A mixture of octane vapor and 150% theoretical air is initially at 298 K, 1 atm pressure. The mixture is ignited, and the system is cooled to a final temperature of 298 K. Calculate the heat transfer from the system and the fuel system pressure.

\[
\sum_{i=1}^{n} \Delta U = 2L \frac{Q - \delta W}{\text{per amount of fuel}}
\]

\[
Q = \left[ 80\text{\,MJ\,kmol}^{-1} + 7.55\text{\,MJ\,kmol}^{-1} \right] \times 2L
\]

\[
\delta W = \Delta H_{\text{f,octane}} + \Delta H_{\text{f,air}} + 62.5\text{\,MJ\,kmol}^{-1}
\]

\[
\Delta H_{\text{f,octane}} = -18.75\text{\,MJ\,kmol}^{-1}
\]

\[
\Delta H_{\text{f,air}} = -70.5\text{\,MJ\,kmol}^{-1}
\]

2nd law issues of fuels:
- how much work could we get from a fuel?
  - fuel cell
- equilibrium issues
  \[
  \text{CH}_4 + \text{O}_2 \rightarrow \text{N}_2 + \text{CO}_2 + \text{H}_2\text{O}
  \]

Reversible heat work, SSSF:
- \( W = m(h_{\text{f,products}} - h_{\text{f,reactants}}) \)

\[
\text{rev work} = \dot{W} + m \left( h_{\text{f,products}} - h_{\text{f,reactants}} \right)
\]

\[
Q_{\text{rev}} = \dot{Q}_{\text{rev}} \cdot \left( \text{heat energy} \right)
\]

\[
\Delta G_{\text{rev}} = \Delta H_{\text{rev}} - T \cdot \Delta S_{\text{rev}}
\]

\[
\Delta H_{\text{rev}} = \Delta H_{\text{products}} - \Delta H_{\text{reactants}}
\]

\[
\Delta G_{\text{rev}} = -394 \text{\,MJ\,kmol}^{-1}
\]

\[
\Delta H_{\text{rev}} = -801 \text{\,MJ\,kmol}^{-1}
\]

\[
\Delta S_{\text{rev}} = 51 \text{\,kJ\,mol}^{-1} \text{\,K}^{-1}
\]

\[
\Delta H_{\text{rev}} = -801 \text{\,MJ\,kmol}^{-1}
\]

\[
LHV = 50.1 \text{\,MJ\,kg}^{-1}
\]

Details:
- how would we derive the reversible work = fuel cell
- Fuel cell: Galvanic cell (i.e., battery) can extend fuel source.
- Most fuel cells: use \( \text{H}_2 \) as the fuel:
  \[
  \text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O}
  \]