_2O	aq			-78.5				
$TlHF_2$		c	243.3748				4.308	34.92	21.25
	in 800 H_2O	aq			-154.3				
TlCl		c	239.8230	-49.091	-48.79	-44.20	3.030	26.59	12.17
		g			-16.2				
	std. state, m = 1	aq			-38.67	-39.11		43.5	
	undissoc.; std. state, m = 1	aq			-41.10	-39.91		41.3	
$TlCl^{2+}$	std. state, m = 1	aq			1.0	9.7		-19.	
$TlCl_2^+$	std. state, m = 1	aq	275.2760		-43.0	-29.6		7.	
$TlCl_2^-$	std. state, m = 1	aq				-70.7			
$TlCl_3$		c	310.7290		-75.3				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(3) — THALLIUM — July 1965

Substance: Formula and Description	State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
			0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$TlCl_3$	aq			-84.0				
std. state, m = 1	aq			-72.9	-42.8		-5.5	
undissoc.; std. state, m = 1	aq			-84.0	-65.6		32.	
$TlCl_3 \cdot 4H_2O$	c	382.7906		-359.4				
$TlCl_4^-$ std. state, m = 1	aq	346.1820		-124.1	-100.8		58.	
Tl_2Cl_2	g	479.6460		-49.4				
$TlClO_3$ std. state, m = 1	aq	287.8212		-22.4	-8.5		68.8	
undissoc.; std. state, m = 1	aq				-9.18			
TlBr	c	284.2790		-41.4	-40.00		28.8	
	g			-9.0				
std. state, m = 1	aq			-27.77	-32.59		49.7	
undissoc.; std. state, m = 1	aq			-30.22	-33.90		45.93	
$TlBr^{2+}$ std. state, m = 1	aq			9.0	13.5		-13.	
$TlBr_2^+$ std. state, m = 1	aq	364.1880		-26.1	-21.4		20.	
$TlBr_2^-$ std. state, m = 1	aq			-53.8	-58.8		84.	
$TlBr_3$	aq	444.0970		-59.7				
std. state, m = 1	aq			-40.2	-23.2		13.	
undissoc.; std. state, m = 1	aq			-59.7	-53.7		49.	
$TlBr_3 \cdot 4H_2O$	c	516.1586		-335.2				
$TlBr_4^-$ std. state, m = 1	aq	524.0060		-90.9	-84.2		80.	

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(4) THALLIUM July 1965

Substance			ΔHf_0°	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C_p°
Formula and Description	State	Formula Weight	0 °K	298.15 °K (25 °C)				
			kcal/mol				cal/deg mol	
$TlBrO_3$	c	332.2772		-32.6	-12.70		40.3	
std. state, m = 1	aq			-18.7	-7.3		69.0	
$TlBrCl^-$ std. state, m = 1	aq	319.7320			-65.1			
$TlCl_2Br$	aq	355.1850		-75.9				
$TlCl_2Br \cdot 4H_2O$	c	427.2466		-352.0				
$TlBr_2Cl$	aq	399.6410		-67.8				
$TlClBr_2 \cdot 4H_2O$	c	471.7026		-344.1				
TlI	c	331.2744		-29.6	-29.97		30.5	
	g			1.7				
std. state, m = 1	aq			-11.91	-20.07		56.6	
undissoc.; std. state, m = 1	aq				-22.1			
TlI_2^- std. state, m = 1	aq	458.1788			-35.1			
TlI_4^- std. state, m = 1	aq	711.987			-39.3			
$TlIO_3$	c	379.2726		-63.9	-45.86		42.2	
std. state, m = 1	aq			-51.6	-38.3		58.3	
$TlIBr^-$ std. state, m = 1	aq	411.1834			-48.0			
Tl_2S	c	440.8040		-23.2	-22.4		36.	
$TlSO_4^-$ std. state, m = 1	aq	300.4316		-216.26	-187.6		40.	
Tl_2SO_4	c	504.8016		-222.7	-198.49		55.1	
std. state, m = 1	aq			-214.76	-193.45		64.8	

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(5) — THALLIUM — July 1965

Substance		State	Formula Weight	ΔHf_0°	ΔHf°	ΔGf°	$H_{298}^\circ - H_0^\circ$	S°	C_p°
Formula and Description				0 °K	298.15 °K (25 °C)				
				kcal/mol				cal/deg mol	
$TlHSO_4$	in $H_2SO_4 \cdot 30H_2O$	aq	301.4395		-212.4				
Tl_2Se		c	533.6824		-14.	-14.1		41.	
Tl_2SeO_4		c	551.6976		-151.	-126.4		56.	
$Te(SeO_3)_3$		c	789.6146			-215.4			
Tl_2Te		c	536.3400		-22.				
TlN_3		c	246.3901		55.8	70.38		35.1	
$TlNO_3$		c	266.3749		-58.30	-36.44		38.4	23.78
	std. state, m = 1	aq			-48.28	-34.35		65.0	
	undissoc.; std. state, m = 1	aq			-48.93	-34.85		64.5	
$TlNO_3^{2+}$	std. state, m = 1	aq				21.6			
$TlNH_3^+$	std. state, m = 1	aq	221.4007			-12.9			
$TlCl \cdot 3NH_3$		c	290.9151		-102.6				
$TlCl_3 \cdot 3NH_3$		c	361.8211		-135.0				
$TlBr \cdot 3NH_3$		c	335.3711		-95.3				
$TlI \cdot 3NH_3$		c	382.3665		-83.5				
Tl_2CO_3		c	468.7493		-167.3	-146.9		37.1	
$TlOCH_3$		c	235.4045		-27.5				
$Tl(CH_3CO_2)$		c	263.4150		-126.1				
		aq			-115.8				

National Bureau of Standards — Washington, D. C.

Enthalpy and Gibbs Energy of Formation; Entropy and Heat Capacity

Table 32(6) — THALLIUM — July 1965

Substance		State	Formula Weight	ΔHf°_0	ΔHf°	ΔGf°	$H^\circ_{298} - H^\circ_0$	S°	C°_p
Formula and Description				0°K	298.15°K (25°C)				
				kcal/mol				cal/deg mol	
$Tl(CH_3CO_2)$	std. state, m = 1	aq			-114.88	-96.03		50.7	
$TlOC_2H_5$		liq	249.4311		-56.5				
		aq			-56.0				
$Tl(CN)_4^-$	std. state, m = 1	aq	308.4412			168.			
TlONC	thallous fulminate	c	246.3872		27.6				
TlCNS		c	262.4518		6.8	9.21		39.	
	std. state, m = 1	aq			19.55	14.41		64.5	
	undissoc.; std. state, m = 1	aq			16.59	13.32		58.2	

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