In – Pb (Indium – Lead)

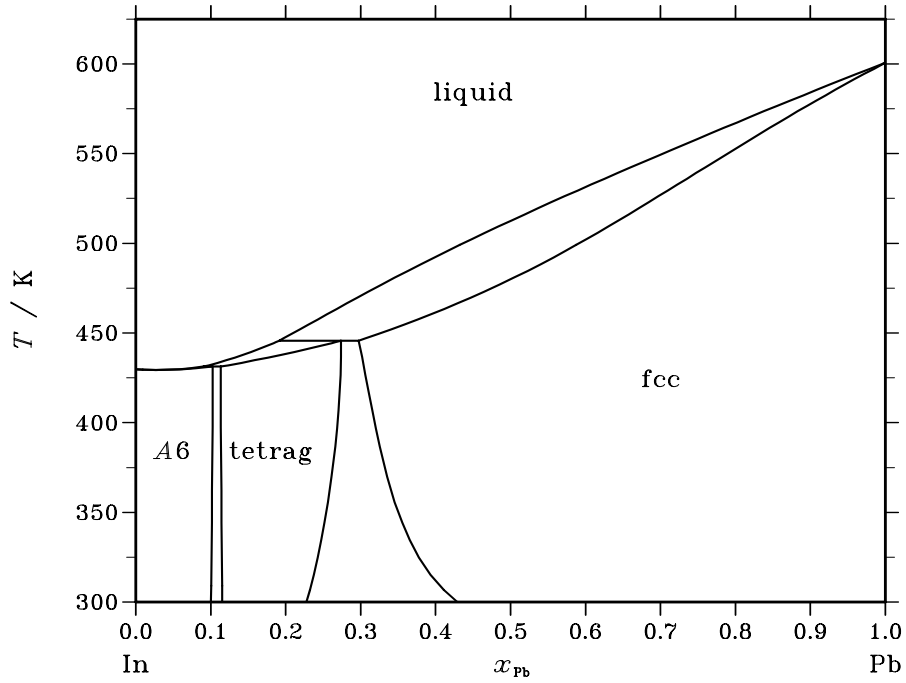

Fig. 1. Calculated phase diagram for the system In-Pb.

The In-Pb system is characterised by three solid solution phases, fcc ($A1$), In rich tetragonal $A6$ phase and an intermediate tetragonal α phase in addition to the liquid phase. The phase diagram has been studied by Kurnakow and Puschin [07Kur], Ageew and Ageewa [34Age], Valentiner and Haberstroh [38Val], Klemm and Volk [47Kle], Heumann and Predel [66Heu], Liao *et al.* [75Lia], Evans and Prince [78Eva] and Marcotte [78Mar]. Thermodynamic properties have been determined by high temperature calorimetry, thermal analysis, EMF studies, vapour pressure measurements and Knudsen effusion methods.
The data for the system have been reviewed by Nabot and Ansara [87Nab]. The critically assessed data adopted by SGTE were taken from an assessment of Bolcavage *et al.* [95Bol] and reported by Boa and Ansara [98Boa]. The data for the tetragonal α phase were remodelled by Dinsdale [01Din] using revised unary data for In consistent with values used for the In-Sn system.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(In,Pb)_1$
$A6$	$A6$	In	$tI2$	$I4/mmm$	TETRAGONAL_A6	$(In,Pb)_1$
tetrag.	$A6$	In	$tI2$	$I4/mmm$	TET_ALPHA1	$(In,Pb)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(In,Pb)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Pb}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid + fcc $\rightleftharpoons$ tetrag.	peritectic	445.7	0.191	0.297	0.274	−761
liquid + tetrag. $\rightleftharpoons$ $A6$	peritectic	431.2	0.090	0.113	0.103	−1528
liquid $\rightleftharpoons$ $A6$	congruent	429.4	0.028	0.028		−3293

Table IIIa. Integral quantities for the liquid phase at 650 K.

x_{Pb}	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)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−1459	354	2.790	298	0.087	0.000
0.200	−2181	623	4.315	523	0.154	0.000
0.300	−2623	809	5.281	678	0.202	0.000
0.400	−2872	915	5.827	765	0.231	0.000
0.500	−2960	943	6.004	786	0.241	0.000
0.600	−2892	895	5.827	745	0.231	0.000
0.700	−2658	775	5.281	643	0.202	0.000
0.800	−2221	583	4.315	483	0.154	0.000
0.900	−1489	324	2.790	268	0.087	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: In(liquid), Pb(liquid)

Table IIIb. Partial quantities for In in the liquid phase at 650 K.

x_{In}	ΔG_{In} [J/mol]	ΔH_{In} [J/mol]	ΔS_{In} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{In}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{In}}$ [J/(mol·K)]	a_{In}	γ_{In}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−533	43	0.886	37	0.010	0.906	1.007
0.800	−1062	169	1.894	144	0.039	0.822	1.027
0.700	−1611	373	3.052	317	0.087	0.742	1.060
0.600	−2211	650	4.401	550	0.154	0.664	1.107
0.500	−2908	995	6.004	838	0.241	0.584	1.168
0.400	−3775	1403	7.965	1177	0.347	0.497	1.243
0.300	−4945	1868	10.482	1562	0.472	0.401	1.335
0.200	−6712	2387	13.998	1987	0.616	0.289	1.444
0.100	−9997	2954	19.925	2447	0.780	0.157	1.573
0.000	$-\infty$	3564	∞	2938	0.963	0.000	1.722

Reference state: In(liquid)

Table IIIc. Partial quantities for Pb in the liquid phase at 650 K.

x_{Pb}	ΔG_{Pb} [J/mol]	ΔH_{Pb} [J/mol]	ΔS_{Pb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Pb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Pb}}$ [J/(mol·K)]	a_{Pb}	γ_{Pb}
0.000	$-\infty$	3979	∞	3353	0.963	0.000	1.860
0.100	−9795	3156	19.925	2649	0.780	0.163	1.633
0.200	−6658	2440	13.998	2040	0.616	0.292	1.459
0.300	−4986	1828	10.482	1521	0.472	0.398	1.325
0.400	−3865	1313	7.965	1088	0.347	0.489	1.223
0.500	−3012	891	6.004	734	0.241	0.573	1.146
0.600	−2304	557	4.401	457	0.154	0.653	1.088
0.700	−1678	306	3.052	249	0.087	0.733	1.047
0.800	−1098	133	1.894	108	0.039	0.816	1.020
0.900	−543	32	0.886	26	0.010	0.904	1.005
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Pb(liquid)

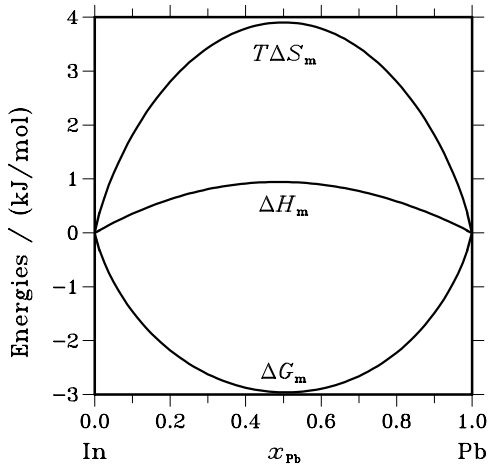

Fig. 2. Integral quantities of the liquid phase at T=650 K.

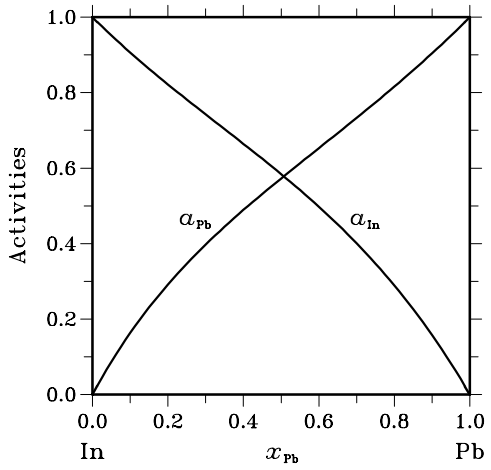

Fig. 3. Activities in the liquid phase at T=650 K.

Table IVa. Integral quantities for the stable phases at 420 K.

Phase	x_{Pb}	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)]
$A6$	0.000	0	0	0.000	0	0.000	0.000
	0.100	−697	438	2.703	438	0.000	0.000
	0.103	−707	448	2.750	448	0.000	0.000
tetrag.	0.113	−749	486	2.939	485	0.002	0.000
	0.200	−1014	793	4.303	733	0.143	0.000
	0.273	−1158	1057	5.275	887	0.405	0.000
fcc	0.309	−1218	1172	5.691	942	0.548	0.000
	0.400	−1334	1275	6.211	1017	0.615	0.000
	0.500	−1397	1293	6.404	1023	0.641	0.000
	0.600	−1395	1213	6.211	955	0.615	0.000
	0.700	−1319	1041	5.617	815	0.538	0.000
	0.800	−1141	779	4.571	606	0.410	0.000
	0.900	−802	430	2.934	333	0.231	0.000
	1.000	0	0	0.000	0	0.000	0.000

Reference states: In($A6$), Pb(fcc)

Table IVb. Partial quantities for In in the stable phases at 420 K.

Phase	x_{In}	ΔG_{In} [J/mol]	ΔH_{In} [J/mol]	ΔS_{In} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{In}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{In}}$ [J/(mol·K)]	a_{In}	γ_{In}
$A6$	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−302	66	0.876	66	0.000	0.917	1.019
	0.897	−309	69	0.900	69	0.000	0.915	1.020
tetrag.	0.887	−309	96	0.965	111	−0.035	0.915	1.032
	0.800	−535	69	1.436	245	−0.419	0.858	1.073
	0.727	−718	67	1.869	393	−0.776	0.814	1.119
fcc	0.691	−718	677	3.322	574	0.245	0.814	1.179
	0.600	−950	1006	4.657	834	0.410	0.762	1.270
	0.500	−1240	1450	6.404	1181	0.641	0.701	1.402
	0.400	−1615	1973	8.541	1585	0.923	0.630	1.574
	0.300	−2165	2567	11.267	2039	1.256	0.538	1.793
	0.200	−3085	3225	15.022	2535	1.641	0.413	2.067
	0.100	−4974	3939	21.221	3067	2.077	0.241	2.407
	0.000	$-\infty$	4703	∞	3626	2.564	0.000	2.825

Reference state: In($A6$)

Table IVc. Partial quantities for Pb in the stable phases at 420 K.

Phase	x_{Pb}	ΔG_{Pb} [J/mol]	ΔH_{Pb} [J/mol]	ΔS_{Pb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Pb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Pb}}$ [J/(mol·K)]	a_{Pb}	γ_{Pb}
$A6$	0.000	$-\infty$	5116	∞	5116	0.000	0.000	4.328
	0.100	−4255	3786	19.145	3786	0.000	0.296	2.957
	0.103	−4193	3758	18.932	3758	0.000	0.301	2.934
tetrag.	0.113	−4193	3533	18.396	3412	0.288	0.301	2.657
	0.200	−2933	3691	15.771	2687	2.389	0.432	2.159
	0.273	−2334	3700	14.367	2206	3.558	0.513	1.881
fcc	0.309	−2334	2277	10.980	1764	1.223	0.513	1.657
	0.400	−1909	1679	8.541	1291	0.923	0.579	1.447
	0.500	−1554	1135	6.404	866	0.641	0.641	1.281
	0.600	−1249	707	4.657	535	0.410	0.699	1.165
	0.700	−956	387	3.196	290	0.231	0.761	1.087
	0.800	−655	167	1.958	124	0.103	0.829	1.036
	0.900	−338	41	0.902	30	0.026	0.908	1.009
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Pb(fcc)

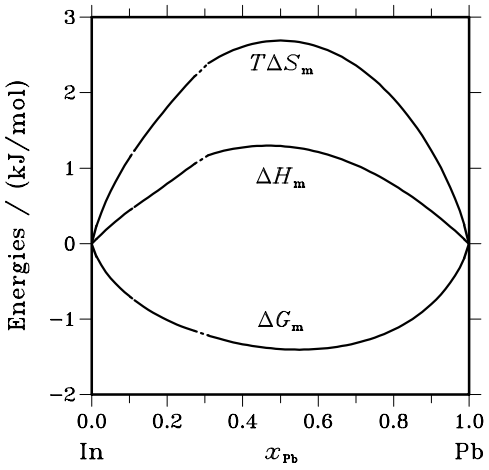

Fig. 4. Integral quantities of the stable phases at T=420 K.

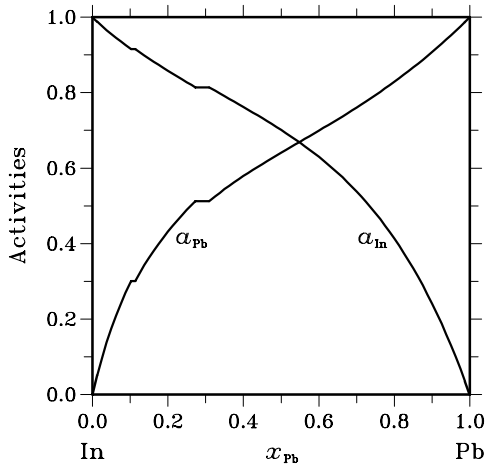

Fig. 5. Activities in the stable phases at T=420 K.

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