Eu – Sn (Europium – Tin)

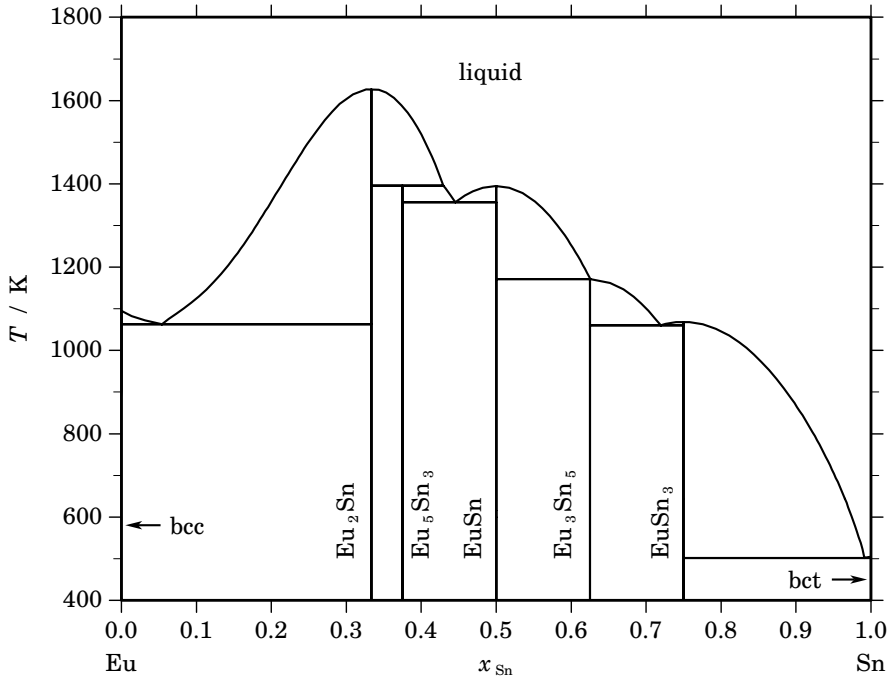

Fig. 1. Calculated phase diagram for the system Eu-Sn.

A review on the Eu-Sn system and a thermodynamic assessment has been given by [2004Liu]. The optimisation is based mostly on data for the phase diagram which have been reported in [1998Pal] throughout the whole composition range. Some additional thermodynamic data have been available from the literature. Bacha *et al.* [1973Bac] have obtained by EMF experiments the enthalpy of formation of $EuSn_3$ as well as the partial enthalpy of Eu in Sn-melts at low concentrations of Eu. Using also EMF techniques Kober *et al.* [1987Kob] have reported activities of Eu in Sn-melts at low Eu contents.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Eu,Sn)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	Eu_1
Eu_2Sn	$C23$	Co_2Si	$oP12$	$Pnma$	EU2SN	Eu_2Sn_1
Eu_5Sn_3	$D8_m$	W_5Si_3	$tI32$	$I4/mcm$	EU5SN3	Eu_5Sn_3
EuSn	$B33$	CrB	$oC8$	$Cmcm$	EUSN	Eu_1Sn_1
Eu_3Sn_5	$\cdots$	Pu_3Pd_5	$oC32$	$Cmcm$	EU3SN5	Eu_3Sn_5
$EuSn_3$	$L1_2$	$AuCu_3$	$cP4$	$Pm\overline{3}m$	EUSN3	Eu_1Sn_3
bct	$A5$	βSn	$tI4$	$I4_1/amd$	BCT_A5	Sn_1

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Sn}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid $\rightleftharpoons$ Eu_2Sn	congruent	1628.2	0.333	0.333		−11150
Eu_2Sn + liquid $\rightleftharpoons$ Eu_5Sn_3	peritectic	1396.0	0.333	0.430	0.375	−6967
liquid $\rightleftharpoons$ EuSn	congruent	1394.7	0.500	0.500		−21211
liquid $\rightleftharpoons$ Eu_5Sn_3 + EuSn	eutectic	1356.1	0.445	0.375	0.500	−17190
EuSn + liquid $\rightleftharpoons$ Eu_3Sn_5	peritectic	1171.0	0.500	0.626	0.625	−21415
liquid $\rightleftharpoons$ bcc + Eu_2Sn	eutectic	1063.0	0.054	0.001	0.333	−9740
liquid $\rightleftharpoons$ $EuSn_3$	congruent	1068.7	0.750	0.750		−27396
liquid $\rightleftharpoons$ Eu_3Sn_5 + $EuSn_3$	eutectic	1060.3	0.719	0.625	0.750	−25335
liquid $\rightleftharpoons$ $EuSn_3$ + bct	eutectic	501.6	0.992	0.750	1.000	−7253

Table IIIa. Integral quantities for the liquid phase at 1800 K.

x_{Sn}	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	−13921	−10202	2.066	−9056	−0.637	0.000
0.200	−26170	−20665	3.059	−18681	−1.102	0.000
0.300	−36515	−30097	3.566	−27373	−1.513	0.000
0.400	−44007	−37403	3.669	−33934	−1.927	0.000
0.500	−47848	−41685	3.424	−37475	−2.339	0.000
0.600	−47479	−42240	2.911	−37407	−2.685	0.000
0.700	−42592	−38562	2.239	−33449	−2.840	0.000
0.800	−33115	−30339	1.542	−25626	−2.619	0.000
0.900	−19130	−17458	0.929	−14265	−1.774	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Eu(liquid), Sn(liquid)

Table IIIb. Partial quantities for Eu in the liquid phase at 1800 K.

x_{Eu}	ΔG_{Eu} [J/mol]	ΔH_{Eu} [J/mol]	ΔS_{Eu} [J/(mol·K)]	$G_{\mathrm{Eu}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Eu}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Eu}	γ_{Eu}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−1017	362	0.766	560	−0.110	0.934	1.038
0.800	−3254	−373	1.601	85	−0.254	0.805	1.006
0.700	−9308	−4491	2.677	−3970	−0.289	0.537	0.767
0.600	−20883	−13692	3.995	−13238	−0.252	0.248	0.413
0.500	−38806	−29088	5.399	−28432	−0.365	0.075	0.150
0.400	−63067	−51202	6.592	−49354	−1.027	0.015	0.037
0.300	−92907	−79968	7.189	−74888	−2.822	0.002	0.007
0.200	−127092	−114732	6.867	−103005	−6.515	0.000	0.001
0.100	−165221	−154253	6.093	−130760	−13.052	0.000	0.000
0.000	$-\infty$	−196701	∞	−154292	−23.561	0.000	0.000

Reference state: Eu(liquid)

Table IIIc. Partial quantities for Sn in the liquid phase at 1800 K.

x_{Sn}	ΔG_{Sn} [J/mol]	ΔH_{Sn} [J/mol]	ΔS_{Sn} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Sn}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Sn}}$ [J/(mol·K)]	a_{Sn}	γ_{Sn}
0.000	$-\infty$	−95926	∞	−81950	−7.764	0.000	0.004
0.100	−130063	−105277	13.770	−95602	−5.375	0.000	0.002
0.200	−117833	−101833	8.889	−93746	−4.493	0.000	0.002
0.300	−99997	−89844	5.641	−81978	−4.370	0.001	0.004
0.400	−78693	−72969	3.180	−64980	−4.439	0.005	0.013
0.500	−56891	−54282	1.449	−46517	−4.314	0.022	0.045
0.600	−37087	−36266	0.456	−29442	−3.791	0.084	0.140
0.700	−21028	−20816	0.117	−15690	−2.848	0.245	0.351
0.800	−9620	−9241	0.211	−6281	−1.644	0.526	0.657
0.900	−2898	−2258	0.355	−1321	−0.521	0.824	0.916
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Sn(liquid)

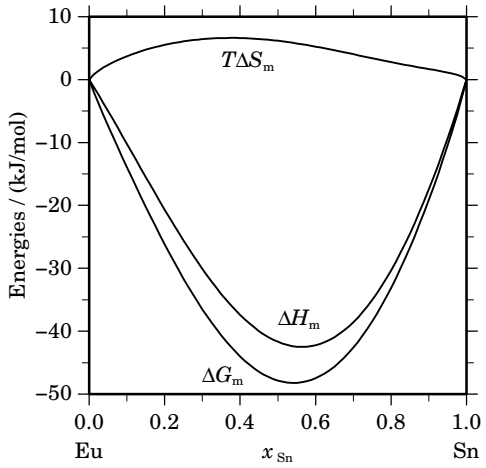

Fig. 2. Integral quantities of the liquid phase at T=1800 K.

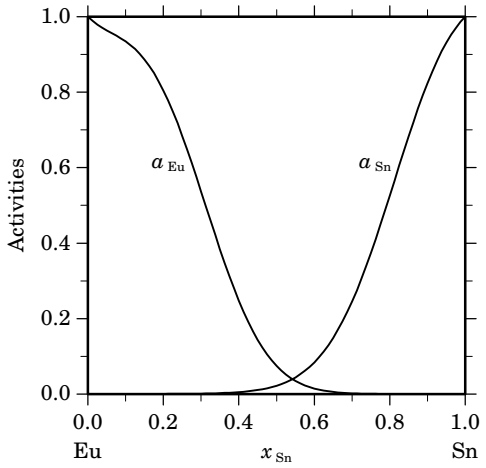

Fig. 3. Activities in the liquid phase at T=1800 K.

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

Compound	x_{Sn}	$\Delta_{\mathrm{f}}G^{\circ}$ / (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))
Eu_2Sn_1	0.333	−38759	−37010	5.867	0.000
Eu_5Sn_3	0.375	−42913	−41643	4.260	0.000
Eu_1Sn_1	0.500	−55167	−55544	−1.265	0.000
Eu_3Sn_5	0.625	−54359	−55526	−3.912	0.000
Eu_1Sn_3	0.750	−51517	−54877	−11.271	0.000

References

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