Do problem 8.9 in Froment & Bischoff, 2nd Ed. (part B has been reworded slightly for clarity):

8.9 The reversible reaction $A \rightleftharpoons R$ has the following coefficient parameters:

\[ A_1 = 7 \text{ s}^{-1} \quad E_1 = 41,868 \text{ kJ/kmol} \]
\[ A_2 = 5000 \text{ s}^{-1} \quad E_2 = 83,736 \text{ kJ/kmol} \]

The reaction is to be carried out in a batch reactor with a maximum allowed temperature of $T_{\text{max}} = 800 \text{K}$. For a conversion of $x_{af} = 0.8$:

(a) Determine the optimum isothermal operating temperature, and the resulting batch holding time. Also determine the heat exchange rate required.

(b) Determine optimum temperature profile as a function of conversion and a function of processing time.

(c) Determine the heat exchange rates required for part (b).

Additional data:
Density of liquid = 1000 kg/m³
Heat capacity = 4.187 kJ/kg °C.
Initial mole fraction of reactant $A = 0.5$
Molecular weights: $= 100$ for $A$
$= 20$ for solvent