Hg – Pb (Mercury – Lead)

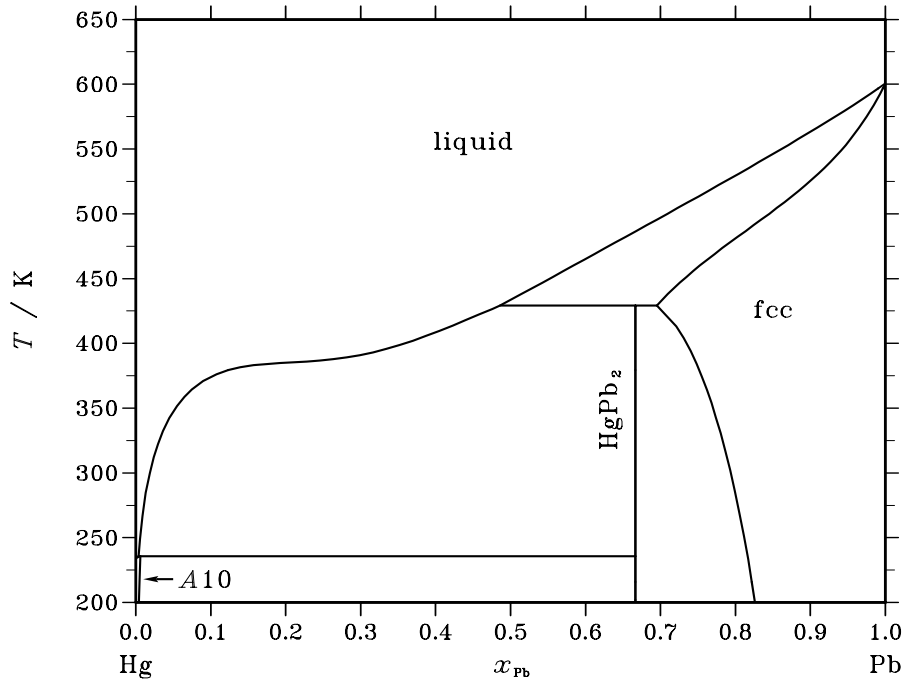

Fig. 1. Calculated phase diagram for the system Hg-Pb.

An understanding of the thermodynamics and phase equilibria in the Hg-Pb system is important in order to model the behaviour of new amalgams for potential use in compact fluorescent lamps. It is also likely to be important in modelling the effects of mercury formation on lead alloy coolant materials in accelerator-driven reactors [02Mai]. The phase diagram is characterised by complete mixing of the pure elements in the liquid phase, substantial solubility of Hg in fcc Pb, slight solubility of Pb in rhombohedral Hg and the formation of an intermetallic compound $HgPb_2$ which has a crystal structure based on the AuCu $L1_0$ phase type which melts peritectically at about 429 K. There is some evidence that this phase exists over a range of homogeneity. The shape of the liquidus curve indicates that there is a suppressed miscibility gap in the liquid for Hg rich compositions. A number of studies have been carried out to define the liquidus surface and these are in reasonable agreement. Rather few studies have been undertaken on the solubility of Hg in fcc Pb. The thermodynamic properties of the liquid phase have been studied by calorimetry, vapour pressure measurements and isopiestic techniques. The critically assessed data adopted by SGTE are based on the assessment of Maitre *et al.* [02Mai] which is in reasonable agreement with the experimental data.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Hg,Pb)_1$
$A10$	$A10$	αHg	$hR1$	$R\overline{3}m$	RHOMBO_A10	$(Hg,Pb)_1$
$HgPb_2$	$L1_0$	AuCu	$tP4$	$P4/mmm$	HGPB2_L10	Hg_1Pb_2
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Hg,Pb)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Pb}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid + fcc $\rightleftharpoons$ $HgPb_2$	peritectic	429.1	0.486	0.695	0.667	−784
liquid + $HgPb_2$ $\rightleftharpoons$ $A10$	peritectic	235.6	0.004	0.667	0.006	−2278

Table IIIa. Integral quantities for the liquid phase at 601 K.

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)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−1029	381	2.347	595	−0.356	0.063
0.200	−1569	554	3.532	932	−0.628	0.749
0.300	−1974	573	4.238	1079	−0.841	1.819
0.400	−2270	488	4.589	1093	−1.007	3.033
0.500	−2444	344	4.639	1019	−1.124	4.155
0.600	−2474	181	4.419	889	−1.177	4.943
0.700	−2331	36	3.940	721	−1.139	5.161
0.800	−1978	−59	3.192	523	−0.969	4.569
0.900	−1336	−79	2.091	289	−0.612	2.928
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Hg in the liquid phase at 601 K.

x_{Hg}	ΔG_{Hg} [J/mol]	ΔH_{Hg} [J/mol]	ΔS_{Hg} [J/(mol·K)]	$G_{\mathrm{Hg}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Hg}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Hg}	γ_{Hg}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−385	113	0.829	142	−0.047	0.926	1.029
0.800	−646	379	1.706	469	−0.149	0.879	1.098
0.700	−921	696	2.690	861	−0.276	0.832	1.188
0.600	−1315	975	3.811	1237	−0.437	0.769	1.281
0.500	−1912	1142	5.083	1551	−0.681	0.682	1.364
0.400	−2782	1137	6.522	1796	−1.096	0.573	1.433
0.300	−4014	913	8.198	2002	−1.813	0.448	1.493
0.200	−5805	435	10.384	2237	−2.998	0.313	1.565
0.100	−8901	−316	14.285	2605	−4.860	0.168	1.684
0.000	$-\infty$	−1347	∞	3248	−7.646	0.000	1.916

Reference state: Hg(liquid)

Table IIIc. Partial quantities for Pb in the liquid phase at 601 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	$-\infty$	5042	∞	7505	−4.100	0.000	4.491
0.100	−6832	2789	16.008	4674	−3.136	0.255	2.548
0.200	−5261	1253	10.837	2782	−2.544	0.349	1.745
0.300	−4431	287	7.850	1585	−2.160	0.412	1.373
0.400	−3702	−242	5.756	877	−1.862	0.477	1.192
0.500	−2977	−455	4.196	487	−1.567	0.551	1.102
0.600	−2269	−456	3.016	284	−1.231	0.635	1.058
0.700	−1610	−339	2.115	172	−0.851	0.724	1.035
0.800	−1021	−183	1.394	94	−0.461	0.815	1.019
0.900	−495	−53	0.736	31	−0.140	0.906	1.006
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Pb(liquid)

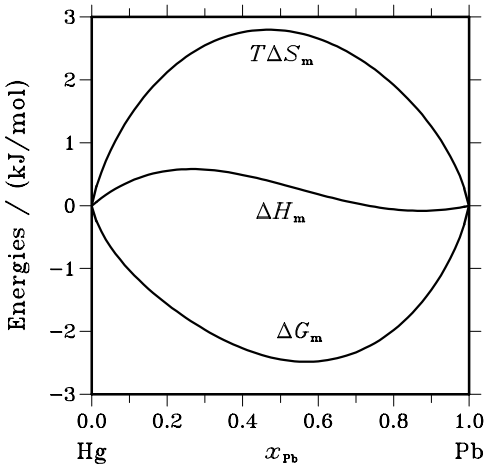

Fig. 2. Integral quantities of the liquid phase at T=601 K.

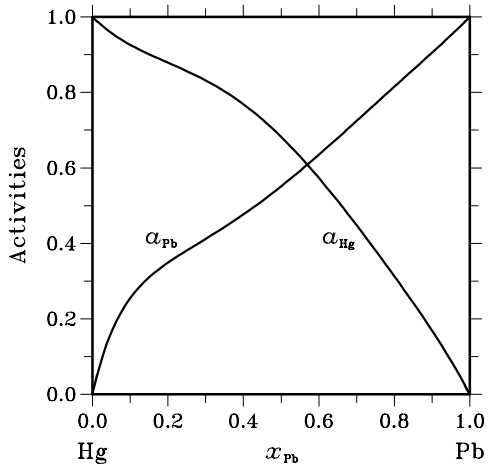

Fig. 3. Activities in the liquid phase at T=601 K.

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

Compound	x_{Pb}	$\Delta_{\mathrm{f}}G^{\circ}$ / (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))
$HgPb_2$	0.667	−1148	−1198	−0.167	0.305

References

[02Mai] A. Maitre, J.M. Fiorani, M. Vilasi: J. Phase Equilibria **23** (2002) 329–238.