Fe – V (Iron – Vanadium)

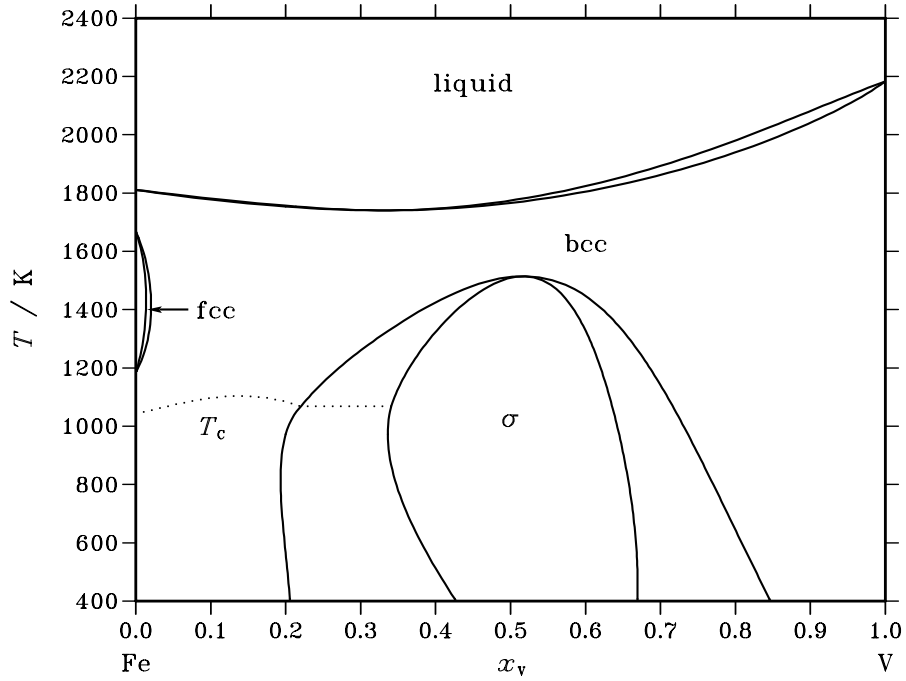

Fig. 1. Calculated phase diagram for the system Fe-V.

There is complete solubility in the liquid and bcc phases in this system. The fcc phase is stable in a narrow "gamma-loop" close to pure Fe. Below the solidus there is a σ-phase stable with a wide composition range. There are many similarities with the Cr-Fe system. In steels V is used as carbide former and it can have high amounts in some tool steels. The present assessment [91Hua] is still the most used in various databases.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Fe,V)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Fe,V)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Fe,V)_1$
σ	$D8_b$	σCrFe	$tP30$	$P4_2/mnm$	D8B_SIGMA	$(Fe,V)_{10}V_4(Fe,V)_{16}$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_V		$\Delta_r H$ / (J/mol)
liquid $\rightleftharpoons$ bcc	congruent	1740.4	0.331	0.331	−13521
bcc $\rightleftharpoons$ σ	congruent	1514.8	0.517	0.517	−2972

Table IIIa. Integral quantities for the liquid phase at 2193 K.

x_{V}	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	−7940	−2386	2.532	−2012	−0.171	0.000
0.200	−13028	−4569	3.857	−3904	−0.303	0.000
0.300	−16691	−6425	4.681	−5552	−0.398	0.000
0.400	−19107	−7833	5.141	−6836	−0.455	0.000
0.500	−20270	−8670	5.289	−7631	−0.474	0.000
0.600	−20087	−8813	5.141	−7816	−0.455	0.000
0.700	−18406	−8140	4.681	−7267	−0.398	0.000
0.800	−14988	−6529	3.857	−5864	−0.303	0.000
0.900	−9410	−3856	2.532	−3482	−0.171	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Fe(liquid), V(liquid)

Table IIIb. Partial quantities for Fe in the liquid phase at 2193 K.

x_{Fe}	ΔG_{Fe} [J/mol]	ΔH_{Fe} [J/mol]	ΔS_{Fe} [J/(mol·K)]	$G_{\mathrm{Fe}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Fe}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Fe}	γ_{Fe}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−1961	−81	0.857	−40	−0.019	0.898	0.998
0.800	−4391	−489	1.780	−323	−0.076	0.786	0.982
0.700	−7597	−1467	2.795	−1093	−0.171	0.659	0.942
0.600	−11911	−3262	3.944	−2597	−0.303	0.520	0.867
0.500	−17717	−6118	5.289	−5079	−0.474	0.378	0.757
0.400	−25491	−10279	6.936	−8783	−0.682	0.247	0.618
0.300	−35909	−15992	9.082	−13956	−0.929	0.140	0.465
0.200	−50188	−23501	12.169	−20842	−1.213	0.064	0.319
0.100	−71670	−33052	17.610	−29685	−1.535	0.020	0.196
0.000	$-\infty$	−44888	∞	−40732	−1.895	0.000	0.107

Reference state: Fe(liquid)

Table IIIc. Partial quantities for V in the liquid phase at 2193 K.

x_{V}	ΔG_{V} [J/mol]	ΔH_{V} [J/mol]	ΔS_{V} [J/(mol·K)]	$G_{\mathrm{V}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{V}}^{\mathrm{E}}$ [J/(mol·K)]	a_{V}	γ_{V}
0.000	$-\infty$	−24470	∞	−20314	−1.895	0.000	0.328
0.100	−61747	−23128	17.610	−19762	−1.535	0.034	0.338
0.200	−47574	−20888	12.169	−18228	−1.213	0.074	0.368
0.300	−37910	−17993	9.082	−15957	−0.929	0.125	0.417
0.400	−29901	−14690	6.936	−13194	−0.682	0.194	0.485
0.500	−22822	−11222	5.289	−10183	−0.474	0.286	0.572
0.600	−16485	−7835	3.944	−7171	−0.303	0.405	0.675
0.700	−10905	−4775	2.795	−4401	−0.171	0.550	0.786
0.800	−6188	−2286	1.780	−2119	−0.076	0.712	0.890
0.900	−2492	−612	0.857	−571	−0.019	0.872	0.969
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: V(liquid)

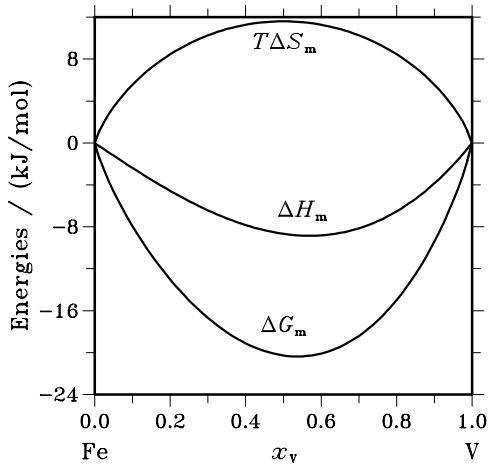

Fig. 2. Integral quantities of the liquid phase at T=2193 K.

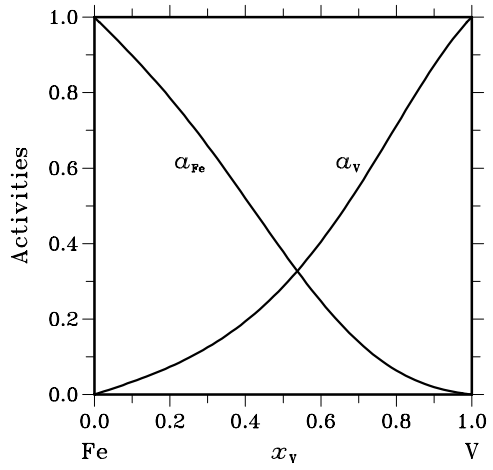

Fig. 3. Activities in the liquid phase at T=2193 K.

Table IVa. Integral quantities for the stable phases at 1700 K.

Phase	x_{V}	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	−6080	−1643	2.610	−1485	−0.093	0.257
	0.200	−9950	−3048	4.060	−2877	−0.100	0.131
	0.300	−12719	−4149	5.041	−4084	−0.038	−0.299
	0.400	−14561	−5052	5.593	−5048	−0.002	−0.547
	0.500	−15473	−5692	5.754	−5676	−0.010	−0.534
	0.600	−15366	−5895	5.571	−5853	−0.025	−0.435
	0.700	−14108	−5529	5.047	−5474	−0.033	−0.326
	0.800	−11511	−4491	4.130	−4438	−0.031	−0.218
	0.900	−7242	−2681	2.683	−2647	−0.020	−0.109
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Fe(bcc), V(bcc)

Table IVb. Partial quantities for Fe in the stable phases at 1700 K.

Phase	x_{Fe}	ΔG_{Fe} [J/mol]	ΔH_{Fe} [J/mol]	ΔS_{Fe} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Fe}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Fe}}$ [J/(mol·K)]	a_{Fe}	γ_{Fe}
bcc	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−1514	−77	0.845	−25	−0.031	0.898	0.998
	0.800	−3412	−577	1.668	−258	−0.188	0.786	0.982
	0.700	−5835	−1169	2.745	−794	−0.221	0.662	0.945
	0.600	−9011	−1854	4.210	−1790	−0.038	0.529	0.881
	0.500	−13368	−3452	5.833	−3571	0.070	0.388	0.777
	0.400	−19309	−6275	7.667	−6357	0.048	0.255	0.638
	0.300	−27327	−10327	10.000	−10309	−0.011	0.145	0.482
	0.200	−38362	−15750	13.301	−15613	−0.080	0.066	0.331
	0.100	−55015	−22740	18.985	−22469	−0.160	0.020	0.204
	0.000	$-\infty$	−31496	∞	−31074	−0.248	0.000	0.111

Reference state: Fe(bcc)

Table IVc. Partial quantities for V in the stable phases at 1700 K.

Phase	x_V	ΔG_V [J/mol]	ΔH_V [J/mol]	ΔS_V [J/(mol·K)]	G_V^E [J/mol]	S_V^E [J/(mol·K)]	a_V	γ_V
bcc	0.000	$-\infty$	−16568	∞	−14836	−1.019	0.000	0.350
	0.100	−47172	−15731	18.495	−14626	−0.650	0.036	0.355
	0.200	−36103	−12931	13.630	−13354	0.249	0.078	0.389
	0.300	−28781	−11102	10.399	−11763	0.389	0.131	0.435
	0.400	−22886	−9849	7.669	−9935	0.050	0.198	0.495
	0.500	−17578	−7932	5.674	−7780	−0.089	0.288	0.577
	0.600	−12737	−5641	4.174	−5516	−0.074	0.406	0.677
	0.700	−8443	−3473	2.924	−3401	−0.042	0.550	0.786
	0.800	−4798	−1676	1.837	−1644	−0.019	0.712	0.890
	0.900	−1933	−452	0.871	−444	−0.005	0.872	0.969
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: V(bcc)

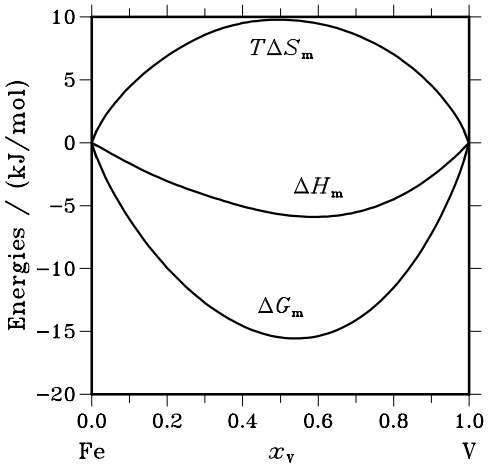

Fig. 4. Integral quantities of the stable phases at T=1700 K.

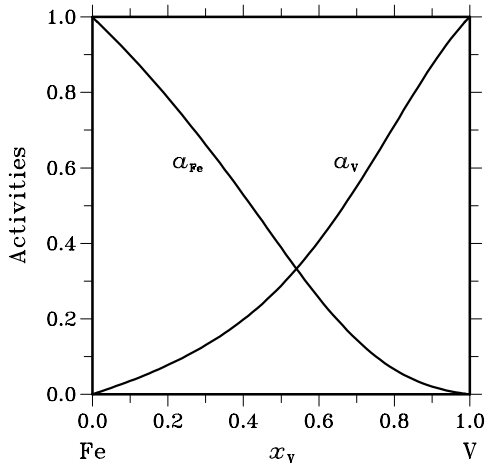

Fig. 5. Activities in the stable phases at T=1700 K.

References

[91Hua] W. Huang: Z. Metallkd. **82** (1991) 391–401.