The residual enthalpy and entropy are

$$H^R = -22180.2 \text{ J/mol},$$
$$S^R = -60.5966 \text{ J/mol K}.$$

Calculation of ideal-gas properties.

The reference state is the ideal-gas state, therefore, H_{0i}^{ig} and S_{0i}^{ig} are zero for both components. With $T_0 = 298.15$ K, $P_0 = 1$ bar for both components, we obtain the following values for the ideal-gas enthalpy of pure component at $T = 277.65$ K, $P = 16.15$ bar:

$$H_1^{\text{ig}} = -749.987 \text{ J/mol}, \quad H_2^{\text{ig}} = -2402.78 \text{ J/mol}.$$

The ideal-gas enthalpy of the mixture is

$$H^{\text{igm}} = (0.32)(-749.987) + (0.68)(-2402.78) = -1873.89 \text{ J/mol}.$$

The ideal-gas entropy of pure components is

$$S_1^{\text{ig}} = -25.7346 \text{ J/mol K}, \quad S_2^{\text{ig}} = -31.4757 \text{ J/mol K}.$$

With these values we calculate the ideal-gas entropy of the mixture:

$$S^{\text{igm}} = (0.32)(-25.7346) + (0.68)(-31.4757) - (8.314)\big((0.32)\ln(0.32) + (0.68)\ln(0.68)\big)$$
$$= -24.4268 \text{ J/mol K}.$$

Calculation of actual properties.

The actual properties of the mixture are calculated by adding the ideal gas and residual contributions:

$$H = (-1873.89) + (-22180.2) = -24054.1 \text{ J/mol},$$
$$S = (-24.4268) + (-60.5966) = -85.02 \text{ J/mol K}.$$

Example 9.4: Enthalpy of Mixing

Consider ~~Determine whether~~ the mixing of carbon dioxide and normal pentane at 4.5 °C, 16.15 bar to form a solution that contains 32% by mol. Is this process endothermic or exothermic? Additional data: At this pressure and temperature pure carbon dioxide is vapor, and pure pentane is liquid.