Answer on Question #71550 - Chemistry - Physical Chemistry

Question:
Calculate ΔS (for the system) when the state of 3.00 mol of a monatomic perfect gas, for which Cp,m =5/2 R, is changed from 25 0C and 1.00 atm to 125 0C and 5.00 atm. How do you rationalize the sign of ΔS?

Solution:
The change in entropy of ideal gas is

$$dS = c_v \frac{dT}{T} + \frac{P}{T} dv;$$

And after simplification and integration from the state 1 to the state 2:

$$\Delta S = c_v \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{v_2}{v_1}\right)$$

Using the equation of state for the ideal gas:

$$pv = nRT$$
$$v = \frac{nRT}{p};\ c_v = c_p - R$$

$$\Delta S = \left(c_p - R\right) \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{nRT_2 p_1}{p_2 nRT_1}\right) = \left(c_p - R\right) \ln\left(\frac{T_2}{T_1}\right) + R \ln\left(\frac{T_2 p_1}{p_2 T_1}\right)$$
$$\Delta S = \left(\frac{5}{2}R - R\right) \ln\left(\frac{125 + 273\ K}{25 + 273\ K}\right) + R \ln\left(\frac{(125 + 273\ K) \cdot 1\ atm}{(25 + 273\ K) \cdot 5 atm}\right)$$
$$\Delta S = \frac{3}{2} R \cdot 0.289 + R \cdot (-1.320) = \ -0.886 \cdot R$$

As one can know, ΔS represents the degree of randomness in the system. Thus, one can expect that with the increase of temperature the randomness with increase; but with increase in pressure the randomness will decrease. Apparently, as the calculated value is negative, the latter effect is more significant and the degree of randomness decreases.

Answer: ΔS = -0.886R. Negative sign of ΔS means that the degree of randomness in the system decreases when state1 passes to state 2.