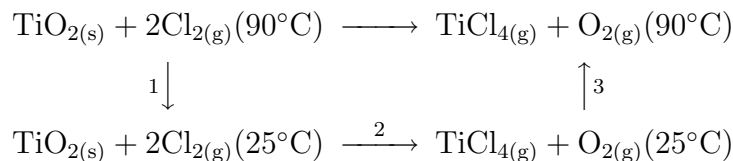


## Chemistry 2720 Fall 2005 Quiz 3 Solution

We could adjust the entropies of all the substances in this reaction to 90°, then calculate the entropy change, but it's actually a better idea to use the same technique for this problem as we used for enthalpy changes:



Now calculate the entropy changes for each of the steps:

$$\begin{aligned}
 \Delta \bar{S}_1 &= \int_{363.15}^{298.15 \text{ K}} \frac{(\bar{C}_{P(\text{TiO}_2)} + 2\bar{C}_{P(\text{Cl}_2)}) dT}{T} = [55.18 + 2(33.91 \text{ J K}^{-1}\text{mol}^{-1})] \ln \frac{298.15 \text{ K}}{363.15 \text{ K}} \\
 &= -24.26 \text{ J K}^{-1}\text{mol}^{-1}.
 \end{aligned}$$

$$\begin{aligned}
 \Delta \bar{S}_2 &= \bar{S}_{\text{O}_2}^\circ + \bar{S}_{\text{TiCl}_4}^\circ - (\bar{S}_{\text{TiO}_2}^\circ + 2\bar{S}_{\text{Cl}_2}^\circ) \\
 &= 205.152 + 353.2 - [50.62 + 2(223.081 \text{ J K}^{-1}\text{mol}^{-1})] = 61.57 \text{ J K}^{-1}\text{mol}^{-1}.
 \end{aligned}$$

$$\begin{aligned}
 \Delta \bar{S}_3 &= \int_{298.15 \text{ K}}^{363.15} \frac{(\bar{C}_{P(\text{TiCl}_4)} + \bar{C}_{P(\text{O}_2)}) dT}{T} = (95.4 + 29.35 \text{ J K}^{-1}\text{mol}^{-1}) \ln \frac{363.15 \text{ K}}{298.15 \text{ K}} \\
 &= 24.6 \text{ J K}^{-1}\text{mol}^{-1}.
 \end{aligned}$$

The overall entropy change is the sum of the entropy changes in processes 1, 2 and 3:

$$\Delta \bar{S} = \Delta \bar{S}_1 + \Delta \bar{S}_2 + \Delta \bar{S}_3 = -24.26 + 61.57 + 24.6 \text{ J K}^{-1}\text{mol}^{-1} = 61.9 \text{ J K}^{-1}\text{mol}^{-1}.$$