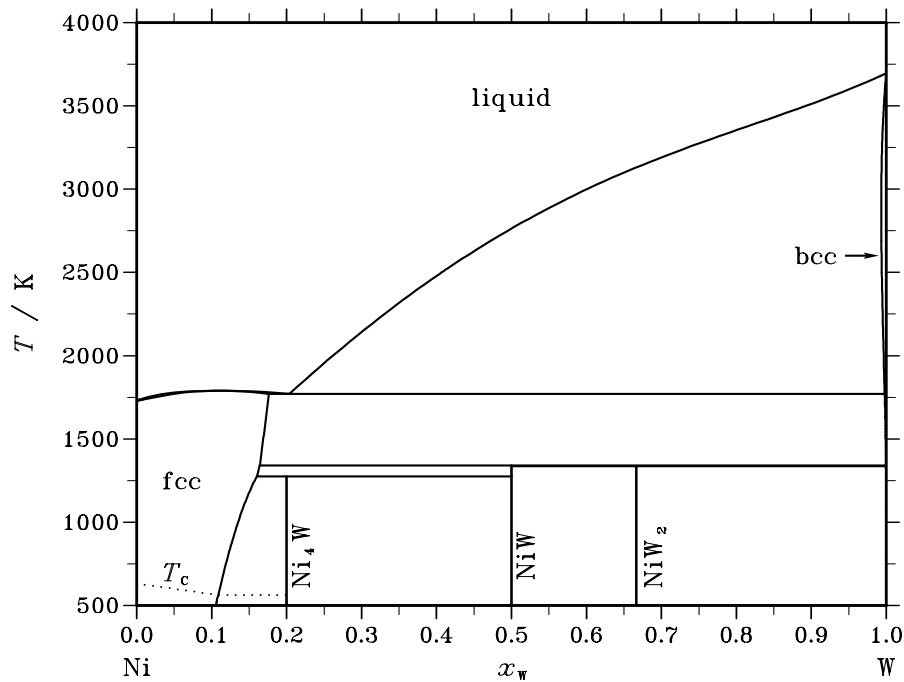


Ni – W (Nickel – Tungsten)**Fig. 1.** Calculated phase diagram for the system Ni-W.

Nickel and tungsten are important element additions to many alloys, such as superalloys. The Ni-W system is fairly simple at temperatures above 1350 K with only three condensed stable phases, liquid, fcc and bcc. Below 1350 K the formation of three intermetallic phases, Ni_4W , NiW and NiW_2 , via peritectoid reactions has been reported. The width of the homogeneity ranges of these intermetallic phases is unknown. Several descriptions of the Ni-W system have been developed. The most complete description of the system is given by the work of [87Gus] and [86Fer]. [87Gus] developed the descriptions for the liquid, fcc and bcc phases from phase diagram data and the W activity in the fcc phase. Because of the lack of sufficient experimental information on the homogeneity ranges of the three intermetallic phases, [86Fer] described them as stoichiometric. Their parameters were determined from the temperatures of the peritectoid reactions and tie-lines in the ternary Fe-Ni-W system.

Table I. Phases, structures and models.

Phase	Struktur- bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(\text{Ni},\text{W})_1$
fcc	A1	Cu	$cF4$	$Fm\bar{3}m$	FCC_A1	$(\text{Ni},\text{W})_1$
Ni_4W	$D1_a$	MoNi_4	$tI10$	$I4/m$	D1A_NI4W	Ni_4W_1
NiW	...	MoNi	o^{**}	...	NIW	Ni_1W_1
NiW_2	$tI96$	$I4$	NIW2	Ni_1W_2
bcc	A2	W	$cI2$	$Im\bar{3}m$	BCC_A2	$(\text{Ni},\text{W})_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{W}			$\Delta_{\text{r}}H / (\text{J/mol})$
liquid \rightleftharpoons fcc	congruent	1789.5	0.109	0.109		–22984
liquid \rightleftharpoons fcc + bcc	eutectic	1771.1	0.204	0.176	0.998	–26319
fcc + bcc \rightleftharpoons NiW	peritectoid	1340.8	0.164	1.000	0.500	–3638
NiW + bcc \rightleftharpoons NiW ₂	peritectoid	1336.6	0.500	1.000	0.667	–10
fcc + NiW \rightleftharpoons Ni ₄ W	peritectoid	1275.1	0.160	0.500	0.200	–808
Ni ₄ W \rightleftharpoons fcc + NiW	eutectoid	400.6	0.200	0.106	0.500	–748

Table IIIa. Integral quantities for the liquid phase at 1873 K.

x_{W}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	G_{m}^{E} [J/mol]	S_{m}^{E} [J/(mol·K)]	ΔC_P [J/(mol·K)]
0.000	0	0	0.000	0	0.000	0.000
0.100	–4367	5066	5.036	695	2.334	0.000
0.200	–5267	10884	8.623	2526	4.462	0.001

Reference states: Ni(liquid), W(bcc)

Table IIIb. Partial quantities for Ni in the liquid phase at 1873 K.

x_{Ni}	ΔG_{Ni} [J/mol]	ΔH_{Ni} [J/mol]	ΔS_{Ni} [J/(mol·K)]	G_{Ni}^{E} [J/mol]	S_{Ni}^{E} [J/(mol·K)]	a_{Ni}	γ_{Ni}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	–2254	–421	0.979	–613	0.102	0.865	0.961
0.800	–5567	–1324	2.265	–2092	0.410	0.699	0.874

Reference state: Ni(liquid)

Table IIIc. Partial quantities for W in the liquid phase at 1873 K.

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}
0.000	– ∞	46002	∞	374	24.361	0.000	1.024
0.100	–23392	54446	41.558	12466	22.413	0.223	2.227
0.200	–4066	59714	34.053	20998	20.671	0.770	3.851

Reference state: W(bcc)

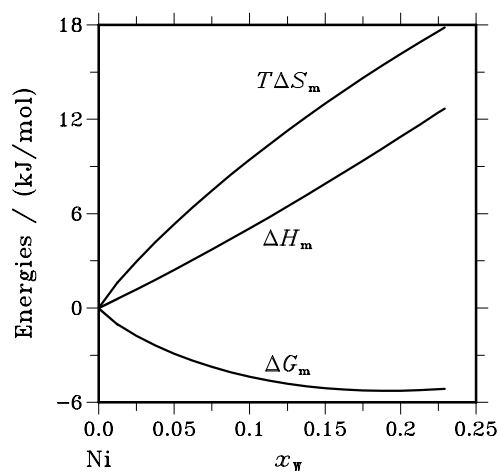


Fig. 2. Integral quantities of the liquid phase at $T=1873$ K.

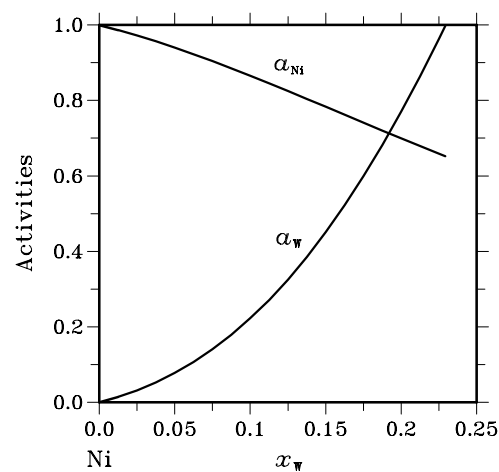


Fig. 3. Activities in the liquid phase at $T=1873$ K.

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

Compound	x_W	$\Delta_f G^\circ$ / (J/mol)	$\Delta_f H^\circ$ / (J/mol)	$\Delta_f S^\circ$ / (J/(mol·K))	$\Delta_f C_P^\circ$ / (J/(mol·K))
Ni ₄ W ₁	0.200	−2154	−1101	3.531	−0.612
Ni ₁ W ₁	0.500	−3557	−3523	0.114	−0.382
Ni ₁ W ₂	0.667	−2373	−2350	0.076	−0.255

References

- [86Fer] A. Fernández Guillermet, L. Östlund: Metall. Trans. A **17A** (1986) 1809–1823.
 [87Gus] P. Gustafson, A. Gabriel, I. Ansara: Z. Metallkd. **78** (1987) 151–156.