Chem. 142 Quiz 4
Name: ________________________________
15 points

Possible useful equations:

\[ q = n \times \Delta \text{H}_{\text{phase change}} \]
\[ q = n \times C \times \Delta T \]
\[ dS \geq \frac{dq}{T} \quad \text{R} = 8.314 \frac{\text{J}}{\text{mol} \cdot \text{K}} \]
\[ \Delta S_p = n \times C_p \times \ln \frac{T_2}{T_1} \quad \Delta S_v = n \times C_v \times \ln \frac{T_2}{T_1} \quad \Delta S_T = n \times R \times \ln \frac{V_2}{V_1} \quad \Delta S_{\text{mix}} = -R \sum n_i \ln X_i \]

1. (4 points) A heat engine operates at 23% efficiency. If 250 J flow from the hot reservoir, how much work is done by the system and how much heat was dumped into the cold reservoir?

\[ \varepsilon = \frac{w}{q} \quad w = \frac{q \cdot \varepsilon}{\varepsilon_h} = 250J \times 0.23 = -58J \]

\[ 250J - 58J = 192J \text{ goes into T} \]

2. (3 points) Under what conditions does entropy behave like a state function?

Reversible

3. (4 points) 2.5 moles of an ideal monatomic (C_v = 1.5R, C_p = 2.5R) gas is taken through the following changes:
   - Step 1: isothermal compression where the volume is halved.
   - Step 2: heating at constant volume where the temperature is doubled.

Determine the overall change in entropy for the process?

\[ \Delta S (1) = 2.5 \text{ mol} \times R \times \ln \frac{0.5V_1}{V_1} = -14.4 \text{ JK}^{-1} \]

\[ \Delta S (2) = 2.5 \text{ mol} \times 1.5R \times \ln \frac{2T_1}{T_1} = +21.6 \text{ JK}^{-1} \]

\[ \Delta S_{\text{net}} = 7.2 \text{ JK}^{-1} \]

4. (4 points) 2.02 g of hydrogen and 3.9 grams of nitrogen are mixed, calculate the entropy change associated with the process.

\[ 2.02g \text{ H}_2 \times \frac{\text{ mol}}{2.02g} = 1 \text{ mol H}_2 \quad 0.281g \text{ N}_2 \times \frac{\text{ mol}}{28.01g} = 0.010 \text{ mol N}_2 \]

\[ \Delta S_{\text{mix}} = -R \left( \ln 0.99 + 0.09 \ln 0.99 \right) = -2.29 \text{ JK}^{-1} \]

\[ \chi_{\text{H}_2} = \frac{1.0}{1.0 + 0.1} = 0.91 \quad \chi_{\text{N}_2} = 0.09 \]

\[ \frac{1}{1.0 + 0.1} = 0.91 \quad \chi_{\text{N}_2} = 0.09 \]