Standard Sublimation Enthalpies of Erbium Trichloride, Tribromide, and Triiodide

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The total vapor pressures of the erbium trihalides $ErCl_3$, $ErBr_3$, and ErI_3 were measured by the torsion method, and their temperature dependences can be expressed by the following equations over the given temperature ranges: $ErCl_3$(s), $\log(p/\text{kPa}) = 12.04 \pm 0.15 - (15159 \pm 200)(\text{K}/T)$ from (880 to 1040) K; $ErBr_3$(s), $\log(p/\text{kPa}) = 11.09 \pm 0.15 - (14256 \pm 200)(\text{K}/T)$ from (919 to 1058) K; ErI_3(s), $\log(p/\text{kPa}) = 11.55 \pm 0.15 - (13862 \pm 200)(\text{K}/T)$ from (871 to 1082) K. Treating the results by second- and third-law methods, the standard sublimation enthalpies were determined to be $\Delta_{\text{sub}}H°(298\ \text{K}) = \{(308 \pm 4)\ \text{kJ}\cdot\text{mol}^{-1}$ and $(293 \pm 4)\ \text{kJ}\cdot\text{mol}^{-1}\}$ for $ErCl_3$ and $ErBr_3$, respectively. For ErI_3 the proposed enthalpy, $\Delta_{\text{sub}}H°(298\ \text{K}) = (282 \pm 6)\ \text{kJ}\cdot\text{mol}^{-1}$, was only derived by the second-law method. From this standard enthalpy a set of free energy functions for solid ErI_3 was evaluated by third-law treatment of the data.

Introduction

Vapor pressures and thermodynamic properties of rare earth halides, and, in particular, of erbium trichloride, tribromide, and triiodide, are quite scarce. Apparently, the only vapor pressure data for $ErCl_3$ are some values for saturated liquid measured by Moriarty[1] with the Knudsen method and two pressure−temperature equations obtained at high temperature with the boiling point method by Polyachenok and Novikov[2] and by Dudchik et al.,[3] respectively. For $ErBr_3$ the only reliable vapor pressures and thermodynamic data are those obtained mass-spectrometrically by Gietmann et al.[4,5] and some values measured by the same author[4] with the mass-loss Knudsen effusion method. In the last work, the authors reported that in addition to the monomer form also the dimer form is present for about 1% in the vapor. The vapor pressure of erbium triiodide was measured by Hirayama et al.[6] by the Knudsen method, and the derived standard sublimation enthalpy $\Delta_{\text{sub}}H°(298\ \text{K}) = (306.3 \pm 5.0)\ \text{kJ}\cdot\text{mol}^{-1}$ is in fair agreement with the value $(290 \pm 16\ \text{kJ}\cdot\text{mol}^{-1})$ obtained by the same authors in a subsequent mass-spectrometric investigation.[7] On this basis, in the context of a continuing research program on the study of the vaporization of lanthanide trihalides (except for trifluorides)[8−15] carried out in our laboratory, the vapor pressures of erbium trihalides were measured by the torsion-effusion method, from which the corresponding standard sublimation enthalpies were derived.

Experimental Section

Chemicals. All erbium trihalide samples, supplied by Aldrich, show a nominal purity of (99.8 to 99.9) mass %. Despite the certified purities and cautions in manipulation in order to prevent the contact of the samples with the moisture during their loading in the torsion cell, the vaporization of about (1 to 2)% of the original mass of all samples was observed in the first step of their heating at about 500 K. After the impurities (or moisture) were depleted by vaporization (since no further vaporization was detected when heating), the vaporization experiment was started and the torsion cell was heated until the vapor pressure of the studied component began to be detectable.

Apparatus and Procedures. The torsion assembly used in the present study was the same as that used in our previous works and described in detail in ref 16. Three conventional graphite torsion cells were used having different areas of their effusion holes (diameters 1.8, 1, and 0.6 mm for the cells A, B, and C, respectively). The studied sample was held in a tantalum liner.

As usual, the cell constant values of these cells necessary to convert the measured torsion angles of the assembly into pressure data were determined by vaporizing reference substances with well-known vapor pressures (silver and lead[17] in this study). The cell constant of each cell was checked in separate runs carried out between the vaporization runs of a compound. The calibration constant values for all the cells were found to be reproducible with a maximum spread of about 10% around their average value, and this converts to a change of about 0.1 in log *p*. The experimental error associated with torsion angles smaller than about 5° ranges from about 20% to 5% of the measured values (with a corresponding displacement for log *p* of about 0.1 to 0.02) while for larger angles the error is negligible. Considering that the uncertainties of the first points influence heavily the slope of the derived log *p* versus 1/*T* equation, the torsion measurements started when the torsion angles were about 5° or higher. The sample temperatures were measured by a calibrated Pt−Pt/Rh (10%) thermocouple inserted in a second cell placed beneath the torsion working cell and recalibrated “in situ”.[16] The accuracy associated with the temperature values should not exceed (1−2) K. To check the reliability of the torsion apparatus, some vaporization enthalpy values of lead were determined from the slopes of log α versus 1/*T* equations (α is the measured torsion angle) obtained during the calibration runs. The enthalpy values so obtained $\{(183.6 \pm 1.5)\ \text{kJ}\cdot\text{mol}^{-1}$ (2), $(184.1 \pm 2)\ \text{kJ}\cdot\text{mol}^{-1}$

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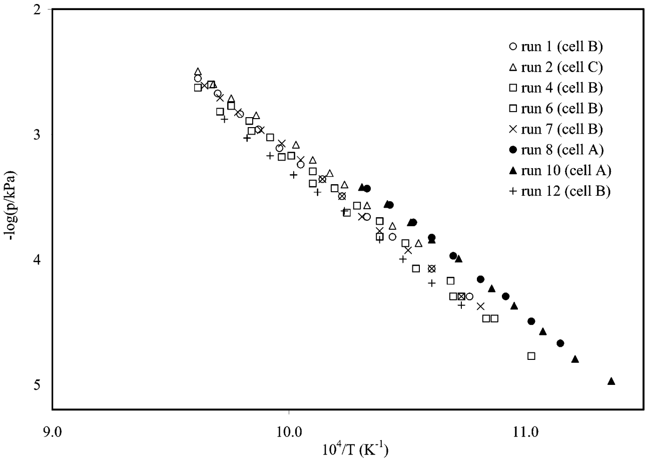

Figure 1. Experimental vapor pressure of $ErCl_3$ measured by the torsion method.

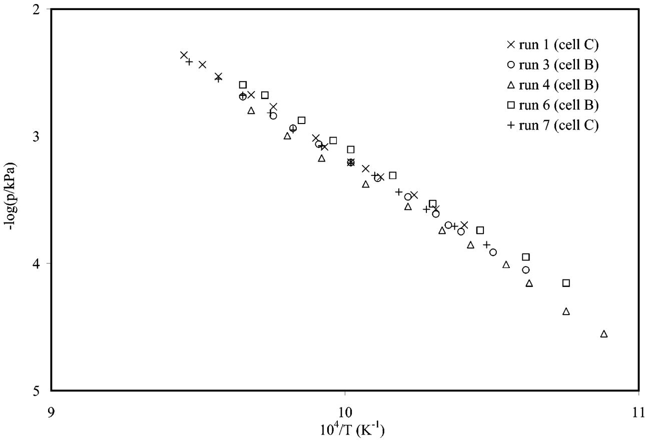

Figure 2. Experimental vapor pressure of $ErBr_3$ measured by the torsion method.

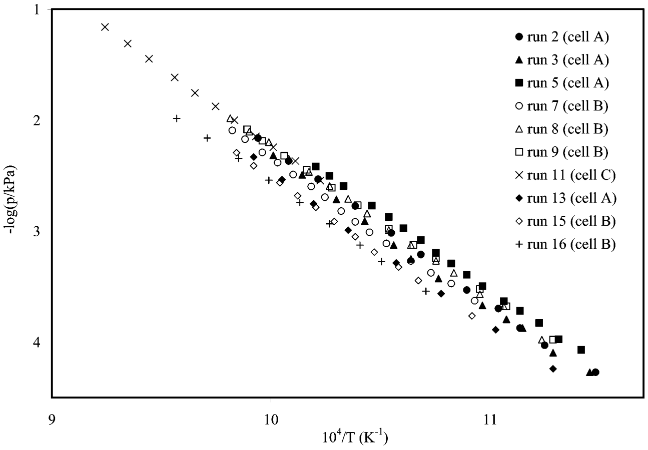

Figure 3. Experimental vapor pressure of ErI_3 measured by the torsion method.

(3), and (184.9 ± 1.5) kJ·mol^{-1} (4), obtained by using cells A, B, and C, respectively; the errors are semidispersions, and in parentheses is reported the number of the calibration runs} were in fair agreement within their uncertainties with the value selected in the literature, 184.6 kJ·mol^{-1}.[17]

Vapor Pressures. The experimental vapor pressures for the studied compounds are reported in Tables 1−3 and Figures 1−3. The log *p* versus 1/*T* equations obtained by a least squares treatment of the experimental data for each run are summarized in Table 4. The vapor pressures measured above the molten $ErCl_3$ were not taken into account because the few values determined above the melting point (mp = 1049 K)[18] were not sufficient for a reliable evaluation of the *p*−*T* equation. Apparently, the vapor pressures measured by cell A above $ErCl_3$ and ErI_3 are slightly higher than those measured by the other cells, and we are persuaded that this can be due to a small systematic error connected with the used cell constant. By weighting slopes and intercepts of the equations reported in Table 4 proportionally to the number of experimental points, the following equations were selected that are representative of the temperature dependence of the total vapor pressure of erbium trihalides in the covered temperature ranges:

$ErCl_3(s)$

$$\log(p/\mathrm{kPa}) = 12.04 \pm 0.15 - (15159 \pm 200)(\mathrm{K}/T) \quad \text{from (880 to 1040) K} \quad (1)$$

$ErBr_3(s)$

$$\log(p/\mathrm{kPa}) = 11.09 \pm 0.15 - (14256 \pm 200)(\mathrm{K}/T) \quad \text{from (919 to 1058) K} \quad (2)$$

$ErI_3(s)$

$$\log(p/\mathrm{kPa}) = 11.55 \pm 0.15 - (13862 \pm 200)(\mathrm{K}/T) \quad \text{from (871 to 1082) K} \quad (3)$$

The errors associated with these equations were estimated to be the same for all compounds. These selected equations were compared with the data found in the literature in Figures 4−6. For $ErCl_3$ and ErI_3 the data are in agreement, whereas for $ErBr_3$ our vapor pressures are lower than those reported by Gietmann et al.,[4,5] though the slopes of the corresponding log *p* versus 1/*T* equations are practically equal.

Discussion

The vaporization behavior of erbium trihalides was considered to be coherent and similar to that of the other rare earth trihalides;[8−15] thus, the monomer forms were assumed to be the abundant species present in the vapor above erbium trihalides and their vapor pressures were assumed to be equal to the values of the measured total pressures. In this way, the second-law sublimation or vaporization enthalpies for these compounds in the monomer form at the midrange experimental temperatures were calculated from the slopes of the selected pressure−temperature equations (eqs 1−3).

$ErCl_3$. The second-law sublimation enthalpy of this compound at the average temperature of the covered range, $\Delta_{sub}H°(960\ \mathrm{K}) = (290 \pm 4)$ kJ·mol^{-1}, was derived from the slope of eq 1. This value was reduced to 298 K, $\Delta_{sub}H°(298\ \mathrm{K}) = (306 \pm 4)$ kJ·mol^{-1}, by using the enthalpy increments for solid and gaseous $ErCl_3$ reported by Pankratz. [19] The standard sublimation enthalpy of this compound was also evaluated by a third-law treatment of its vapor pressures calculated by eq 1 at three temperatures [(900, 1000, and 1049) K]. The necessary free energy functions, $[G°(T) - H°(298\ \mathrm{K})]/T$ (fef), for solid and gaseous phases were those selected by Pankratz.[19] The absence of an evident temperature trend in the third-law sublimation enthalpy values (see Table 5) leads us to believe that no large errors were made both in the absolute vapor pressures and in the employed fef values. The average third-law sublimation enthalpy value, 310 kJ·mol^{-1}, with an estimated error of ±1 kJ·mol^{-1}, agrees with the second-law result, and this

Table 1. Total Vapor Pressures Measured by the Torsion Method above $ErCl_3$

run 1 (cell B)		run 2 (cell C)		run 4 (cell B)		run 6 (cell B)		run 7 (cell B)		run 8 (cell A)		run 10 (cell A)		run 12 (cell B)	
T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$
929	4.30	948	3.87	907	4.77	920	4.47	925	4.37	897	4.67	880	4.97	932	4.37
943	4.07	958	3.73	923	4.47	932	4.30	932	4.30	907	4.49	892	4.80	943	4.19
958	3.82	968	3.57	935	4.30	936	4.17	943	4.07	916	4.29	903	4.57	954	4.00
968	3.66	977	3.40	949	4.07	953	3.87	952	3.93	925	4.16	913	4.37	963	3.84
978	3.49	983	3.31	963	3.82	963	3.69	963	3.77	935	3.97	921	4.23	977	3.61
986	3.36	990	3.20	976	3.63	972	3.57	970	3.66	943	3.83	933	3.99	988	3.46
995	3.24	997	3.08	990	3.39	981	3.43	978	3.49	950	3.70	943	3.84	998	3.32
1004	3.11	1014	2.85	1003	3.18	990	3.30	986	3.36	959	3.56	951	3.70	1008	3.17
1013	2.96	1025	2.71	1016	2.97	999	3.17	995	3.20	968	3.43	960	3.56	1018	3.03
1021	2.84	1033	2.60	1030	2.82	1008	3.03	1003	3.07			970	3.42	1028	2.88
1031	2.67	1040	2.50	1040	2.63	1017	2.89	1012	2.97						
1040	2.55					1025	2.77	1022	2.82						
						1034	2.60	1030	2.71						
								1037	2.61						

Table 2. Total Vapor Pressures Measured by the Torsion Method above $ErBr_3$

run 1 (cell C)		run 3 (cell B)		run 4 (cell B)		run 6 (cell B)		run 7 (cell C)	
T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$
961	3.70	942	4.05	919	4.55	930	4.15	954	3.85
970	3.57	952	3.91	930	4.38	942	3.95	964	3.71
977	3.46	962	3.75	941	4.15	956	3.74	973	3.57
988	3.32	966	3.70	948	4.01	971	3.53	982	3.44
993	3.25	970	3.61	959	3.85	984	3.31	990	3.31
998	3.20	979	3.48	968	3.74	998	3.10	998	3.21
1007	3.08	989	3.33	979	3.55	1004	3.03	1008	3.07
1010	3.01	998	3.21	993	3.38	1015	2.87	1018	2.95
1025	2.77	1009	3.06	1008	3.17	1028	2.68	1026	2.82
1033	2.67	1018	2.94	1020	3.00	1036	2.59	1036	2.68
1045	2.53	1025	2.84	1033	2.80			1045	2.55
1051	2.44	1036	2.69					1056	2.41
1058	2.36								

Table 3. Total Vapor Pressures Measured by the Torsion Method above ErI_3

run 2 (cell A)		run 3 (cell A)		run 5 (cell A)		run 7 (cell B)		run 8 (cell B)	
T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$
871	4.27	873	4.27	876	4.07	915	3.63	890	3.98
889	4.03	886	4.10	884	3.97	924	3.47	904	3.68
898	3.87	897	3.87	891	3.83	932	3.38	913	3.57
906	3.70	903	3.79	898	3.72	940	3.27	923	3.38
918	3.53	912	3.67	904	3.63	950	3.11	930	3.27
936	3.21	929	3.43	912	3.50	957	3.01	940	3.12
948	3.02	940	3.25	918	3.39	963	2.92	949	2.99
963	2.77	947	3.13	924	3.29	969	2.82	958	2.84
979	2.53	959	2.91	930	3.20	976	2.69	966	2.71
992	2.37	971	2.72	936	3.08	982	2.60	974	2.59
1006	2.16	986	2.49	943	2.97	990	2.49	983	2.47
		999	2.32	949	2.87	997	2.38	992	2.35
				956	2.77	1004	2.29	1001	2.20
				968	2.59	1012	2.17	1010	2.10
				974	2.50	1018	2.09	1019	1.98
				980	2.42				

run 9 (cell B)		run 11 (cell C)		run 13 (cell A)		run 15 (cell B)		run 16 (cell B)	
T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$	T/K	$-\log(p/\text{kPa})$
886	3.98	978	2.54	886	4.24	916	3.76	934	3.54
903	3.68	989	2.37	907	3.89	928	3.56	952	3.27
913	3.52	999	2.24	928	3.56	937	3.44	961	3.13
930	3.24	1007	2.15	946	3.29	945	3.32	974	2.93
939	3.12	1017	2.00	966	2.99	955	3.19	987	2.74
949	2.98	1026	1.88	981	2.75	963	3.05	1001	2.54
962	2.77	1036	1.75	995	2.53	972	2.91	1015	2.34
973	2.61	1046	1.61	1008	2.33	980	2.79	1030	2.16
984	2.45	1059	1.45			988	2.68	1045	1.99
994	2.32	1070	1.31			996	2.56		
1004	2.19	1082	1.16			1008	2.41		
1011	2.08					1016	2.29		

leads us to propose as standard sublimation enthalpy for $ErCl_3$ the average value of (308 ± 4) kJ·mol^{-1}. This value is slightly lower than the value evaluated as the difference between the heats of formation reported in Pankratz's Tables for solid and gaseous $ErCl_3$ (320 kJ·mol^{-1}) but higher than the approximate value reported by Dudchik et al. [3] (284 kJ·mol^{-1}). Considering the standard sublimation enthalpies for other trichlorides of the heavy lan-

Table 4. Temperature Dependence of the Total Vapor Pressure of Solid ErX_3 (X= Cl, Br, I)

					$\log(p/\text{kPa}) = A - B/(T/\text{K})$	
compd	cell	run	no. of points	ΔT/K	A^a	B^a
$ErCl_3$	B	1	12	929−1040	12.07 ± 0.11	15 224 ± 107
	C	2	11	948−1040	11.75 ± 0.15	14 815 ± 144
	B	4	11	907−1040	11.90 ± 0.14	15 135 ± 140
	B	6	13	920−1034	12.21 ± 0.16	15 349 ± 159
	B	7	14	925−1037	12.27 ± 0.15	15 420 ± 147
	A	8	9	897−968	12.38 ± 0.18	15 292 ± 166
	A	10	10	880−970	12.20 ± 0.20	15 134 ± 185
	B	12	10	932−1028	11.50 ± 0.10	14 780 ± 99
$ErBr_3$	C	1	13	961−1058	11.09 ± 0.20	14 234 ± 199
	B	3	12	942−1036	11.03 ± 0.10	14 211 ± 95
	B	4	11	919−1033	11.10 ± 0.20	14 358 ± 195
	B	6	10	930−1036	11.17 ± 0.11	14 250 ± 105
	C	7	12	954−1056	11.06 ± 0.10	14 237 ± 104
ErI_3	A	2	11	871−1006	11.79 ± 0.18	14 038 ± 165
	A	3	12	873−999	11.35 ± 0.24	13 681 ± 220
	A	5	16	876−980	11.78 ± 0.11	13 920 ± 98
	B	7	15	915−1018	11.69 ± 0.16	14 043 ± 154
	B	8	15	890−1019	11.69 ± 0.10	13 918 ± 96
	B	9	12	886−1011	11.28 ± 0.06	13 514 ± 57
	C	11	11	978−1082	11.78 ± 0.09	14 014 ± 88
	A	13	8	886−1008	11.41 ± 0.19	13 880 ± 176
	B	15	12	916−1016	11.20 ± 0.11	13 719 ± 108
	B	16	9	934−1045	11.28 ± 0.10	13 843 ± 98

[a] The quoted errors are standard deviations.

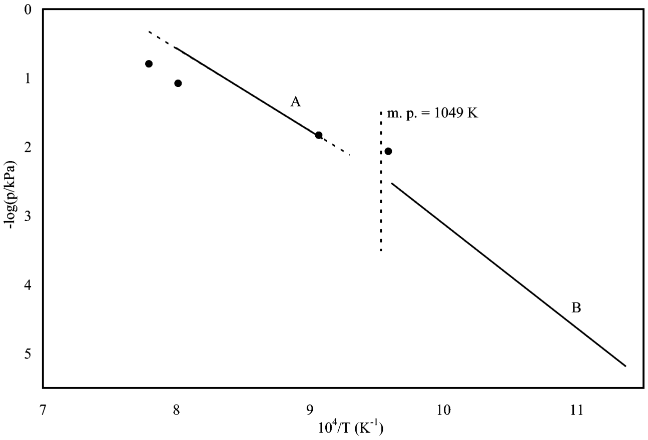

Figure 4. Comparison of vapor pressures for $ErCl_3$: (●) Moriarty; [1] (A) this line is representative of two practically equal log p vs $1/T$ equations reported by Polyachenok and Novikov[2] and Dudchik et al.; [3] (B) this work.

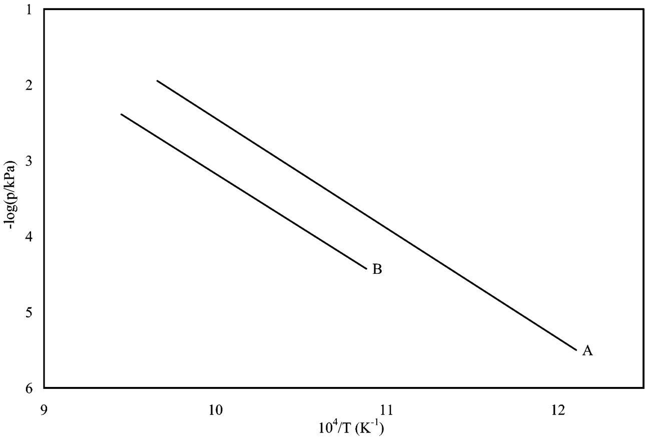

Figure 5. Comparison of vapor pressures for $ErBr_3$: (A) Gietmann et al.; [4] (B) this work.

thanides determined by us in previous works, ($GdCl_3$ = 311 ± 4,[14] $TbCl_3$ = (296 ± 4),[14] $DyCl_3$ = (283 ± 5),[8] and $HoCl_3$ = (297 ± 10) kJ·mol^{-1} [15]), the value obtained for $ErCl_3$ seems to be comparable.

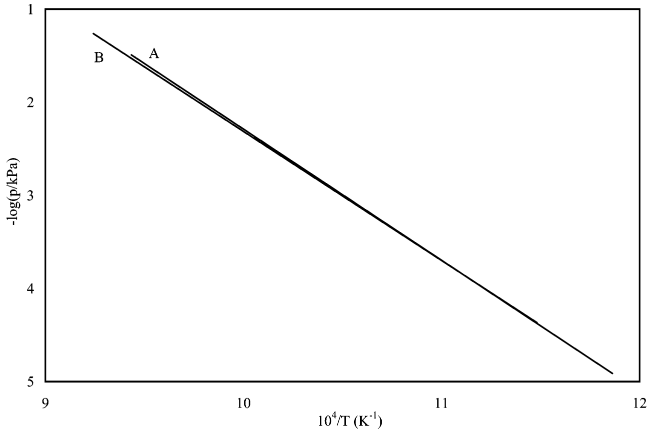

Figure 6. Comparison of vapor pressures for ErI_3: (A) Hirayama;[6] (B) this work.

Table 5. Third-Law Sublimation Enthalpies for $ErCl_3$ and $ErBr_3$

compd	T/K	p/kPa	$-R\ln(p/\text{atm})$ J·K^{-1}·mol^{-1}	$-\Delta$fef J·K^{-1}·mol^{-1}	$\Delta_{\text{sub}}H°(298\text{ K})$ kJ·mol^{-1}
$ErCl_3$	900	1.59×10^{-5}	130.2	213.8	309.6
	1000	7.69×10^{-4}	98.0	212.1	310.0
	1049^a	3.93×10^{-3}	84.4	211.2	310.1
				avg	310 ± 1
$ErBr_3$	900	1.76×10^{-5}	129.4	198.9	295.5
	1000	6.75×10^{-4}	99.1	197.3	296.4
	1100	1.33×10^{-2}	74.3	195.7	297.0
				avg	296 ± 2

[a] Melting point for $ErCl_3$.[18]

***$ErBr_3$*.** The second-law sublimation enthalpy of $ErBr_3$ derived from the slope of the selected eq 2, $\Delta_{\text{sub}}H°(989\text{ K}) = (273 \pm 4)$ kJ·mol^{-1}, was reduced to 298 K, $\Delta_{\text{sub}}H°(298\text{ K}) = (289 \pm 4)$ kJ·mol^{-1}, by the enthalpy increment selected by Pankratz[19] for the gaseous compound (57.6 kJ·mol^{-1}), and the value $H°(989\text{ K}) - H°(298\text{ K}) = 73.5$ kJ·mol^{-1} was calculated by the temperature dependence equation of the heat capacity reported by Myers and Graves,[20] $C_p(\text{J·mol}^{-1}\text{·K}^{-1}) = 97.97 + 0.0109\ T/\text{K}$, for the solid compound. Three third-law values of the standard sublimation enthalpy of this compound were calculated at 900, 1000, and 1100 K from the corresponding vapor pressures calculated with eq 2. The necessary fef values for the gaseous phase were those reported in the Pankratz's Tables, while for the solid phase they were evaluated using the entropy, $S°(298\text{ K}) = 195$ J·mol^{-1}·K^{-1},[4] and the heat capacities calculated by the above-reported equation. The sublimation enthalpies so obtained (see Table 5) present a very small temperature trend, and the average value, $\Delta_{\text{sub}}H°(298\text{ K}) = 296$ kJ·mol^{-1}, with an estimated error of 2 kJ·mol^{-1}, is slightly higher than that determined by the second-law procedure. On this basis we propose as standard sublimation enthalpy for $ErBr_3$ the value 293 kJ·mol^{-1} with an estimated error of ±4 kJ·mol^{-1}, obtained as the average of the second- and third-law results. This average value agrees with that selected by Gietmann et al.,[4,5] (288.2 ± 6.1) kJ·mol^{-1}, obtained from the second-law, (293 ± 7) kJ·mol^{-1}, and third-law, (279 ± 10) kJ·mol^{-1}, values. Our selected value seems to be decidedly comparable with those obtained by us for tribromides of other heavy lanthanides: $GdBr_3$ = (292 ± 2),[14] $TbBr_3$ = (287 ± 4),[14] $DyBr_3$ = (289 ± 6),[8] and $HoBr_3$ = (290 ± 5) kJ·mol^{-1}.[15]

***ErI_3*.** Apparently, no heat capacity and thermodynamic data for this compound in the solid phase are available.

Table 6. Free Energy Function for Solid ErI_3 Calculated by the Third-Law Method, $\Delta_{sub}H°(298\ K) = (282 \pm 6)$ $kJ\cdot mol^{-1}$ ($p° = 1\ atm = 101.325\ kPa$)

T/K	p/kPa	$-R\ \ln(p/atm)$ $J\cdot K^{-1}\cdot mol^{-1}$	$-\Delta fef$ $J\cdot K^{-1}\cdot mol^{-1}$	$-fef(g)^a$ $J\cdot K^{-1}\cdot mol^{-1}$	$-fef(s)$ $J\cdot K^{-1}\cdot mol^{-1}$
900	1.40×10^{-4}	112.2	201	467.4	266
950	9.05×10^{-4}	96.6	200	470.4	270
1000	4.86×10^{-3}	82.7	200	473.3	273
1050	2.22×10^{-2}	70.0	199	476.2	277
1100	8.84×10^{-2}	58.6	198	479.0	281

[a] Selected by Pankratz.[19]

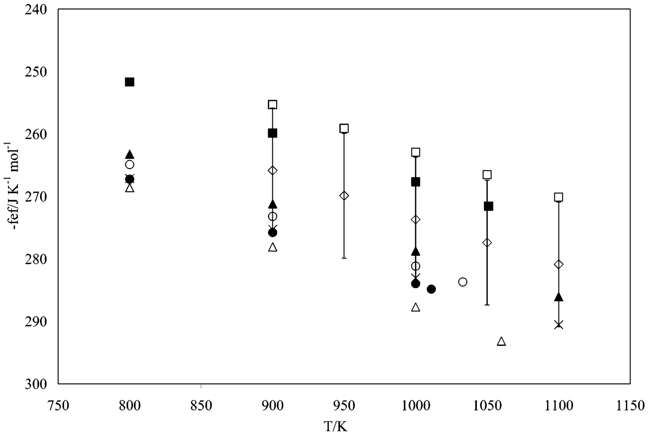

Figure 7. Comparison of the free energy function for solid lanthanide triiodides reported by Pankratz:[19] (■) LaI_3; (○) CeI_3; (●) PrI_3; (△) NdI_3; (▲) GdI_3; (×) TbI_3; (□) HoI_3 (Piacente et al.[15]); (◇) ErI_3 (this work).

The second-law sublimation enthalpy, $\Delta_{sub}H°(976\ K) = (265 \pm 4)\ kJ\cdot mol^{-1}$ obtained from the slope of eq 3, was reported at 298 K, $\Delta_{sub}H°(298\ K) = (282 \pm 6)\ kJ\cdot mol^{-1}$, using for the difference of the enthalpy increment for solid and gaseous ErI_3 the value $\Delta[H°(977\ K) - H°(298\ K)] = 17\ kJ\cdot mol^{-1}$, estimated considering that the corresponding values for the triiodide of other lanthanides range from 15 (HoI_3) to18 $kJ\cdot mol^{-1}$ (LaI_3, DyI_3). Using this second-law standard sublimation enthalpy and the vapor pressures calculated from selected eq 3 at 50 K intervals from (900 and 1100) K, values of the fef change associated with the sublimation of ErI_3 at these temperatures were determined by a third-law treatment of the data (see Table 6). From the fef of the ErI_3(g) reported in Pankratz's Tables at these temperatures, the corresponding fef values for solid phase of this compound were derived and reported in Table 6. The uncertainties associated with these values were evaluated to be about $\pm 10\ J\cdot K^{-1}\cdot mol^{-1}$ considering the error of 6 $kJ\cdot mol^{-1}$ estimated for the $\Delta_{sub}H°(298\ K)$ and the uncertainty of ±0.2 in the logarithm of the vapor pressure data. These fef values, compared in Figure 7 with those of the triiodide of other lanthanides selected by Pankratz,[19] can be considered, within this uncertainty, comparable with those of the other triiodides.

Literature Cited

(1) Moriarty, J. L. Vapor Pressures of Yttrium and Rare Earth Chlorides Above Their Melting Points. *J. Chem. Eng. Data* **1963**, *8*, 422−424.

(2) Polyachenok, O. G.; Novikov, G. I. Thermodynamic Study of di- and trichlorides of rare earth elements. *Ser. Fiz. I Khim. 3* **1963**, 133 (*Vestn. Leningr. Univ. 18* (16)).

(3) Dudchik, G. P.; Polyachenok, O. G.; Novikov, G. I. The Vapour Pressures of the Chlorides of Holmium, Thulium, and Lutetium. *Russ. J Phys. Chem.* **1969**, *43* (8), 1203.

(4) Gietmann, C.; Hilpert, K.; Nickel, H. Thermodynamic Properties of Rare Earth Bromides. *Ber. Forschungszent. Juelich* **1997**, Juel *3337*, 1−171.

(5) Gietmann, C.; Gigli, G.; Niemann, U.; Hilpert, K. Vaporization and Gas-Phase Chemistry of the Rare Earth Halides. *Proc. Electrochem. Soc.* **1997**, *97−39*, 657−665.

(6) Hirayama, C.; Rome, J. F.; Camp, F. E. Vapor Pressures and Thermodynamic of Lanthanide Triiodides. *J Chem. Eng. Data* **1975**, *20*, 1−6.

(7) Hirayama, C.; Castle, P. M. Mass Spectra of Rare Earth Triiodides. *J. Phys. Chem.* **1973**, *77*, 3110−3114.

(8) Brunetti, B.; Vassallo, P.; Piacente, V.; Scardala, P. Vaporization Studies of Dysprosium Trichloride, Tribromide, and Triiodide. *J. Chem. Eng. Data* **1999**, *44*, 509−515.

(9) Brunetti, B.; Villani, A. R.; Piacente, V.; Scardala, P. Vaporization Studies of Lanthanum Trichloride, Tribromide, and Triiodide. *J. Chem. Eng. Data* **2000**, *45*, 231−236.

(10) Villani, A. R.; Brunetti, B.; Piacente, V. Vapor Pressure and Enthalpies of Vaporization of Cerium Trichloride, Tribromide and Triiodide. *J. Chem. Eng. Data* **2000**, *45*, 823−828.

(11) Villani, A. R.; Brunetti, B.; Piacente, V. Vapor Pressures and Sublimation Enthalpies of Praseodymium Trichloride, Tribromide, and Triiodide. *J. Chem. Eng. Data* **2000**, *45*, 1167−1172.

(12) Villani, A. R.; Scardala, P.; Brunetti, B.; Piacente, V. Sublimation Enthalpies of Neodymium Trichloride, Tribromide and Triiodide from Torsion Vapor Pressure Measurements. *J. Chem. Eng. Data* **2002**, *47*, 428−434.

(13) Scardala, P.; Villani, A. R.; Brunetti, B.; Piacente, V. Vaporization Study of Samarium Trichloride, Samarium Tribromide and Samarium Diiodide. *Mater. Chem. Phys. J.* **2003**, *78*, 637−644.

(14) Piacente, V.; Scardala, P.; Brunetti, B. Vapor Pressures and Sublimation Enthalpy of Gadolinium Trichloride, Tribromide, and Triiodide and Terbium Trichloride, Tribromide, and Triiodide. *J. Chem. Eng. Data*, in press.

(15) Piacente, V.; Brunetti, B.; Scardala, P.; Villani, A. R. Vapor Pressure and Sublimation Enthalpies of Holmium Trichloride, Tribromide, and Triiodide. *J. Chem. Eng. Data* **2002**, *47*, 388−396.

(16) Piacente, V.; Fontana, D.; Scardala, P. Enthalpies of Vaporization of a Homologous Series of *n*-Alkanes Determined from Vapor Pressure Measurements. *J. Chem. Eng. Data* **1994**, *39*, 231−237.

(17) Hultgren, R.; Desai, P. D.; Hawkins, D. T.; Gleiser, M.; Kelley, K. K.; Wagman, D. D. *Selected Values of the Thermodynamic Properties of the Elements*; American Society for Metals: Metals Park, OH, 1973.

(18) Gaune-Escard, M.; Rycez, L.; Szczepaniak, W.; Bogacz, A. Enthalpies of Phase Transition in the Lanthanides $LaCl_3$, $CeCl_3$, $PrCl_3$, $NdCl_3$, $GdCl_3$, $DyCl_3$, $ErCl_3$ and $TuCl_3$. *J. Alloys Compd.* **1994**, *204*, 193−196.

(19) Pankratz, L. B. Thermodynamic Properties of Halides; Bull. U. S. Department Int., Bureau of Mines 674; Washington, DC, 1984.

(20) Myers, C. E.; Graves, D. T. Vaporization Thermodynamics of Lanthanide Trihalides. *J. Chem. Eng. Data* **1977**, *22*, 440−445.

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