Temperature Effects on Equilibrium: A Study Guide

Show that

\[
\frac{\text{DH}}{R} \frac{d \ln K}{d(1/T)} = - \frac{1}{R} \frac{d}{d(1/T)} \frac{1}{T}
\]

**Solution**

Since

\[
\begin{align*}
DG &= - RT \ln K, \\
\ln K &= - \frac{DG}{RT}
\end{align*}
\]

Differentiate both sides with respect to \(1/T\) in the above equation gives,

\[
\frac{d(\ln K)}{dT} = - \frac{1}{R} \frac{d}{dT} \frac{1}{T}
\]

\[
= - \frac{\text{DH}}{RT^2}
\]

**DISCUSSION**

If \(K_1\) and \(K_2\) are the equilibrium constant at \(T_1\) and \(T_2\) respectively, show further that

\[
\ln \left( \frac{K_1}{K_2} \right) = - \left( \frac{\text{DH}}{R} \right) \left( \frac{1}{T_1} - \frac{1}{T_2} \right).
\]

This is achieved by definite integral. This relationship indicates that the plot of \(\ln (K)\) versus \(1/T\) is a straight line, and the slope is \(- (\text{DH} / R)\). Thus, \(\text{DH}\) can be determined by measuring the equilibrium constant at different temperatures.

\[
\begin{align*}
101,300 \text{ N m}^{-2} & \quad 23.756 \quad = 3166 \text{ Pa} \\
760 \text{ mmHg} & \quad 8.312 \text{ J} \ast 298 \ln(3166) \\
& \quad = 20.0 \text{ kJ / hr}
\end{align*}
\]

**DISCUSSION**

This example illustrates the evaluation of Gibb's energy when the equilibrium constant is known.

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**Contributors and Attributions**

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