

ANEXO 7 DATOS TERMODINMICOS DE ALGUNOS ELEMENTOS Y COMPUESTOS QUE SE ENCUENTRAN EN PROCESOS METALURGICOS

Table 13-11. Thermodynamic Data^a on Some Elements and Compounds Encountered in Ferrous Metallurgical Processes—Continued.

Substance	$-\Delta H_{298}^{\circ}$	S_{298}°	$C_p = a + bT - cT^{-2}$			Temp. Range °C	l.p. °C	m.p. °C	h.p. °C	ΔH_f	ΔH_f	Remarks
			a	$b \times 10^4$	$c \times 10^5$							
$Ca_3P_2O_8$	45.2	53.03	14.76	11.16	25-1140	1140	1353	dec.	1600	24,100		
Ca_2SiO_4	342,400	25.5	16.78	23.60	25-1100	1193	1465	dec.	(6,700)			
Ca_2SiO_5	27,000 ^a	40.3	49.85	8.62	25-1300	697; 1437	2130	dec.	440; 3390		from its oxides.	
Ca_2SiO_6	30,200 ^a	30.5	34.87	9.74	25-697	697; 1437	2130	dec.			from its oxides.	
$CaSiO_3$	21,500 ^a	19.6	26.64	3.60	25-1180	1190	1540	dec.	(1300)	(13,400)	from its oxides.	
$CaTiO_3$	0	16.64	5.70	3.98	25-730	730	804	2927	300	2,200		
Ce	0	16.64	8.20	—	730-804	—	804	2927	300	2,200		
CeO_2	245,000	17.7	8.00	—	804-2700	—	> 2600	—	—	—		
CeS	118,000	15.1	15.1	—	25-100	—	—	—	—	—		
Co	0	7.18	4.74	4.00	25-437	437; 1120	1495	2877	105; 0	-4,100		
CoO	57,100	12.65	2.16	7.02	437-1120	—	1495	2877	105; 0	-4,100		
Co_2O_3	216,300	24.5	17.49	-1.92	1120-1495	—	1805	dec.	—	—		
Co_3O_4	197,000	(1110.0)	9.00	—	1495-2900	—	834	dec.	—	—		
Co_3S_8	20,400	13.6	30.84	2.04	25-1700	—	835	dec.	—	—		
$Co_3S_8^{*}$	75,000	—	—	—	25-1700	—	835	dec.	—	—		
$Co_3S_8^{**}$	33,500	—	—	—	25-1700	—	625	dec.	—	—		
Cr	0	5.68	4.16	3.62	25-1903	1835	1903	2665	—	5,000		
Cr_2O_3	272,650	19.4	9.40	—	1903-2700	—	—	dec.	—	—		
CrO_2	139,400	17.2	28.53	2.20	25-1500	—	(2400)	dec.	—	—		
CrO_3	140,000	18.0	11.01	16.40	25-500	—	185	dec.	—	—		
Cr_2N	28,200	8.0	12.20	—	25-500	—	—	—	—	—		
Cr_3C_6	98,300	151.8	169.16	42.66	25-1400	—	1520	—	—	—		
$Cr_3C_6^{*}$	44,100	48.0	56.96	14.54	25-1200	—	1780	—	—	—		
$Cr_3C_6^{**}$	23,200	20.4	30.03	5.58	25-1300	—	1890	—	—	—		
Cr	0	7.97	5.41	1.50	25-1084	—	1084	2547	—	3,120		
Cr_2O	40,400	22.45	7.50	—	1084-2500	—	1230	dec.	—	(13,400)		
			14.90	5.70	25-900	(56)	—	—	—	—		

^a See appropriate "Remarks." (a) See note at end of table.

Table 13—II. Thermodynamic Data* on Some Elements and Compounds Encountered in Ferrous Metallurgical Processes—Continued.

Substance	-ΔH _f ⁰	S ₂₉₈ ⁰	$C_p = a + bT - cT^{-2}$			Temp. Range °C	tp, °C	mp, °C	bp, °C	ΔH _f	ΔH _f	Remarks
			a	b × 10 ⁴	c × 10 ⁶							
MgC ₂	-21,000	14.0										
MgAl ₂ O ₄	19,25	19.25	36.80	6.40	9.78	25-1500	—	dec.	—	—	—	from its oxides.
Mg ₂ CO ₃	262,000	15.7	18.62	13.80	4.16	25-500	—	dec.	—	—	—	from its oxides.
Mg ₃ P ₂ O ₇	110,940*											from its oxides.
Mg ₂ SiO ₄	15,100*	22.75	35.81	6.54	8.52	25-1500	—	1590	—	—	—	from its oxides.
MgSiO ₃	8,700*	16.2	24.55	4.74	6.28	25-1300 +	—	1560	—	—	—	from its oxides; dieneustatic.
Mg ₂ TiO ₇		21.8	35.96	8.54	6.89	25-1500	—	1830	—	—	—	
Mg ₂ TiO ₆		17.8	28.29	3.28	6.53	25-1500	—	1840	—	—	—	
Mg ₂ Ti ₂ O ₇		30.4	40.68	9.20	7.35	25-1700	—	—	—	—	—	
Mn	0	7.60	5.70	3.38	0.37	25-727	727, 1101, 1137	1244	2095	535, 545, 430	3,500	
"Mn ₂ O"	92,000	14.3	8.33	0.66	—	727-1101	—	—	—	—	—	
"Mn ₂ O ₂ "	331,400	35.5	10.70	—	—	1101-1137	—	—	—	—	—	
"Mn ₂ O ₃ "			11.30	—	—	1137-1244	—	—	—	—	—	
"Mn ₂ O ₄ "			11.00	—	—	1244-2000	—	—	—	—	—	
"Mn ₂ O ₅ "	229,400	26.4	24.73	8.38	3.23	25-1500	-56	1785	dec.	—	—	
"Mn ₂ O ₆ "	124,300	12.7	16.60	2.44	3.88	25-550	250	dec.	—	—	—	
Mn ₂ S	49,000	18.7	11.40	1.80	—	25-1530	—	1530	—	—	—	
"Mn ₂ N"	31,200		16.00	—	—	1530-1700	—	—	—	—	—	
"Mn ₂ N ₂ "	55,200		21.15	30.50	—	25-500	—	—	—	—	—	
Mn ₂ P ₂ O ₇	105,230*		30.55	38.40	—	25-500	—	—	—	—	—	
Mn ₂ SiO ₄	11,800*	39.0										from its oxides.
Mn ₂ SiO ₃	5,900*	21.3	26.42	3.88	6.16	25-1200	—	1270	—	—	—	from its oxides.
MnO	0	6.83	5.18	1.66	—	25-2617	—	2600	5550	—	6,650	
"MnO ₂ "	139,500	13.6	10.00	—	—	2617-2700	—	dec.	—	—	—	
"MnO ₃ "	178,200	18.6	20.73	5.18	4.18	25-795	—	795	1100	—	12,500	
"Mn ₂ O ₇ "			32.00	—	—	795-1100	—	—	—	—	—	
Mn ₂ S ₃	102,000	28.0										
"Mn ₂ N"	16,600	(21.0)	11.19	13.80	—	25-500	—	2690	—	—	—	
"Mn ₂ C"	-4,200	(19.8)										
N ₂	0	45.77	6.83	0.90	0.12	25-2700	-237.5	-210	-196	—	172	
NH ₃	11,000	45.97	7.11	6.00	0.37	25-1500	—	-78	-33.5	—	1,352	
Na	0	12.3	4.02	9.04	—	25-98	—	98	905	—	622	
			6.83	1.05	—	98-905	—	—	—	—	—	

Substance	-H ₂₉₈ ^o	S ₂₉₈ ^o	C _p = a + bT + cT ²			Temp. Range °C	f.p. °C	m.p. °C	b.p. °C	ΔH _f	ΔH _f	Remarks
			a	b × 10 ³	c × 10 ⁶							
Na ₂ O	100,700	17.0	15.70	5.40	—	25-920	—	920	dec.	—	—	
Na ₂ S	92,400	23.5	19.81	1.64	—	25-700	—	950	—	—	(1,600)	from its oxides.
NaAlO ₂	20,900 ^o	16.9	19.18	7.14	3.36	25-467	—	—	—	310	—	
			20.21	4.24	—	467-1400	—	—	—	—	—	
Na ₂ CO ₃	271,600	32.5	27.13	15.62	4.78	25-851	359; 481	851	dec.	—	7,100	
			45.00	—	—	851-1200	—	—	—	—	—	
Na ₂ SiO ₃	55,500 ^o	27.2	31.14	9.60	6.47	25-1088	—	1088	—	—	12,470	from its oxides.
			42.80	—	—	1088-1700	—	—	—	—	—	
			44.38	16.86	10.67	25-874	678	874	—	1700	8,500	from its oxides.
			62.35	—	—	874-1700	—	—	—	—	—	
Ni	0	7.12	4.06	7.04	—	25-360	360	1452	2910	0	4,210	
			6.00	1.80	—	360-1452	—	—	—	—	—	
			9.20	—	—	1452-2900	—	—	—	—	—	
			—	37.58	—	25-252	252; 292	1960	dec.	0; 0	—	
			13.88	—	—	252-292	—	—	—	—	—	
			11.18	2.02	—	292-1700	—	—	—	—	—	
			9.25	6.40	—	25-300	396	>800	dec.	630	—	
"NiS" ^a	22,200	16.1	9.25	—	—	25-2700	-250	-219	-183	224; 178	106	
O ₂	0	49.02	7.16	1.00	0.40	25-2700	—	—	—	—	—	
P ^o	0	9.80	5.50	—	—	25-44	—	44	280	—	150	white
			5.88	—	—	44-130	—	Sub.	590	—	—	
P ^o	4,400	5.46	4.74	3.90	—	25-500	—	—	—	—	—	red.
P ₂ ^o	-33,600	52.1	8.31	0.46	0.72	25-1700	—	—	—	—	—	gas.
P ₂ O ₃	370,000	32.5	8.38	54.00	—	25-358	—	570	600	—	(5,800)	
S	0	7.62	3.58	6.24	—	25-95	95	119	444	85	335	
			6.20	—	—	95-119	—	—	—	—	—	
			8.73	—	—	419-444	—	—	—	—	—	
S ₂	-31,000	54.4	8.72	0.16	0.90	25-2700	—	—	—	—	—	
SO	6,000	53.1	8.26	0.32	1.00	25-2700	—	—	—	—	—	
SO ₂	70,950	59.25	11.04	1.88	1.84	25-1700	—	-76	-10	—	1,770	
Si	0	4.53	5.70	0.70	1.04	25-1412	—	1413	2600	—	12,100	
			6.10	—	—	1412-1700	—	—	—	—	—	
SiO	22,200	50.55	7.70	0.74	0.70	25-1700	—	—	—	—	—	alpha-quartz.
SiO ₂ ^o	218,500	10.0	11.22	8.20	2.70	25-575	575	(1610)	—	290	—	
			14.41	1.94	—	575-1700	—	—	—	—	—	
			4.28	21.06	—	25-250	250	1713	dec.	200	3,600	beta-cristobalite.
SiO ₂	217,600	10.2	14.40	2.04	—	250-1713	—	—	—	—	—	

^a See appropriate "Remarks."

(a) See note at end of table.

Substance	- ΔH_{fus}	S_{298}^{gas}	$C_p = a + bT - cT^{-2}$			Temp. Range °C	f.p. °C	m.p. °C	b.p. °C	ΔH_f	ΔH_g
			a	$b \times 10^4$	$c \times 10^{-6}$						
Si, N ₂	179,000	23.0	16.83	23.60	—	25–600	—	—	—	—	
SiC	12,400	3.95	9.97	1.82	3.64	25–1700	>2700	—	—	—	
Th	0	12.76	5.17	4.56	—	25–1400	1400	1695	4227	670	
			11.00	—	—	1400–1695	—	—	—	—	
			11.00	—	—	1695–2700	—	—	—	—	
ThO ₂	293,200	15.6	15.84	2.88	1.60	25–1700	—	(3000)	—	—	
Th	0	7.33	5.25	2.52	—	25–882	882	1667	3260	950	
			7.50	—	—	882–1667	—	—	—	—	
			8.00	—	—	1667–2700	—	—	—	—	
"TO"	123,900	8.3	10.57	3.60	1.86	25–991	991	1760	—	820	
"TO ₂ "	225,500	12.0	11.85	3.00	—	991–1760	—	—	—	—	
"TN"	80,400	7.4	17.97	0.28	4.35	25–1500	—	dec.	—	—	
"TC"	43,900	5.8	11.91	0.94	2.96	25–1700	—	2950	dec.	—	
			11.83	0.80	3.58	25–1700	—	3150	—	—	
V	0	7.0	4.90	2.58	–0.20	25–1917	—	1917	3350	—	
			9.50	—	—	1917–2700	—	—	—	—	
VO	102,000	9.3	11.32	3.22	1.26	25–1700	—	1700	—	5,050	
VO ₂	294,000	23.5	29.35	4.76	5.42	25–1500	—	>2000	—	—	
VO ₂	171,000	12.3	14.96	—	—	25–72	72	1545	—	1,025	
			17.85	1.70	3.95	72–1545	—	—	—	—	
			25.50	—	—	1545–2700	—	—	—	—	
VO ₃	371,800	31.3	46.54	–3.90	13.22	25–670	—	670	dec.	15,500	
			45.60	—	—	—	—	—	—	—	
"VN"	60,000	8.9	10.94	2.10	2.21	25–1500	—	(2050)	—	—	
"VC"	(12,500)	6.77	9.18	3.30	1.95	25–1400	—	(2850)	—	—	
W	0	8.0	5.74	0.76	—	25–2700	—	3380	(5400)	—	
"WO ₃ "	200,000	19.9	(17.75)	(5.87)	—	25–1473	720	1473	(1850)	—	
WC	9,100	8.5	(7.98)	(2.17)	—	25–2700	—	dec.	—	—	
Zn	0	9.95	5.35	2.40	—	25–420	—	420	907	—	
			7.50	—	—	420–907	—	—	—	—	
ZnO	83,200	10.4	11.71	1.22	2.18	25–1700	—	1975	—	—	
ZnS	48,200	13.8	12.16	1.24	1.36	25–900	1020	dec.	—	(3,200)	
Zr	0	9.3	6.50	1.42	0.82	25–862	862	1857	(4750)	915	
			7.90	—	—	862–1857	—	—	—	—	
			8.00	—	—	1857–2700	—	—	—	—	
"ZnO ₂ "	250,500	12.1	16.64	1.80	3.36	25–1205	1205	2700	(4300)	1,420	
ZnN	67,300	9.3	11.10	1.68	1.72	25–1400	—	2950	—	—	
"ZnC"	44,100	8.5	—	—	—	—	—	3500	—	—	
ZnSiO ₃	20,2	20.2	31.48	3.92	8.08	25–1500	—	2430	—	—	