Ga – In (Gallium – Indium)

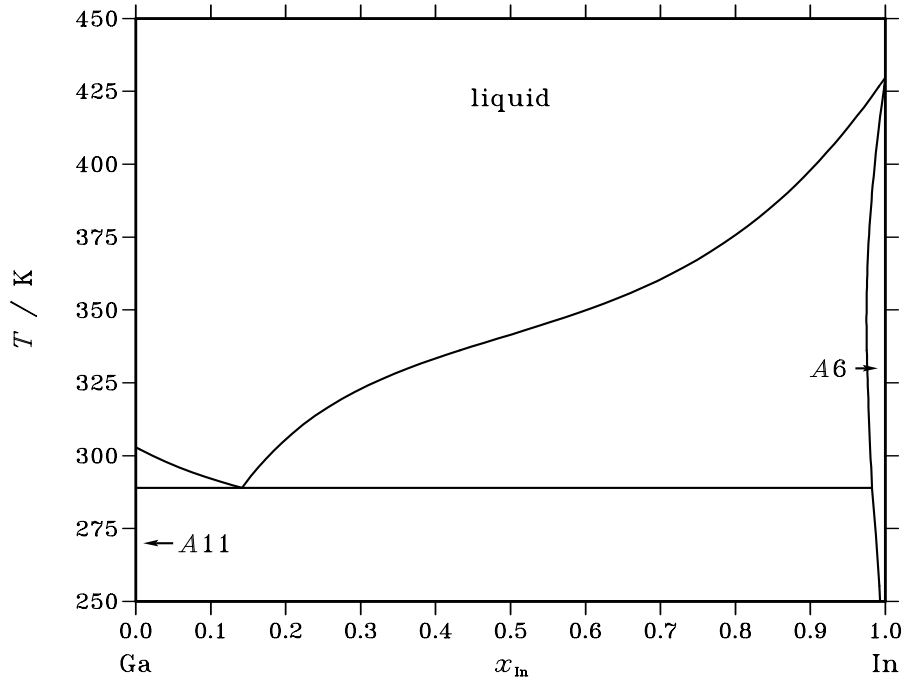

Fig. 1. Calculated phase diagram for the system Ga-In.

The Ga-In system forms part of a technologically important group of III-V semiconductor systems such as the Al-Ga-In-As system. Reliable thermodynamic data and understanding of the phase equilibria are essential in order to model the conditions required for the growth of semiconductor crystals. The Ga-In system has been the subject of many studies over the years both in terms of the phase diagram and in terms of the thermodynamic properties. The system is very simple being characterised by complete mixing of the components in the liquid phase, modest solubility of Ga in tetragonal In and negligible solubility of In in crystalline Ga. There is a eutectic in the system at 289 K with the liquid composition corresponding to 14.2 at.% In. The liquidus surface is well studied experimentally but the results show some disagreement presumably due to difficulties associated with the tendency of Ga to undercool. Thermodynamic properties of the liquid phase have been studied by calorimetry, EMF and Knudsen cell effusion techniques. The system has been critically assessed several times [69Hay, 72Rao, 78Ans, 90Rug, 91And, 93Red, 98Xin]. The dataset adopted by SGTE is that derived by Rugg and Chart [90Rug].

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Ga,In)_1$
$A11$	$A11$	αGa	$oC8$	$Cmca$	ORTHORHOMBIC_CMCA	Ga_1
$A6$	$A6$	In	$tI2$	$I4/mmm$	TETRAGONAL_A6	$(Ga,In)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{In}			$\Delta_r H$ / (J/mol)
liquid $\rightleftharpoons$ $A11$ + $A6$	eutectic	289.0	0.142	0.000	0.982	−5738

Table IIIa. Integral quantities for the liquid phase at 443 K.

x_{In}	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	−720	395	2.516	477	−0.186	0.000
0.200	−1007	695	3.844	836	−0.317	0.000
0.300	−1166	909	4.683	1084	−0.396	0.000
0.400	−1250	1038	5.165	1229	−0.430	0.000
0.500	−1279	1086	5.338	1275	−0.425	0.000
0.600	−1256	1052	5.210	1223	−0.386	0.000
0.700	−1176	933	4.761	1074	−0.318	0.000
0.800	−1019	724	3.933	824	−0.227	0.000
0.900	−729	416	2.583	469	−0.120	0.000
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Ga in the liquid phase at 443 K.

x_{Ga}	ΔG_{Ga} [J/mol]	ΔH_{Ga} [J/mol]	ΔS_{Ga} [J/(mol·K)]	$G_{\mathrm{Ga}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Ga}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Ga}	γ_{Ga}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−327	48	0.847	61	−0.029	0.915	1.017
0.800	−590	184	1.747	232	−0.109	0.852	1.065
0.700	−817	396	2.737	497	−0.228	0.801	1.144
0.600	−1032	683	3.871	850	−0.376	0.756	1.259
0.500	−1264	1050	5.222	1289	−0.541	0.710	1.419
0.400	−1552	1508	6.906	1823	−0.712	0.656	1.640
0.300	−1970	2076	9.132	2465	−0.878	0.586	1.953
0.200	−2692	2780	12.353	3236	−1.029	0.481	2.407
0.100	−4316	3655	17.993	4165	−1.151	0.310	3.098
0.000	$-\infty$	4739	∞	5287	−1.236	0.000	4.201

Reference state: Ga(liquid)

Table IIIc. Partial quantities for In in the liquid phase at 443 K.

x_{In}	ΔG_{In} [J/mol]	ΔH_{In} [J/mol]	ΔS_{In} [J/(mol·K)]	$G_{\mathrm{In}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{In}}^{\mathrm{E}}$ [J/(mol·K)]	a_{In}	γ_{In}
0.000	$-\infty$	4447	∞	5406	−2.164	0.000	4.339
0.100	−4258	3513	17.542	4223	−1.602	0.315	3.147
0.200	−2677	2743	12.234	3251	−1.147	0.483	2.417
0.300	−1981	2104	9.223	2453	−0.788	0.584	1.947
0.400	−1578	1571	7.107	1797	−0.512	0.652	1.629
0.500	−1293	1123	5.454	1260	−0.309	0.704	1.408
0.600	−1059	749	4.079	823	−0.168	0.750	1.250
0.700	−836	443	2.888	478	−0.078	0.797	1.138
0.800	−601	209	1.828	221	−0.027	0.850	1.062
0.900	−330	56	0.871	58	−0.005	0.914	1.016
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: In(liquid)

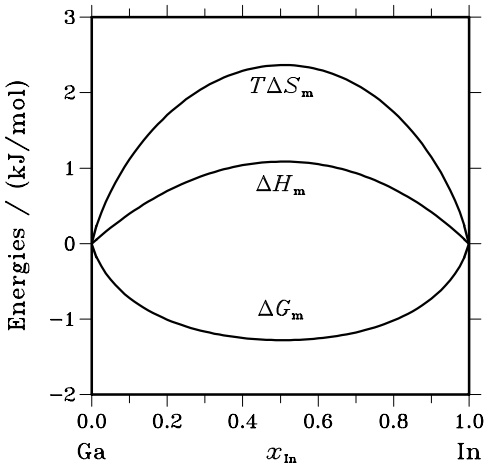

Fig. 2. Integral quantities of the liquid phase at T=443 K.

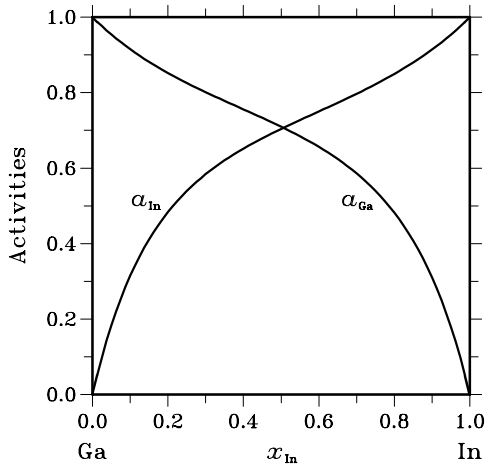

Fig. 3. Activities in the liquid phase at T=443 K.

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