Temperature Effects on Equilibrium: A Study Guide

Show that

\[ \frac{\Delta H}{d \ln K} = - \frac{\Delta G}{R} d(1/T) \]

Solution

Since

\[ \Delta G = - R \, T \ln K, \]
\[ \ln K = - \frac{\Delta G}{R \, T} \]

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

\[ \frac{d(\ln K)}{d(T)} = - \frac{1}{R} \frac{\Delta G}{T} / \frac{d(T)}{d(T)} \]
\[ = - \frac{\Delta H}{R \, T^2} \]

DISCUSSION

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

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

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 \( - (\Delta H / R) \). Thus, \( \Delta H \) can be determined by measuring the equilibrium constant at different temperatures.

\[ 101,300 \, \text{N m}^{-2} \]
\[ 23.756 \, \text{mmHg} \]
\[ = \frac{3166 \, \text{Pa}}{760 \, \text{mmHg}} \]

\[ G^o = 8.312 \, \text{J} \, \text{K}^{-1} \ln(3166) \]
\[ = 20.0 \, \text{kJ/hr} \]

DISCUSSION

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

Contributors and Attributions

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