Nb – W (Niobium – Tungsten)

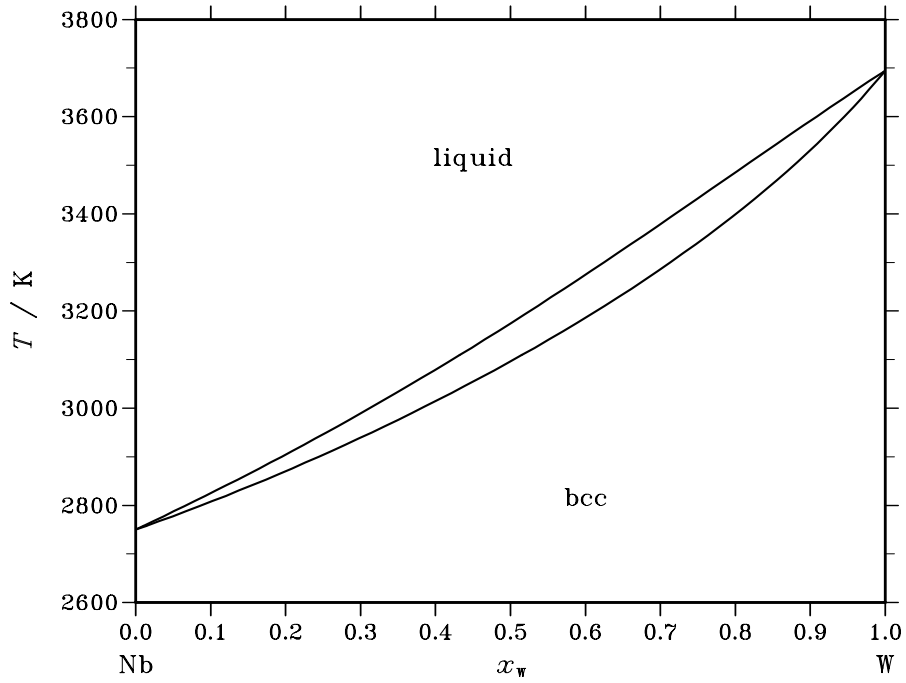

Fig. 1. Calculated phase diagram for the system Nb-W.

Niobium and tungsten are important additions to many alloys, such as superalloys and refractory alloys. The Nb-W system is fairly simple with only two condensed stable phases, liquid and bcc. Due to the high melting temperatures, experimental data are only available for the solidus. The reported solidus temperatures scatter widely. The assessment of [97Hua] agrees well with the phase diagram data of [69Rud] and the enthalpies of mixing predicted from Miedema's model [83Nie].

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Nb,W)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Nb,W)_1$

Table IIa. Integral quantities for the liquid phase at 3700 K.

x_{W}	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	−11865	−3064	2.379	−1864	−0.324	0.000
0.200	−18708	−5447	3.584	−3314	−0.576	0.000
0.300	−23142	−7149	4.322	−4350	−0.757	0.000
0.400	−25675	−8170	4.731	−4971	−0.865	0.000
0.500	−26502	−8511	4.862	−5178	−0.901	0.000
0.600	−25675	−8170	4.731	−4971	−0.865	0.000
0.700	−23142	−7149	4.322	−4350	−0.757	0.000
0.800	−18708	−5447	3.584	−3314	−0.576	0.000
0.900	−11865	−3064	2.379	−1864	−0.324	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Nb(liquid), W(liquid)

Table IIb. Partial quantities for Nb in the liquid phase at 3700 K.

x_{Nb}	ΔG_{Nb} [J/mol]	ΔH_{Nb} [J/mol]	ΔS_{Nb} [J/(mol·K)]	$G_{\mathrm{Nb}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Nb}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Nb}	γ_{Nb}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−3448	−340	0.840	−207	−0.036	0.894	0.993
0.800	−7693	−1362	1.711	−828	−0.144	0.779	0.973
0.700	−12837	−3064	2.641	−1864	−0.324	0.659	0.941
0.600	−19029	−5447	3.671	−3314	−0.576	0.539	0.898
0.500	−26502	−8511	4.862	−5178	−0.901	0.423	0.845
0.400	−35645	−12256	6.321	−7456	−1.297	0.314	0.785
0.300	−47188	−16681	8.245	−10149	−1.765	0.216	0.719
0.200	−62768	−21788	11.076	−13256	−2.306	0.130	0.650
0.100	−87613	−27575	16.226	−16777	−2.918	0.058	0.580
0.000	$-\infty$	−34043	∞	−20712	−3.603	0.000	0.510

Reference state: Nb(liquid)

Table IIc. Partial quantities for W in the liquid phase at 3700 K.

x_{W}	ΔG_{W} [J/mol]	ΔH_{W} [J/mol]	ΔS_{W} [J/(mol·K)]	$G_{\mathrm{W}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{W}}^{\mathrm{E}}$ [J/(mol·K)]	a_{W}	γ_{W}
0.000	$-\infty$	−34043	∞	−20712	−3.603	0.000	0.510
0.100	−87613	−27575	16.226	−16777	−2.918	0.058	0.580
0.200	−62768	−21788	11.076	−13256	−2.306	0.130	0.650
0.300	−47188	−16681	8.245	−10149	−1.765	0.216	0.719
0.400	−35645	−12256	6.321	−7456	−1.297	0.314	0.785
0.500	−26502	−8511	4.862	−5178	−0.901	0.423	0.845
0.600	−19029	−5447	3.671	−3314	−0.576	0.539	0.898
0.700	−12837	−3064	2.641	−1864	−0.324	0.659	0.941
0.800	−7693	−1362	1.711	−828	−0.144	0.779	0.973
0.900	−3448	−340	0.840	−207	−0.036	0.894	0.993
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(liquid)

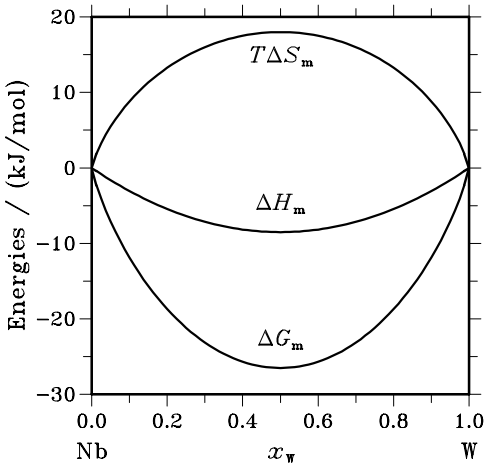

Fig. 2. Integral quantities of the liquid phase at T=3700 K.

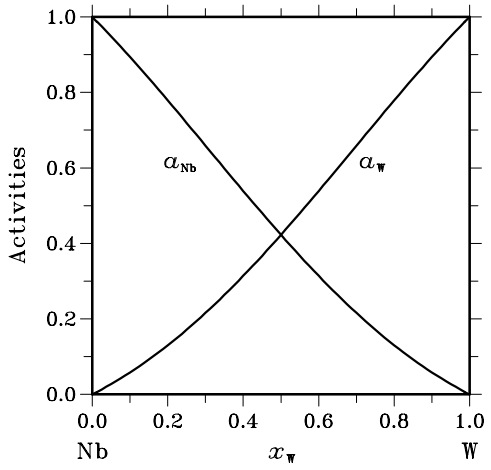

Fig. 3. Activities in the liquid phase at T=3700 K.

Table IIIa. Integral quantities for the stable phases at 1500 K.

Phase	x_{W}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{m}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{m}}$ [J/(mol·K)]	ΔC_P [J/(mol·K)]
bcc	0.000	0	0	0.000	0	0.000	0.000
	0.100	−6325	−3091	2.156	−2271	−0.547	0.000
	0.200	−10278	−5495	3.189	−4037	−0.972	0.000
	0.300	−12917	−7212	3.804	−5299	−1.276	0.000
	0.400	−14449	−8242	4.138	−6056	−1.458	0.000
	0.500	−14953	−8586	4.245	−6308	−1.518	0.000
	0.600	−14449	−8242	4.138	−6056	−1.458	0.000
	0.700	−12917	−7212	3.804	−5299	−1.276	0.000
	0.800	−10278	−5495	3.189	−4037	−0.972	0.000
	0.900	−6325	−3091	2.156	−2271	−0.547	0.000
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Nb(bcc), W(bcc)

Table IIIb. Partial quantities for Nb in the stable phases at 1500 K.

Phase	x_{Nb}	ΔG_{Nb} [J/mol]	ΔH_{Nb} [J/mol]	ΔS_{Nb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Nb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Nb}}$ [J/(mol·K)]	a_{Nb}	γ_{Nb}
bcc	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−1566	−343	0.815	−252	−0.061	0.882	0.980
	0.800	−3792	−1374	1.612	−1009	−0.243	0.738	0.922
	0.700	−6719	−3091	2.419	−2271	−0.547	0.583	0.834
	0.600	−10408	−5495	3.275	−4037	−0.972	0.434	0.723
	0.500	−14953	−8586	4.245	−6308	−1.518	0.302	0.603
	0.400	−20511	−12364	5.432	−9084	−2.187	0.193	0.483
	0.300	−27379	−16828	7.034	−12364	−2.976	0.111	0.371
	0.200	−36221	−21980	9.494	−16149	−3.887	0.055	0.274
	0.100	−49155	−27818	14.225	−20438	−4.920	0.019	0.194
	0.000	$-\infty$	−34343	∞	−25232	−6.074	0.000	0.132

Reference state: Nb(bcc)

Table IIIc. Partial quantities for W in the stable phases at 1500 K.

Phase	x_W	ΔG_W [J/mol]	ΔH_W [J/mol]	ΔS_W [J/(mol·K)]	G_W^E [J/mol]	S_W^E [J/(mol·K)]	a_W	γ_W
bcc	0.000	$-\infty$	−34343	∞	−25232	−6.074	0.000	0.132
	0.100	−49155	−27818	14.225	−20438	−4.920	0.019	0.194
	0.200	−36221	−21980	9.494	−16149	−3.887	0.055	0.274
	0.300	−27379	−16828	7.034	−12364	−2.976	0.111	0.371
	0.400	−20511	−12364	5.432	−9084	−2.187	0.193	0.483
	0.500	−14953	−8586	4.245	−6308	−1.518	0.302	0.603
	0.600	−10408	−5495	3.275	−4037	−0.972	0.434	0.723
	0.700	−6719	−3091	2.419	−2271	−0.547	0.583	0.834
	0.800	−3792	−1374	1.612	−1009	−0.243	0.738	0.922
	0.900	−1566	−343	0.815	−252	−0.061	0.882	0.980
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(bcc)

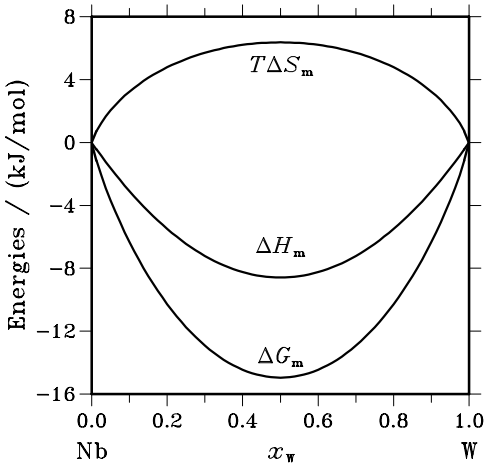

Fig. 4. Integral quantities of the stable phases at T=1500 K.

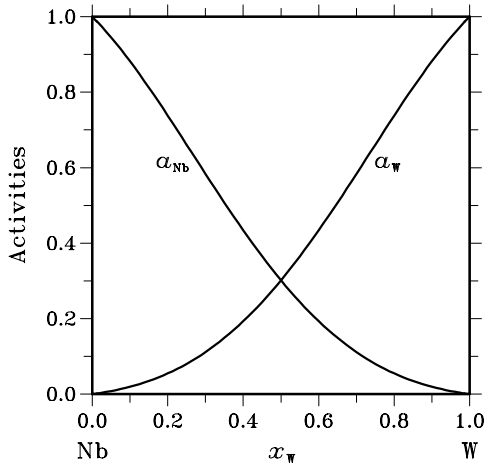

Fig. 5. Activities in the stable phases at T=1500 K.

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