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

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

$$
\begin{align*}
A_1 &= 7 \text{ s}^{-1} & E_1 &= 41,868 \text{ kJ/kmol} \\
A_2 &= 5000 \text{ s}^{-1} & E_2 &= 83,736 \text{ kJ/kmol}
\end{align*}
$$

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 $x_{\text{af}} = 0.8$:

(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/m$^3$
Heat capacity = 4.187 kJ/kg C.
Initial mole fraction of reactant $\text{A} = 0.5$
Molecular weights: $\text{A} = 100$ for $\text{A}$
$\text{solvent} = 20$ for solvent