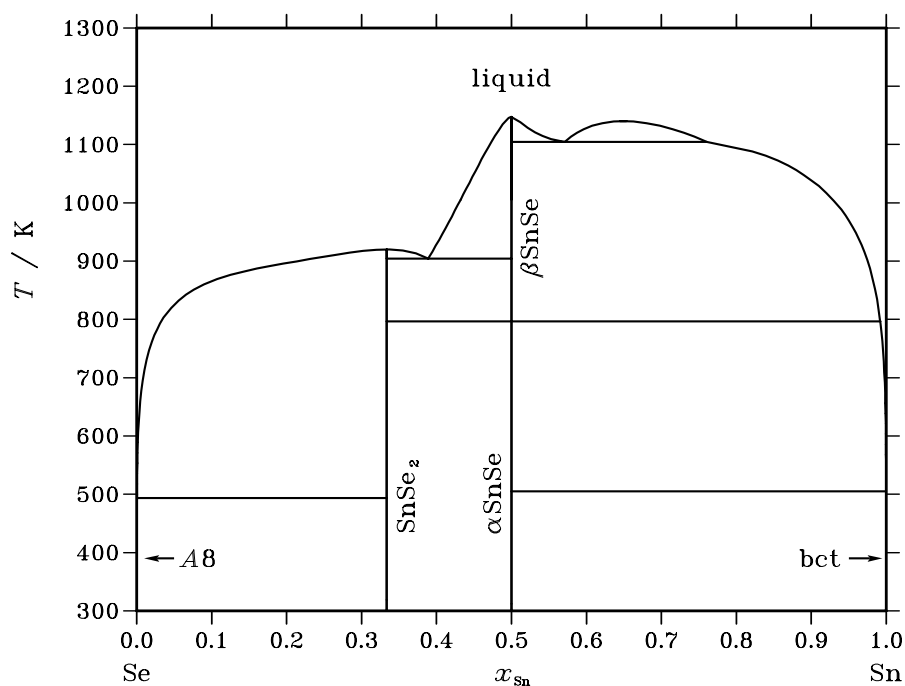


Se – Sn (Selenium – Tin)**Fig. 1.** Calculated phase diagram for the system Se-Sn.

The Se-Sn system has been assessed by [96Feu]. Two intermediate compounds exist, SnSe and SnSe₂, which melt congruently at 1147 K and 920 K, respectively. These values are deduced from a calculation using the optimised data, which is based on enthalpies of mixing in the liquid, the heat content, C_p measurements, and heat of formation for both compounds, chemical potential obtained by Knudsen effusion method. SnSe presents a binary solid solution and exhibits a phase transition involving peritectic and eutectoid invariants at 799 K and 793 K. On the Sn-rich side a miscibility gap is present in the liquid with a monotectic reaction at 1104 K. No terminal solid solutions have been determined, and the invariants are degenerated on Sn and Se.

Table I. Phases, structures and models.

Phase	Strukturbericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	(Se,SeSn,Sn) ₁
A8	A8	γ Se	<i>hP3</i>	<i>P3₁21</i>	TRIGONAL_A8	Se ₁
SnSe ₂	C6	CdI ₂	<i>hP3</i>	<i>P3₁m1</i>	C6_SNSE2	Sn ₁ Se ₂
β SnSe	B33	CrB	<i>oC8</i>	<i>Cmcm</i>	SNSE_H	Sn ₁ Se ₁
α SnSe	B16	GeS	<i>oP8</i>	<i>Pnma</i>	SNSE_L	Sn ₁ Se ₁
bct	A5	β Sn	<i>tI4</i>	<i>I4₁/amd</i>	BCT_A5	Sn ₁

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Sn}			$\Delta_r H / (\text{J/mol})$
liquid $\rightleftharpoons \beta\text{SnSe}$	congruent	1147.2	0.500	0.500		–15828
liquid $\rightleftharpoons \text{liquid}' + \text{liquid}''$	critical	1140.0	0.649	0.649	0.649	0
liquid' $\rightleftharpoons \beta\text{SnSe} + \text{liquid}''$	monotectic	1104.3	0.571	0.500	0.761	–13148
liquid' $\rightleftharpoons \text{SnSe}_2$	congruent	920.1	0.333	0.333		–16156
liquid' $\rightleftharpoons \text{SnSe}_2 + \beta\text{SnSe}$	eutectic	904.2	0.389	0.333	0.500	–14180
$\beta\text{SnSe} \rightleftharpoons \alpha\text{SnSe}$	polymorphic	796.5	0.500	0.500		–642
liquid'' $\rightleftharpoons \alpha\text{SnSe} + \text{bct}$	eutectic	505.1	1.000	0.500	1.000	–7032
liquid' $\rightleftharpoons \text{A8} + \text{SnSe}_2$	eutectic	493.9	0.000	0.000	0.333	–6700

Table IIIa. Integral quantities for the liquid phase at 1175 K.

x_{Sn}	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	–11190	–7588	3.066	–8014	0.363	3.310
0.200	–21017	–16174	4.122	–16128	–0.039	6.618
0.300	–30021	–25879	3.525	–24053	–1.554	9.929
0.400	–37563	–36666	0.763	–30988	–4.833	13.279
0.500	–40756	–46966	–5.284	–33985	–11.048	22.099
0.600	–33784	–32426	1.155	–27209	–4.441	13.767
0.700	–25978	–21287	3.993	–20010	–1.086	10.148
0.800	–18015	–12704	4.521	–13127	0.360	6.710
0.900	–9659	–5782	3.299	–6483	0.596	3.339
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Se in the liquid phase at 1175 K.

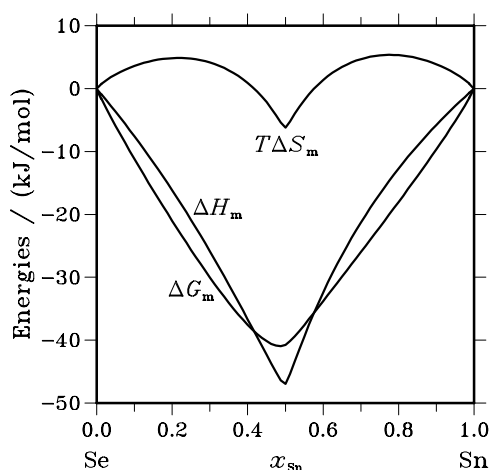
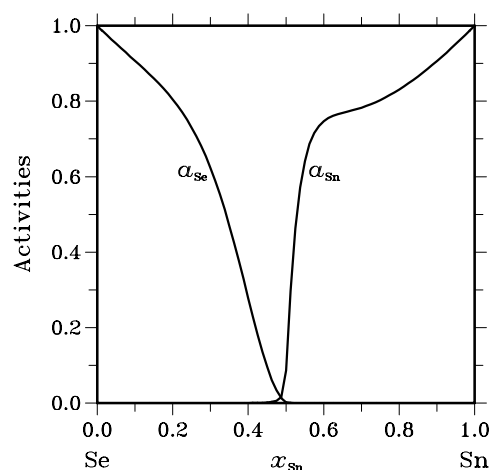
x_{Se}	ΔG_{Se} [J/mol]	ΔH_{Se} [J/mol]	ΔS_{Se} [J/(mol·K)]	G_{Se}^{E} [J/mol]	S_{Se}^{E} [J/(mol·K)]	a_{Se}	γ_{Se}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	–953	475	1.215	76	0.339	0.907	1.008
0.800	–2122	2090	3.585	58	1.729	0.805	1.006
0.700	–4623	4958	8.154	–1138	5.188	0.623	0.890
0.600	–12495	8155	17.574	–7504	13.327	0.278	0.464
0.500	–57589	–70237	–10.764	–50817	–16.527	0.003	0.006
0.400	–80184	–109655	–25.082	–71232	–32.701	0.000	0.001
0.300	–81014	–88959	–6.762	–69252	–16.772	0.000	0.001
0.200	–82837	–73839	7.658	–67114	–5.724	0.000	0.001
0.100	–87948	–62348	21.788	–65453	2.643	0.000	0.001
0.000	– ∞	–53324	∞	–64228	9.280	0.000	0.001

Reference state: Se(liquid)

Table IIIc. Partial quantities for Sn in the liquid phase at 1175 K.

x_{Sn}	ΔG_{Sn} [J/mol]	ΔH_{Sn} [J/mol]	ΔS_{Sn} [J/(mol·K)]	G_{Sn}^{E} [J/mol]	S_{Sn}^{E} [J/(mol·K)]	a_{Sn}	γ_{Sn}
0.000	$-\infty$	−71379	∞	−79230	6.682	0.000	0.000
0.100	−103326	−80148	19.726	−80831	0.581	0.000	0.000
0.200	−96597	−89229	6.271	−80874	−7.111	0.000	0.000
0.300	−89285	−97834	−7.276	−77522	−17.286	0.000	0.000
0.400	−75165	−103898	−24.454	−66213	−32.072	0.000	0.001
0.500	−23924	−23695	0.195	−17152	−5.568	0.086	0.173
0.600	−2850	19060	18.646	2141	14.399	0.747	1.245
0.700	−2391	7716	8.602	1093	5.636	0.783	1.118
0.800	−1810	2580	3.736	370	1.881	0.831	1.039
0.900	−960	503	1.245	69	0.369	0.906	1.007
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 $T=1175$ K.**Fig. 3.** Activities in the liquid phase at $T=1175$ K.**Table IV.** Standard reaction quantities at 298.15 K for the compounds per mole of atoms.

Compound	x_{Sn}	$\Delta_f G^\circ$ / (J/mol)	$\Delta_f H^\circ$ / (J/mol)	$\Delta_f S^\circ$ / (J/(mol·K))	$\Delta_f C_P^\circ$ / (J/(mol·K))
Sn_1Se_2	0.333	−38759	−38295	1.558	−0.822
$\beta\text{Sn}_1\text{Se}_1$	0.500	−53431	−54117	−2.302	−0.050
$\alpha\text{Sn}_1\text{Se}_1$	0.500	−53833	−54760	−3.109	−0.050

References

[96Feu] Y. Feutelais, M. Majid, B. Legendre, S.G. Fries: J. Phase Equilibria **17** (1996) 40–49.