Radon (Rn)

REFERENCES

**REFERENCE STATE**

\[ A_1 = 222 \text{ Radon (Rn)} \]

\[ \Delta H^\circ(0 \text{ K}) = 0 \text{ kJ mol}^{-1} \]

\[ \Delta H^\circ(298.15 \text{ K}) = 0 \text{ kJ mol}^{-1} \]

Electronic Levels and Quantum Weights

<table>
<thead>
<tr>
<th>State</th>
<th>( \epsilon \text{ cm}^{-1} )</th>
<th>( \delta )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( ^{1}S_0 )</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Heat of Formation

Zero by definition.

Heat Capacity and Entropy

Information on the electronic energy levels and quantum weights is taken from Moore. Many of the theoretically predicted levels have not been observed. Our calculations indicate that any reasonable method of filling in these missing levels and cutting off the summation in the partition function\(^2\) has little effect on the thermodynamic properties to 6000 K. This is undoubtedly a result of the high energy of these levels; the first excited level is over 54620 cm\(^{-1}\) above the ground state. Therefore, we list the ground state only. Extension to higher temperatures may require consideration of excited states and utilization of different fill and cutoff procedures.\(^2\)

Thermodynamic functions at 298.15 K are recommended by CODATA\(^4\) for all rare gases except radon. This table agrees with other tabulations except for two minor changes. First, the entropy differs by 0.1094 J K\(^{-1}\) mol\(^{-1}\) because this table uses a reference pressure of 1 bar, whereas the other tabulations are based on 1 atm. Second, entropy differences of the order of 0.001-0.004 J K\(^{-1}\) mol\(^{-1}\) for the rare gases arise due to the use of slightly different values for \( R \) and the relative atomic mass; this table uses \( R = 8.3144 \text{ J K}^{-1}\text{ mol}^{-1} \). With some minor changes, our tables agree within the estimated uncertainty with those by Hilsenrath et al.\(^5\), Gurvich et al.\(^6\), and Wagman et al.\(^7\). The estimated uncertainty due to uncertainties in the relative atomic mass and fundamental constants which are based on the 1981 values,\(^7\) respectively.

Phase Data

Holgate et al.\(^8\) had recommended a melting point of 202 K and a boiling point of 211 K (1 atm). These values are provided for the convenience of the reader and have not been evaluated by the present authors. As a result of the low values, the reference state for radon is chosen to be the ideal gas at all temperatures. This may differ from the choice of other authors.

References


PREVIOUS:

CURRENT: March 1982 (1 bar)
Radon, Ion (Rn$^+$)

**Ideai Gas**

$M_r = 221.99945$  
Radon, Ion (Rn$^+$)

$S^{(298.15\,K)} = 187.761 \pm 0.003\,K^{-1}\cdot mol^{-1}$

- $\Delta H^f(298.15\,K) = 1037.073 \pm 0.002\,kJ\cdot mol^{-1}$
- $\Delta H^f(298.15\,K) = [1043.270]\,kJ\cdot mol^{-1}$

<table>
<thead>
<tr>
<th>State</th>
<th>$e$, cm$^{-1}$</th>
<th>$g_l$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{g2}$</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>$P_{g2}$</td>
<td>30895.1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Heat of Formation**

The ionization limit of radon gas (86692.5 ± 0.2 cm$^{-1}$) reported by Moore$^1$ is adopted as $\Delta H^f(0\,K)$ for Rn$^+(g)$. The ionization limit is converted from cm$^{-1}$ to K$^{-1}$ by using the factor, 1 cm$^{-1}$ = 0.0196266 K$^{-1}$, which is derived from the latest CODATA fundamental constants$^2$. The uncertainty in the ionization limit is estimated to be ±0.2 cm$^{-1}$ which corresponds to an uncertainty of ±0.002 kJ mol$^{-1}$ in the heat of formation. Gurvich et al.$^3$ adopted the same ionization potential, but the use of slightly different values by Wagner et al.$^4$ results in a heat of formation difference of 0.010 kJ mol$^{-1}$.

$\Delta H^f(Rn^+, g \rightarrow 298.15\,K)$ is obtained from $\Delta H^f(Rn, g \rightarrow 0\,K)$ by using IP(Rn) with JANAF$^5$ enthalpies $H^f(0\,K)-H^f(298.15\,K)$ for Rn$^+(g)$, Rn$^0(g)$, and $e^-(g)$. $\Delta H^f$ for Rn$^+(g) - e^+ + e^-$ at 298.15 K differs from a room temperature threshold energy due to inclusion of these enthalpies and threshold effects discussed by Rosenstock et al.$^6$. $\Delta H^f(298.15\,K)$ should be changed by $-6.197$ kJ mol$^{-1}$ if it is to be used in the ion convention that excludes the enthalpy of the electron.

**Heat Capacity and Entropy**

The information on electronic energy levels and quantum weights of Moore$^1$ is incomplete because no levels have been observed. Our calculations indicate that any reasonable method of filling in missing levels and cutting off the summation in the partition function$^7$ has no effect on the thermodynamic functions to 6000 K. This is a result of the high energy of all levels other than the ground state and the $P_{g2}$ level, the next lowest level is estimated to be over 5000 cm$^{-1}$ above the ground state. Since inclusion of these upper levels has no effect on the thermodynamic functions to 6000 K we list only the ground state and the $P_{g2}$ state, with the energy of the latter state taken from a recent study by Moore.$^8$ The reported uncertainty in $S^{(298.15\,K)}$ is due to uncertainties in the relative ionic mass and fundamental constants.

Extension of these calculations above 6000 K may require consideration of the higher excited states and use of different cut-off procedures.

The thermodynamic functions reported here agree with those of Green et al.$^9$, Hilsenrath et al.$^10$, and Gurvich et al.$^3$ except for two minor changes. First, the entropy differs by 0.1094 kJ mol$^{-1}$ because this table uses a standard state pressure of 1 bar, whereas the cited references used a pressure of 1 atm. Second, smaller differences arise from the use of different values for the fundamental constants, the relative ionic mass, and the $P_{g2}$ electronic level.

**References**

3. JANAF Thermochmical Tables: Rn$^+$, 3–31–82; e$^-$, 31–82.