THERMOCHEMICAL PROPERTIES OF THE ELEMENTS Rn, 112, 114, AND 118: II. VAPOR PRESSURE EQUATION AND VOLATILIZATION PROPERTIES

R. Eichler, B. Eichler (PSI)

The vapor pressure equations for the solid and liquid state of the elements Rn, 112, 114, and 118 have been deduced, applying the critical data and the Debye temperatures. Thermochemical constants for the volatilization processes were calculated.

The reduced vapor pressure equations are given introducing reduced parameters $T_r = T/T_c$ and $p_r = p/p_c$ into the typical vapor pressure equation (eqn. 1).

$$\log(p/kPa) = -\frac{A}{T} + B \qquad (1)$$

Using the critical values T_c and p_c from [1] the reduced vapor pressure equations (eqn. 2) are deduced for noble gases (see Tab.1).

$$\log(p_r) = -\frac{a}{T_r} + b \qquad (2)$$

Table 1: Coefficients of the reduced vapor pressure equations for noble gases

State	solid		liquid	
element	a	b	a	b
Ne	-	-	-2.1992	2.1659
Ar	-2.6996	3.0130	-2.2959	2.2834
Kr	-2.7992	3.1985	-2.3041	2.2937
Xe	-2.8811	3.3361	-2.3154	2.2043
$\varnothing_{Ar..Xe}$	-2.7930	3.1830	-2.3050	2.2940

According to [2] the coefficients should be the same for ideal solids and liquids. This is fairly given for the heavy noble gases Ar to Xe.

Assuming the corresponding states principle to be valid for the heavy noble gases and Rn, 112, 114, and 118 the coefficients of the vapor pressure equations have been calculated for the elements Rn, 112, 114, and 118 using the predicted critical data from [3] according to eqn. 3.

$$\log(p/kPa) = -\frac{a \cdot T_c}{T} + b + \log(p_c/kPa) = -\frac{A}{T} + B \qquad (3)$$

The coefficients A and B are compiled in Table 2.

Table 2: Coefficients of the vapor pressure equations of the elements Rn, 112, 114, and 118. Calculated enthalpies (kJ/mol) and entropies (J/molK) of phase transition at the corresponding triple points.

state	solid			
element	-A, K	B	ΔH_{subl}	ΔS_{subl}
^{222}Rn	1012.3	6.983	19.38	95.41
^{283}112	1038.8	6.987	19.89	95.49
^{288}114	1118.3	6.999	21.41	95.71
^{292}118	1226.1	7.014	23.45	96.01
state	liquid			
element	-A, K	B	ΔH_{vap}	ΔS_{vap}
^{222}Rn	835.4	6.094	16	78.4
^{283}112	857.3	6.098	16.41	78.5
^{288}114	922.9	6.110	17.67	78.7
^{292}118	1011.9	6.125	19.37	79.0

According to Lennard-Jones [4] the potential curves for elements revealing only van der Waals interaction in the solid state should be very similar. A constant proportionality between the depths of the potentials and the critical temperatures is expected according to eqn. 4.

$$k^{\Theta} = \frac{\left(\Delta H^{0}{}_{subl} + U_0\right)}{R \cdot T_c} = 6.45 \qquad (4)$$

We checked this expectation for the noble gases. Therefore, the zero point energies (U_0) have been calculated according to eqn. 5 [5].

$$U_0 = \frac{9}{8} \cdot R \cdot \Theta_D \qquad (5)$$

The Debye temperatures (Θ_D) are taken from [6]. The results are compiled in table 3. Indeed, the constant proportionality is deduced for the heavy noble gases as $k^{\Theta} \sim 6.8$. Hence, it is possible to calculate the sublimation enthalpies at 0 K (ΔH^0_{subl}) for the elements Rn, 112, 114, and 118. The results are listed in table 3.

Table 3: Thermochemical data of noble gases [1,2,6] and deduced data for elements Rn, 112, 114, and 118.

Element	T_c, K	Θ_D, K	U_0, J/mol	ΔH^0_{subl}, kJ/mol	k^{Θ}
Ne	44.40	64	598.6	1.875	6.700
Ar	150.87	80	748.3	7.732	6.760
Kr	209.41	63	598.3	11.210	6.770
Xe	289.73	55	514.4	15.865	6.799
^{220}Rn	362.43	45.09	421.7	20.07	6.8
^{283}112	371.92	40.20	376.0	20.65	6.8
^{288}114	400.38	40.57	379.5	22.26	6.8
^{292}118	438.99	41.14	384.8	24.43	6.8

The calculated sublimation enthalpies are used to predict the adsorption behavior of the elements 112 and 114 under the assumption that they behave as typical heavy noble gases, revealing pure van der Waals interaction with metal surfaces [7].

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