ChemE 2200 - Physical Chemistry II for Engineers

Quiz 6 - March 5, 2025

Name: *Solution*

To calculate ΔS_{gas} we must devise reversible paths that connect the initial and final states. Path 1 - reversible and isothermal expansion to 10. L at 298 K. Path 2 - reversible and isochoric cooling to 233 K.

Calculate the entropy change for the first path. Because the path is reversible and isothermal, and because the gas is ideal,

$$\Delta S_{\text{gas}} = R \ln \frac{V_2}{V_1} = (8.314\ \text{J/K·mol}) \ln \frac{10\ \text{atm}}{1\ \text{atm}} = 19.1\ \text{J/K·mol}$$

Calculate the entropy change for path 2.

$$\delta q_{\text{rev}} = C_V\, dT$$

$$\frac{\delta q_{\text{rev}}}{T} = \frac{C_V}{T}\, dT$$

$$\Delta S_2 = \int \frac{\delta q_{\text{rev}}}{T} = \int_{T_1}^{T_2} \frac{C_V}{T}\, dT = C_V \ln \frac{T_2}{T_1} = n\overline{C}_V \ln \frac{T_2}{T_1} = n \frac{3}{2} R \ln \frac{T_2}{T_1}$$

$$= (1\ \text{mol}) \frac{3}{2} (8.314\ \text{J/K·mol}) \ln \frac{233\ \text{K}}{298\ \text{K}} = -3.07\ \text{J/K·mol}$$

Calculate the total entropy change.

$$\Delta S_{\text{gas}} = \Delta S_1 + \Delta S_2 = 19.1\ \text{J/K·mol} - 3.07\ \text{J/K·mol} = 16.0\ \text{J/K·mol}$$

Because no heat transferred to the surroundings in the actual process, $\Delta S_{\text{surroundings}} = 0$.

Grading Rubric:

+2 → developed 2 reversible paths

+2 → solved ΔS of reversible path 1 correctly

-1 → sign error

+2 → solved ΔS of reversible path 2 correctly

-1 → sign error

+2 → correct ΔS_{gas}

-1 → ΔS_{gas} incorrect because either ΔS_1 or ΔS_2 was incorrect but the other was correct

+2 → correct ΔS_{surr}

-1 → incorrect units / missing units