QUESTION OF THE DAY

Problem: The heat capacity of chloroform, $CHCl_3$, in the range of 240 K to 330 K is given by $C_{p,m} = 91.47 + 7.5\times10^{-2}T$ in units of $J/mol\cdot K$ In a particular experiment, 1.00 mol $CHCl_3$ is heated from 273 K to 300 K. Calculate the change in molar entropy of the sample.

The heat capacity of chloroform, CHCl3, in the range of 240 K to 330 K is given by C=91.47 + .075T in units of J/(mol K) In a particular experiment, 1.00 mol CHCl3 is heated from 273 K to 300 K. Calculate the change in molar entropy of the sample.

Solution:

Use the definition of change in entropy, which is $\Delta S = \int \frac{C_{p,m}}{T} dt$

Plugging in $T_i = 273K$ and $T_f = 300K$ and $C_{p,m} = 91.47 + 7.5\times10^{-2}T$ into the definition we get

$$\Delta S = \int \frac{C_{p,m}}{T} dt = \int_{273}^{300} \frac{91.47 + 7.5\times10^{-2}T}{T} dt = \int_{273}^{300} \frac{91.47}{T} dt + \int_{273}^{300} 7.5\times10^{-2} dt$$

Integrating this gives

$$\Delta S = 91.47 \ln\left(\frac{300}{273}\right) + 7.5\times10^{-2}(300-273) = 8.6266 + 2.025 = 10.65\ J/mol\cdot K$$

If you are confused about the units (as to why they are the same as $C_{p,m}$), remember in the integrand we divided by temperature (in K) so the units of the integrand are $J/mol\cdot K^2$. When this is integrated with respect to T, the units change back to $J/mol\cdot K$

Then, for 1.00 mol of $CHCl_3$, we have 10.65 $\left(10.65\ J/mol\cdot K\right)(1.00mol)$=10.65 J/K

Thus, the change in entropy is 10.65 J/K