

A Torsion Study on the Sublimation Process of InCl_3

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The temperature dependence of the total vapor pressure above InCl_3 , as measured by the torsion-effusion method, is expressed by the equation $\log(p/\text{kPa}) = 12.76 \pm 0.15 - (8570 \pm 200)/(T/\text{K})$ in the temperature range 495 to 648 K. In addition to $\text{InCl}_3(\text{g})$, the presence of the dimeric form $\text{In}_2\text{Cl}_6(\text{g})$ was observed in the vapor at high temperature. The sublimation process $\text{InCl}_3(\text{s}) = \text{InCl}_3(\text{g})$ was studied, and the standard enthalpy of this reaction was found to be $(158 \pm 4) \text{ kJ mol}^{-1}$.

Introduction

The vaporization of $\text{InCl}_3(\text{s})$ has been extensively studied by static methods at higher pressures. The first series of vapor pressure data for this compound was determined using a static method by Robert (1936) and subsequently by the torsion method by Smith and Barrow (1958); these results, obtained at different temperature ranges, are decidedly in disagreement. In both studies, $\text{InCl}_3(\text{g})$ was considered to be the only gaseous species present in the vapor. In contrast Fadeev and Fedorov (1964) using a static method found that the unsaturated vapor above the solid phase at about 800 K consisted primarily of $\text{In}_2\text{Cl}_6(\text{g})$. Later, Polyachenok and Komshilova (1970), Sryvtsev (1973), and Komshilova et al. (1969) [these last authors working at high pressures (~ 2 bar) and high temperatures (~ 1200 K)] found that monomeric and dimeric forms are both present in the vapor; therefore, they were able to study also the dissociative equilibrium: $\text{In}_2\text{Cl}_6(\text{g}) = 2\text{InCl}_3(\text{g})$. Considering that $\text{InCl}_3(\text{g})$ at high temperature partially decomposes into $\text{InCl}(\text{g})$ and $\text{Cl}_2(\text{g})$ [as reported by Kuniya and Hosaka (1975) and Kuniya et al. (1974)], the data of Komshilova et al. (1969) probably is not reliable considering that the authors did not take into account the contribution of the decomposition processes. Defoort et al. (1988) analyzed by mass spectrometry the gaseous phase in equilibrium with solid indium chlorides at different compositions [$\text{InCl}_x(\text{s})$ ($x = 1$ to 3)]. In agreement with an earlier mass spectrometric work (Schaefer and Binnewies, 1976), Defoort et al. (1988) confirmed that monomers and dimers are both present in the vapor above $\text{InCl}_3(\text{s})$ in the temperature range (478–572) K; however, no absolute vapor pressure data are reported in their work. Krausze et al. (1987), by a membrane-zero manometry, studied only the thermal dissociation at high temperatures (1040 K) of $\text{In}_2\text{Cl}_6(\text{g})$ to $\text{InCl}_3(\text{g})$. Recently, using the same method, Oppermann et al. (1994) measured a new set of partial pressures of $\text{InCl}_3(\text{g})$ and $\text{In}_2\text{Cl}_6(\text{g})$ above solid InCl_3 .

Considering the scatter of the vapor pressure data reported in the literature and the lack of values at low temperatures and carrying on a vaporization study of indium halides (Bardi et al., 1997; Brunetti et al., 1997a,b), we investigated the vaporization thermodynamics of indium trichloride, and the results are reported in the present work.

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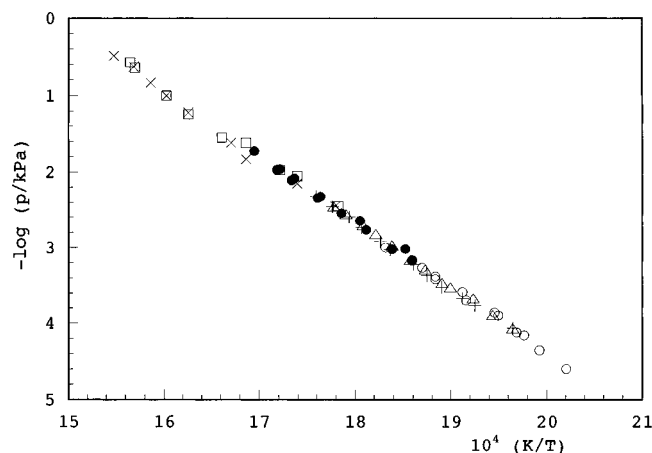


Figure 1. Total vapor pressure of solid InCl_3 measured by torsion assembly T_1 : \times (run c); \square (run d); \bullet (run l); \triangle (run f); $+$ (run g); \circ (run q).

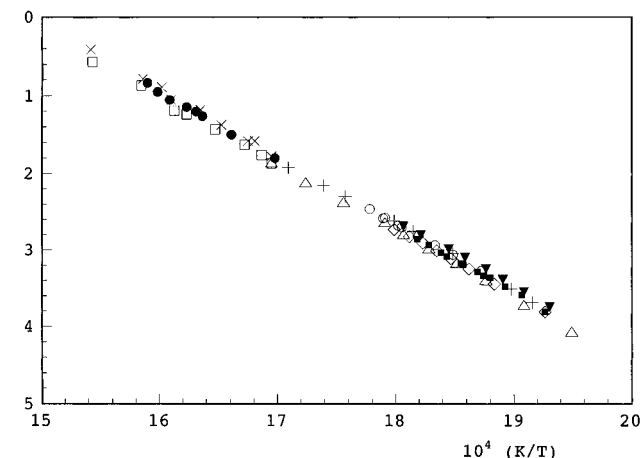


Figure 2. Total vapor pressure of solid InCl_3 measured by torsion assembly T_2 : \times (run b); \square (run e); \bullet (run a); \triangle (run h); $+$ (run i); \circ (run p); \blacktriangledown (run m); \blacksquare (run n); \diamond (run o).

Experimental and Results

Very pure InCl_3 (99.999%, as stated by the supplier, STREM Chemical INC.) was used in this investigation without further purification. As the compound is very hygroscopic, the cells were loaded in a drybox. The vapor pressure was measured by the torsion-effusion method. Three conventional graphite torsion cells with different

Table 1. Total Vapor Pressure Values above InCl₃

| A. Assembly T ₁ | | | | | |
|----------------------------|-------------|--------------------|-------------|--------------------|-------------|
| cell A | | | | | |
| run c | | run d | | run l | |
| T/K | -log(p/kPa) | T/K | -log(p/kPa) | T/K | -log(p/kPa) |
| 562.0 | 2.45 | 561.0 | 2.45 | 538.0 | 3.16 |
| 575.0 ^a | 2.15 | 575.0 | 2.05 | 540.0 | 3.02 |
| 593.0 | 1.83 | 581.0 ^a | 1.97 | 544.0 | 3.02 |
| 598.5 | 1.62 | 593.0 ^a | 1.62 | 552.0 ^a | 2.76 |
| 615.0 ^a | 1.22 | 602.0 ^a | 1.55 | 554.0 | 2.64 |
| 624.0 ^a | 1.00 | 615.0 | 1.25 | 560.0 ^a | 2.54 |
| 630.5 ^a | 0.84 | 624.0 | 1.00 | 567.0 | 2.32 |
| 637.5 | 0.63 | 637.0 | 0.64 | 568.0 | 2.34 |
| 646.0 | 0.49 | 639.0 ^a | 0.57 | 576.0 | 2.08 |
| | | | | 577.0 ^a | 2.11 |
| | | | | 581.0 ^a | 1.96 |
| | | | | 582.0 | 1.97 |
| | | | | 590.0 | 1.72 |

| cell B | | | | | |
|--------------------|-------------|--------------------|-------------|--------------------|-------------|
| run f | | run g | | cell C | |
| T/K | -log(p/kPa) | T/K | -log(p/kPa) | T/K | -log(p/kPa) |
| 509.0 | 4.07 | 509.5 | 4.07 | 495.0 | 4.60 |
| 514.5 | 3.89 | 519.5 | 3.77 | 502.0 ^a | 4.35 |
| 520.0 | 3.67 | 523.0 ^a | 3.67 | 506.0 | 4.16 |
| 526.5 | 3.52 | 529.0 | 3.52 | 508.0 | 4.12 |
| 529.0 ^a | 3.47 | 533.5 | 3.37 | 513.0 | 3.90 |
| 534.0 | 3.29 | 537.5 | 3.22 | 514.0 | 3.86 |
| 538.5 | 3.16 | 544.5 ^a | 3.03 | 522.0 | 3.69 |
| 544.0 | 2.97 | 547.5 ^a | 2.92 | 523.0 | 3.59 |
| 549.0 | 2.82 | 553.5 | 2.73 | 531.0 | 3.41 |
| 553.0 | 2.71 | 557.5 | 2.60 | 531.0 ^a | 3.38 |
| 558.5 | 2.56 | 563.0 | 2.46 | 535.0 ^a | 3.26 |
| 562.5 | 2.45 | 568.5 | 2.32 | 538.0 | 3.17 |
| | | | | 546.0 | 3.00 |

B. Assembly T₂

| cell A | | | | | |
|--------|-------------|-------|-------------|-------|-------------|
| run b | | run e | | run a | |
| T/K | -log(p/kPa) | T/K | -log(p/kPa) | T/K | -log(p/kPa) |
| 590.0 | 1.78 | 590.0 | 1.87 | 589.0 | 1.80 |
| 595.0 | 1.58 | 593.0 | 1.76 | 602.0 | 1.50 |
| 597.0 | 1.58 | 598.0 | 1.62 | 611.0 | 1.26 |
| 605.0 | 1.37 | 607.0 | 1.43 | 613.0 | 1.20 |
| 611.5 | 1.18 | 616.0 | 1.24 | 616.0 | 1.14 |
| 621.0 | 1.05 | 620.0 | 1.19 | 621.5 | 1.05 |
| 624.0 | 0.89 | 631.0 | 0.87 | 625.5 | 0.95 |
| 630.5 | 0.79 | 648.0 | 0.57 | 629.0 | 0.84 |
| 648.5 | 0.41 | | | | |

| cell B | | | | | |
|--------|-------------|-------|-------------|-------|-------------|
| run h | | run i | | run p | |
| T/K | -log(p/kPa) | T/K | -log(p/kPa) | T/K | -log(p/kPa) |
| 513.0 | 4.07 | 522.0 | 3.68 | 534.0 | 3.27 |
| 524.0 | 3.71 | 527.0 | 3.51 | 541.0 | 3.06 |
| 533.0 | 3.39 | 533.0 | 3.32 | 545.5 | 2.93 |
| 540.0 | 3.16 | 541.0 | 3.05 | 549.5 | 2.80 |
| 547.0 | 2.98 | 551.0 | 2.76 | 549.5 | 2.80 |
| 553.5 | 2.79 | 556.0 | 2.62 | 554.0 | 2.70 |
| 558.5 | 2.64 | 569.0 | 2.30 | 555.0 | 2.68 |
| 569.5 | 2.37 | 575.0 | 2.15 | 558.5 | 2.58 |
| 580.0 | 2.11 | 585.0 | 1.92 | 559.0 | 2.58 |
| 590.0 | 1.85 | | | 562.5 | 2.46 |

| cell C | | | | | |
|--------|-------------|-------|-------------|-------|-------------|
| run m | | run n | | run o | |
| T/K | -log(p/kPa) | T/K | -log(p/kPa) | T/K | -log(p/kPa) |
| 518.0 | 3.74 | 519.0 | 3.81 | 519.0 | 3.81 |
| 524.0 | 3.55 | 524.5 | 3.59 | 531.0 | 3.44 |
| 529.0 | 3.38 | 528.5 | 3.47 | 537.0 | 3.25 |
| 533.0 | 3.25 | 532.0 | 3.36 | 541.5 | 3.11 |
| 538.0 | 3.10 | 533.5 | 3.33 | 545.0 | 3.01 |
| 542.0 | 2.99 | 535.0 | 3.29 | 548.5 | 2.91 |
| 549.0 | 2.80 | 538.5 | 3.19 | 552.0 | 2.82 |
| 553.5 | 2.69 | 539.0 | 3.17 | 556.0 | 2.73 |
| | | 542.5 | 3.08 | | |
| | | 544.0 | 3.03 | | |
| | | 547.0 | 2.93 | | |
| | | 550.0 | 2.86 | | |

^a At this temperature the mass loss rate of the sample was also measured in order to evaluate the molecular weight of the vapor by the Knudsen equation (see text).

Table 2. Temperature Dependence Equations of the Total Vapor Pressures above Solid InCl₃

| assem- bly | cell | run | $\Delta T/K$ | no. of points | $\log(p/\text{kPa}) = A - B(K/T)$ | | |
|----------------|----------------|------------------|--------------|------------------|-----------------------------------|----------------|------------|
| | | | | | A ^a | B ^a | |
| T ₁ | A | c | 562.0–646.0 | 9 | 12.92 ± 0.45 | 8679 ± 271 | |
| | | d | 561.0–639.0 | 9 | 12.42 ± 0.51 | 8350 ± 307 | |
| | | l | 538.0–590.0 | 13 | 12.77 ± 0.34 | 8509 ± 191 | |
| | B | f | 509.0–562.5 | 12 | 12.94 ± 0.20 | 8657 ± 105 | |
| | | g | 509.5–568.5 | 12 | 13.04 ± 0.26 | 8735 ± 142 | |
| | C | q | 495.0–546.0 | 13 | 12.60 ± 0.38 | 8490 ± 197 | |
| | | avg ^b | | | 12.79 ± 0.35 | 8573 ± 194 | |
| | T ₂ | A | a | 589.0–629.0 | 8 | 13.06 ± 0.32 | 8755 ± 194 |
| | | | b | 590.0–648.5 | 9 | 13.13 ± 0.40 | 8770 ± 247 |
| e | | | 590.0–648.0 | 8 | 12.51 ± 0.35 | 8469 ± 214 | |
| h | | | 513.0–590.0 | 10 | 12.86 ± 0.19 | 8668 ± 103 | |
| B | | i | 522.0–585.0 | 9 | 12.72 ± 0.25 | 8548 ± 134 | |
| | | p | 534.0–562.5 | 10 | 12.32 ± 0.27 | 8318 ± 148 | |
| | | m | 518.0–553.5 | 8 | 12.76 ± 0.26 | 8542 ± 142 | |
| C | | n | 519.0–550.0 | 12 | 12.64 ± 0.25 | 8521 ± 137 | |
| | | o | 519.0–556.0 | 8 | 12.64 ± 0.22 | 8535 ± 118 | |
| | | avg ^b | | | 12.73 ± 0.28 | 8566 ± 158 | |

^a The quoted errors are the standard deviations. ^b Obtained weighting the slopes and intercepts of each equation proportionally to the experimental points.

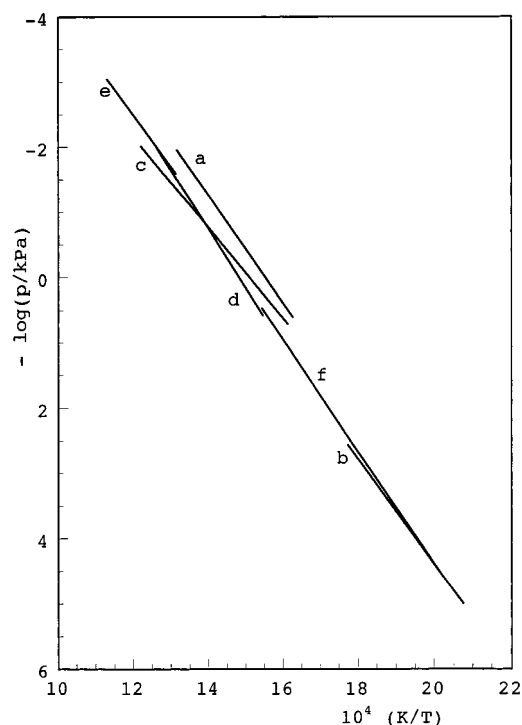


Figure 3. Total vapor pressures above solid InCl₃: a Robert; b Smith; c Fadeev; d Polyachenok; e Srytsev; f this work.

areas of their effusion holes (0.3, 1.0, and 1.9 mm being the nominal diameter of the holes of the cells A, B, and C, respectively) and two torsion assemblies [T₁ and T₂, as described in previous works, Piacente et al. (1991, 1994)] having different sensitivities (where the difference is primarily due to the different length of the tungsten torsion wire) were employed.

To evaluate the molecular weight of the effusing vapor through the Knudsen equation (Knudsen, 1950), $M = [(C/p)(dg/dt)]^2 T$, at fixed temperatures (T), in addition to the experimental torsion pressure (p), also the rate of mass loss of the sample (dg/dt) was simultaneously measured by a vacuum electrobalance (Cahn 1000) to which the torsion assembly T₁ was suspended. C is the Knudsen instrument constant including also the geometrical characteristics of the effusion holes of the cell used. The two values of the

Table 3. Third-Law Standard Sublimation Enthalpy of InCl₃

| <i>T</i> /K | p_{tot} /kPa | $\Delta_{\text{sub}}(\text{fef})^a/$ (J mol ⁻¹ K ⁻¹) | $\Delta_{\text{sub}}H^{\circ}(298 \text{ K})^b/$ (kJ mol ⁻¹) | $p(\text{InCl}_3)^c/$ kPa |
|-------------|-----------------------|--|---|------------------------------|
| 500 | 4.17×10^{-5} | -194.4 | 158.2 | 4.17×10^{-5} |
| 650 | 3.76×10^{-1} | -191.4 | 154.5 | 1.92×10^{-1} |

^a Free energy function change associated to the sublimation process (eq 2): $\text{InCl}_3(\text{s}) = \text{InCl}_3(\text{g})$; $\text{fef} = [G^{\circ}(T) - H^{\circ}(298 \text{ K})]/T$.

^b Calculated considering at both temperatures $p(\text{InCl}_3) = P_{\text{tot}}$.
^c $\text{InCl}_3(\text{g})$ partial pressure calculated by third-law procedure employing at 650 K the same $\Delta_{\text{sub}}H^{\circ}(298 \text{ K}) = 158.2 \text{ kJ mol}^{-1}$ calculated at 500 K (see text).

Table 4. Temperature Dependence of the Equilibrium Constants of the Dissociation Process: $\text{In}_2\text{Cl}_6(\text{g}) = 2\text{InCl}_3(\text{g})$

| references | ΔT /K | $\log(K_p/\text{kPa}) = \frac{A - B(K/T)}{A - B(K/T)}$ | | $K_p(650 \text{ K})/$ kPa |
|-------------------|----------------|--|---------------|------------------------------|
| | | <i>A</i> | <i>B</i> | |
| Sryvtsev (1973) | 760–880 | 9.43 ± 0.06 | 6720 ± 70 | 0.123 |
| Komshilova (1969) | 753–1261 | 8.96 ± 0.05 | 6313 ± 30 | 0.177 |
| Kuniya (1974) | 763–1113 | 9.23 | 6645 | 0.102 |
| Oppermann (1994) | <i>T</i> = 710 | 9.98 | 6829 | 0.298 |
| this work | <i>T</i> = 650 | | | 0.188 |

instrument constants of each crucible, when either as torsion or Knudsen cell was employed, were measured by vaporizing pure cadmium and lead, standards having very reliable vapor pressures (Hultgren et al., 1973). These constants, often checked between the various vaporization runs of InCl_3 , were reproducible within about 5% of their average values.

The total torsion vapor pressures above InCl_3 are reported in Table 1 and shown in Figures 1 and 2. No evidence on the dependence of the results on the different effusion hole area of the cells was observed. The $\log p$ vs $1/T$ equations in Table 2 were derived from a linear least-squares treatment of the data obtained in each run. From these, a pressure equation for each assembly was selected and reported in same table. These selected equations are in good agreement so that the following one, representative of the total vapor pressure above InCl_3 in the temperature range (495 to 648) K, is proposed:

Table 5. Temperature Dependence of the Total Vapor Pressures and $\text{InCl}_3(\text{g})$ Partial Pressures above InCl_3 and the Enthalpies of the Sublimation Reaction (Eq 2): $\text{InCl}_3(\text{s}) = \text{InCl}_3(\text{g})$

| references | ΔT /K | method | $\log(p/\text{kPa}) = A - B(K/T) - C \log(T/K)$ | | | | second law | | third law | | |
|--------------------|----------------|-----------|---|--------------------|----------------|----------|--------------------|--|--|------------------------------------|----------------------------|
| | | | pressure | <i>A</i> | <i>B</i> | <i>C</i> | \bar{T}/K | $\Delta_{\text{sub}}H^{\circ}(T)/$ kJ mol ⁻¹ | $\Delta_{\text{sub}}H^{\circ}(298 \text{ K})^a/$ kJ mol ⁻¹ | <i>T</i> /K | $p(\text{InCl}_3)/$ kPa |
| Robert (1936) | 615–760 | static | total | 12.75 | 8261 | | | | | | |
| Smith (1958) | 482–564 | torsion | total | 11.78 | 8086 | | | | 482 | 1.01×10^{-5} ^c | 158.4 |
| Fadeev (1964) | ~620–819 | static | total | 10.49 | 6944 | | | | | | |
| Polyachenok (1970) | 647–792 | static | total | 13.53 ± 0.04 | 9074 ± 27 | | | | | | |
| Polyachenok (1970) | 647–792 | static | $\text{InCl}_3(\text{g})^d$ | 24.71 ± 0.05 | 9224 ± 23 | 4 | 738 | 151.4 | 163.0 | 647 1.62×10^{-1} | 158.5 |
| Sryvtsev (1973) | 761–884 | static | total ^e | 11.99 | 7911 | | | | | 792 2.94×10 | 157.2 |
| Kuniya (1974) | 623–773 | static | $\text{InCl}_3(\text{g})$ | 11.77 | 8167 | 698 | 156.3 | 166.6 | 623 4.58×10^{-2} | 773 1.60×10 | 159.5 |
| Defoort (1988) | 478–563 | mass-spec | $\text{InCl}_3(\text{g})^f$ | | | | 524 | 161.1 ± 1.6 | 168.5 | | 157.7 |
| Defoort (1988) | 453–572 | mass-spec | $\text{InCl}_3(\text{g})^f$ | | | | 489 | 151.1 ± 1.2 | 155.6 | | |
| Oppermann (1994) | <i>T</i> = 710 | static | $\text{InCl}_3(\text{g})$ | 11.449 ± 0.155 | 7858 ± 128 | 710 | 150.4 | 161.1 | 710 | 2.41 | 157.0 |
| this work | 495–648 | torsion | total | 12.76 ± 0.15 | 8570 ± 200 | | | | | | |
| | | | $\text{InCl}_3(\text{g})$ | 11.49 | 7940 | 570 | 152 | 158 | 570 | 3.63×10^{-3} | 158.2 |

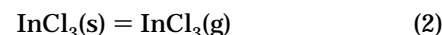
^a Calculated by us by the slope of the pressure equation and the heat capacities reported by Gurvich (1993). ^b Calculated by us by the free energy function reported by Gurvich (1993). ^c Calculated considering the partial pressure of the dimer form to be negligible. ^d Derived by the authors from the total pressures and the equilibrium constants of the dissociation reaction: $\text{In}_2\text{Cl}_6(\text{g}) = 2\text{InCl}_3(\text{g})$ reported by Komshilova et al. (1969). ^e Derived by us from the $\Delta_{\text{sub}}H^{\circ}(T)$ and $\Delta_{\text{sub}}S^{\circ}(T)$ values reported in the work. ^f No absolute vapor pressure data are reported in the work.

$$\log(p/\text{kPa}) = 12.76 \pm 0.15 - (8570 \pm 200)/(TK) \quad (1)$$

The associated errors were estimated considering that in both assemblies the temperatures were measured with an uncertainty of about ± 2 K, the torsion angles, smaller than about 10° , with uncertainties of $\pm 5\%$ (the errors associated to larger angle values are decidedly negligible) and that the torsion instrumental constants are reproducible within 5%, as reported above. This equation is drawn in Figure 3 for comparison with those reported in the literature.

Some values for the molecular weight of the effused vapor were evaluated by the Knudsen-effusion method measuring the sample mass loss rates during the torsion-pressure determinations at fixed temperatures. Even though the molecular weight values present a large spread, most values, especially those measured at high temperatures, seem to be higher than that of the monomeric form.

Considering as a first approximation that the vapor consisted of only $\text{InCl}_3(\text{g})$, from the slope of the selected eq 1, the second-law enthalpies of the sublimation reaction



were calculated, $\Delta_{\text{sub}}H^{\circ}(580 \text{ K}) = 164.0 \text{ kJ mol}^{-1}$ and $\Delta_{\text{sub}}H^{\circ}(298 \text{ K}) = 171.5 \text{ kJ mol}^{-1}$, where the heat capacities necessary to reduce the sublimation enthalpy value to 298 K were taken from Gurvich et al. (1993).

By using the vapor pressure values calculated by the eq 1 at two approximate extreme experimental temperatures (500 and 650 K) and the corresponding free energy function changes associated with the sublimation reaction 2 taken from Gurvich et al. (1993), the third-law standard sublimation enthalpy of this reaction was calculated. The $\Delta_{\text{sub}}H^{\circ}(298 \text{ K})$ values show a temperature trend (see Table 3) and are lower than that obtained by the second-law procedure.

This disagreement is not surprising considering that at high temperatures, as reported in the literature, in addition to $\text{InCl}_3(\text{g})$, the dimer form $\text{In}_2\text{Cl}_6(\text{g})$ is present in a detectable amount in the vapor. The molecular weight values of the vapor, by us evaluated by the Knudsen method at high temperatures, even with large uncertainties, confirmed this vaporization behavior. On this basis, if at high temperatures the $\text{InCl}_3(\text{g})$ partial pressure values

are lower than the total pressures while at low temperature (~ 500 K) they are practically equal, the slope of the plot of $\log P(\text{InCl}_3)$ vs $1/T$ is lower than that of eq 1, so that the derived second-law enthalpy of reaction 2 is less than 164 kJ mol^{-1} . Moreover the use of lower $\text{InCl}_3(\text{g})$ partial pressure values at high temperatures produces an increase of the corresponding third-law sublimation enthalpy at these temperatures and, consequently, reduces the temperature trend of these values. So, considering at 500 K $p(\text{InCl}_3) = p_{\text{tot}}$, the partial pressure of $\text{InCl}_3(\text{g})$ at 650 K was calculated by the third-law procedure using the standard sublimation enthalpy value determined at 500 K (158.2 kJ mol^{-1}) and the free energy function change of reaction 2 ($-191.4 \text{ J mol}^{-1} \text{ K}^{-1}$) at 650 K. The value $p(\text{InCl}_3) = 0.19 \text{ kPa}$, shows that at 650 K the partial pressures of the dimeric and monomeric forms are comparable. It is interesting to note that, considering these partial pressures both equal to $0.5p_{\text{tot}}$, the K_p value of the gaseous dissociation reaction, $\text{In}_2\text{Cl}_6(\text{g}) = 2\text{InCl}_3(\text{g})$ at 650 K, was found to be 0.188 kPa. This value is in satisfactory agreement with those obtained by extrapolation at 650 K of high-temperature K_p data of the dissociation reaction reported in the literature (see Table 4). The two $\text{InCl}_3(\text{g})$ partial pressure values at 500 K and 650 K were used to derive the following pressure-temperature equation:

$$\log[p(\text{InCl}_3)/\text{kPa}] = 11.49 - 7940/(TK) \quad (3)$$

This equation is reported in Table 5 for comparison with those reported in the literature.

From the slope of this equation, the second-law enthalpies, $\Delta_{\text{sub}}H^\circ(580 \text{ K}) = 152 \text{ kJ mol}^{-1}$ and $\Delta_{\text{sub}}H^\circ(298 \text{ K}) = 158 \text{ kJ mol}^{-1}$, associated to the sublimation process (eq 2) were derived. The standard enthalpy value so calculated was close to that found by the third-law procedure so that the final selected value (158 ± 4) kJ mol^{-1} is proposed, where the uncertainty was overestimated. This value is consistent with the trend of the standard sublimation enthalpies of the indium halides, InF_3 ($330 \pm 4 \text{ kJ mol}^{-1}$) (Bardi et al., 1997), InBr_3 ($147 \pm 4 \text{ kJ mol}^{-1}$) (Brunetti et al., 1997b), and InI_3 ($136 \pm 5 \text{ kJ mol}^{-1}$) (Brunetti et al., 1997a) found in previous works.

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