Nd – Sb (Neodymium – Antimony)

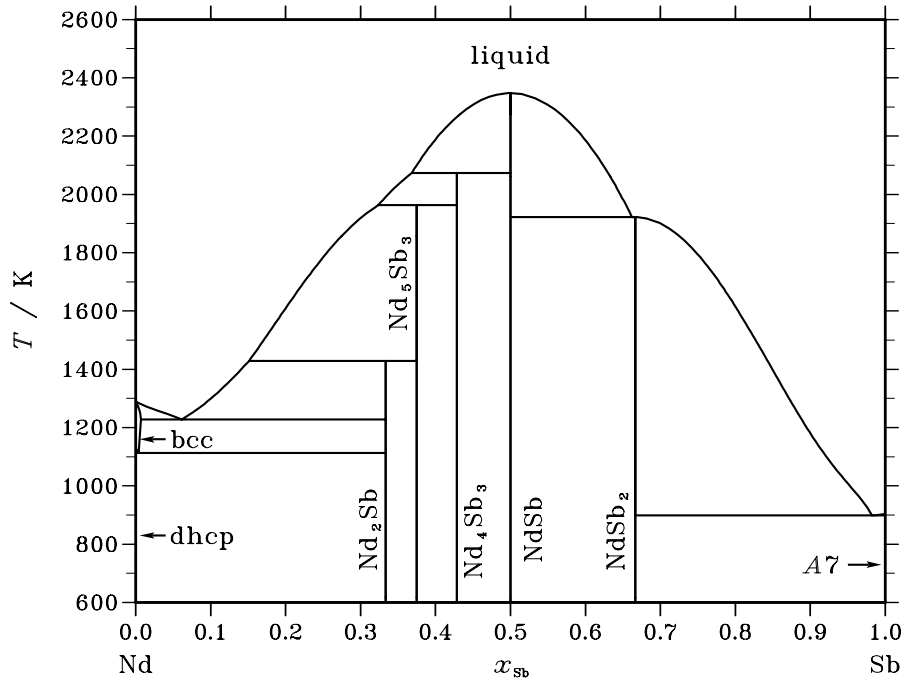

Fig. 1. Calculated phase diagram for the system Nd-Sb.

The thermodynamic assessment of the Nd-Sb system was carried out by Cacciamani *et al.* [92Cac]. The phase diagram was experimentally studied by [72Kob] and [88Abd] using various techniques. The system is characterised by five intermediate compounds: Nd_2Sb, Nd_5Sb_3, Nd_4Sb_3, NdSb and $NdSb_2$. NdSb melts congruently at a temperature much higher than the melting temperatures of the elements. The other compounds, however, decompose peritectically. Two eutectic equilibria are present at compositions very near to the pure elements. The Nd_2Sb was not reported by [72Kob] but is was found later by [85Bor] during a calorimetric investigation of the system. All the intermediate phases were described as stoichiometric compounds. The enthalpies of formation of the Nd-Sb compounds calorimetrically determined by [77Bor] and [82Bor] agree well with those derived from the temperature dependence of the vapour pressure data of [84Vik]. Experimental and calculated invariant equilibria agree satisfactorily.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Nd,Sb)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Nd,Sb)_1$
dhcp	$A3'$	αLa	$hP4$	$P6_3/mmc$	DHCP	Nd_1
Nd_2Sb	···	···	$tI12$	$I4/mmm$	NDPR2SB1	Nd_2Sb_1
Nd_5Sb_3	$D8_8$	Mn_5Si_3	$hP16$	$P6_3/mcm$	NDPR5SB3	Nd_5Sb_3
Nd_4Sb_3	$D7_3$	Th_3P_4	$cI28$	$I\overline{4}3d$	NDPR4SB3	Nd_4Sb_3
NdSb	$B1$	NaCl	$cF8$	$Fm\overline{3}m$	NDPR1SB1	Nd_1Sb_1
$NdSb_2$	···	···	$oC24$	$Cmca$	NDPR1SB2	Nd_1Sb_2
$A7$	$A7$	αAs	$hR2$	$R\overline{3}m$	RHOMBOHEDRAL_A7	Sb_1

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Sb}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid $\rightleftharpoons$ NdSb	congruent	2347.9	0.500	0.500		−50504
liquid + NdSb $\rightleftharpoons$ Nd_4Sb_3	peritectic	2072.9	0.368	0.500	0.429	−23847
liquid + Nd_4Sb_3 $\rightleftharpoons$ Nd_5Sb_3	peritectic	1962.9	0.324	0.429	0.375	−20233
liquid $\rightleftharpoons$ $NdSb_2$	congruent	1922.3	0.667	0.667		−31105
liquid $\rightleftharpoons$ NdSb + $NdSb_2$	eutectic	1921.9	0.662	0.500	0.667	−31320
liquid + Nd_5Sb_3 $\rightleftharpoons$ Nd_2Sb	peritectic	1429.3	0.151	0.375	0.333	−6342
liquid $\rightleftharpoons$ bcc + Nd_2Sb	eutectic	1227.9	0.061	0.007	0.333	−10556
bcc $\rightleftharpoons$ dhcp + Nd_2Sb	eutectoid	1113.0	0.004	0.000	0.333	−3277
liquid $\rightleftharpoons$ $NdSb_2$ + $A7$	eutectic	898.6	0.982	0.667	1.000	−19793

Table IIIa. Integral quantities for the liquid phase at 2500 K.

x_{Sb}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	$G_{\mathrm{m}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{m}}^{\mathrm{E}}$ [J/(mol·K)]	ΔC_P [J/(mol·K)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−23499	−25112	−0.645	−16742	−3.348	0.000
0.200	−43288	−49330	−2.417	−32887	−6.577	0.000
0.300	−58877	−69269	−4.157	−46179	−9.236	0.000
0.400	−68971	−82472	−5.401	−54982	−10.996	0.000
0.500	−72686	−87417	−5.892	−58278	−11.656	0.000
0.600	−69661	−83507	−5.539	−55672	−11.134	0.000
0.700	−60084	−71080	−4.398	−47387	−9.477	0.000
0.800	−44668	−51400	−2.693	−34267	−6.853	0.000
0.900	−24534	−26665	−0.852	−17777	−3.555	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Nd(liquid), Sb(liquid)

Table IIIb. Partial quantities for Nd in the liquid phase at 2500 K.

x_{Nd}	ΔG_{Nd} [J/mol]	ΔH_{Nd} [J/mol]	ΔS_{Nd} [J/(mol·K)]	$G_{\mathrm{Nd}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Nd}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Nd}	γ_{Nd}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−2060	195	0.902	130	0.026	0.906	1.006
0.800	−7439	−4201	1.295	−2800	−0.560	0.699	0.874
0.700	−19788	−18561	0.491	−12374	−2.475	0.386	0.551
0.600	−40931	−45470	−1.815	−30313	−6.063	0.140	0.233
0.500	−70889	−84721	−5.533	−56481	−11.296	0.033	0.066
0.400	−107925	−133319	−10.157	−88879	−17.776	0.006	0.014
0.300	−148675	−185474	−14.719	−123649	−24.730	0.001	0.003
0.200	−188527	−232609	−17.633	−155073	−31.014	0.000	0.001
0.100	−223431	−263354	−15.969	−175569	−35.114	0.000	0.000
0.000	$-\infty$	−263549	∞	−175699	−35.140	0.000	0.000

Reference state: Nd(liquid)

Table IIIc. Partial quantities for Sb in the liquid phase at 2500 K.

x_{Sb}	ΔG_{Sb} [J/mol]	ΔH_{Sb} [J/mol]	ΔS_{Sb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Sb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Sb}}$ [J/(mol·K)]	a_{Sb}	γ_{Sb}
0.000	$-\infty$	−241985	∞	−161323	−32.265	0.000	0.000
0.100	−216445	−252874	−14.572	−168583	−33.716	0.000	0.000
0.200	−186687	−229849	−17.265	−153232	−30.646	0.000	0.001
0.300	−150084	−187587	−15.001	−125058	−25.012	0.001	0.002
0.400	−111031	−137976	−10.778	−91984	−18.397	0.005	0.012
0.500	−74483	−90112	−6.252	−60075	−12.015	0.028	0.056
0.600	−44151	−50300	−2.459	−33533	−6.707	0.120	0.199
0.700	−22117	−22054	0.025	−14703	−2.941	0.345	0.493
0.800	−8704	−6098	1.042	−4065	−0.813	0.658	0.822
0.900	−2434	−366	0.827	−244	−0.049	0.889	0.988
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Sb(liquid)

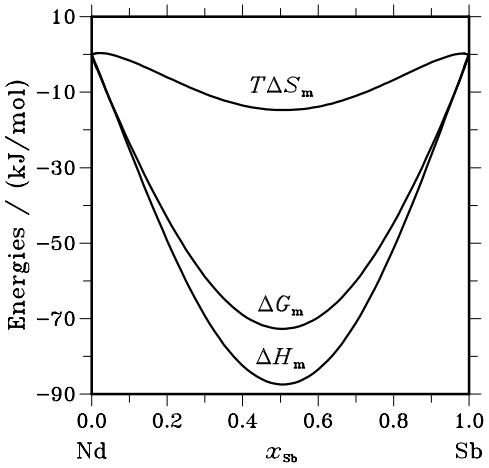

Fig. 2. Integral quantities of the liquid phase at T=2500 K.

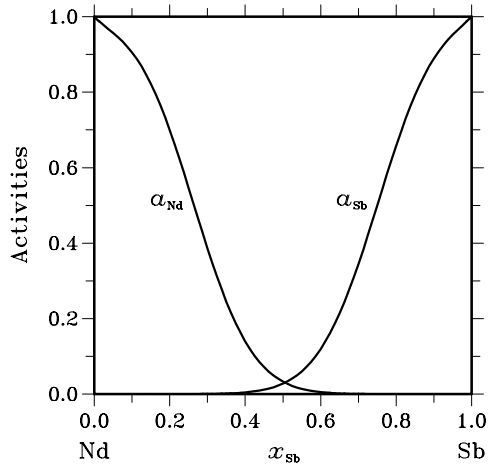

Fig. 3. Activities in the liquid phase at T=2500 K.

Table IV. Standard reaction quantities at 298.15 K for the compounds per mole of atoms.

Compound	x_{Sb}	$\Delta_{\mathrm{f}}G^{\circ}$ / (J/mol)	$\Delta_{\mathrm{f}}H^{\circ}$ / (J/mol)	$\Delta_{\mathrm{f}}S^{\circ}$ / (J/(mol·K))	$\Delta_{\mathrm{f}}C^{\circ}_{P}$ / (J/(mol·K))
Nd_2Sb_1	0.333	−95064	−99000	−13.200	0.000
Nd_5Sb_3	0.375	−103958	−107740	−12.684	0.000
Nd_4Sb_3	0.429	−112121	−116000	−13.012	0.000
Nd_1Sb_1	0.500	−119511	−123260	−12.572	0.000
Nd_1Sb_2	0.667	−89668	−90803	−3.806	0.000

References

[72Kob] G.F. Kobzenko, V.B. Chernogorenko, E.L. Martinchuk, K.A. Lynchak, R.V. Skolozdra: Russ. Metall. **3** (1972) 176–177.
[77Bor] A. Borsese, R. Ferro, R. Capelli, S. Delfino: J. Less-Common Met. **55** (1977) 77–83.
[82Bor] G. Borzone, A. Borsese, G. Zanicchi, R. Ferro: J. Therm. Anal. **25** (1982) 433–440.
[84Vik] G.Sh. Viksman, S.P. Gordienko: Izv. Akad. Nauk SSSR, Neorg. Mater. **20** (1984) 1441–1444.
[85Bor] G. Borzone, A. Borsese, S. Delfino, R. Ferro: Z. Metallkd. **76** (1985) 208–213.
[88Abd] M.N. Abdusalyamova, O.I. Rahmatov, N.D. Faslyeva, A.G. Tchuiko: J. Less-Common Met. **141** (1988) L23–L26.
[92Cac] G. Cacciamani, R. Ferro, H.L. Lukas: Z. Metallkd. **83** (1992) 669–672.