Exercise

Substitution reaction in semi-batch reactor (RC1)

A reaction following the equation $A + B \rightarrow P$ is to be performed as semi-batch in a 4 m^3 reactor. The initial charge is 2000 kg of a solution of A at a concentration of 3 $mol \cdot kg^{-1}$. This solution is heated to 80°C, the intended reaction temperature. Then 1000 kg of reactant B (concentration 7.5 $mol \cdot kg^{-1}$) are added at a constant rate. The solvent is xylene with a boiling point of Tb = 140 °C.

This reaction was studied in a reaction calorimeter with a charge of 1.5 kg of final reaction mass (scale 1/2000). The addition was performed in four hours. During the experiment the specific heat capacity of the reaction mixture was measured:
c'_P= 1700 $J \cdot kg^{-1} \cdot K^{-1}$. The density is 1000 kgm^{-3}.

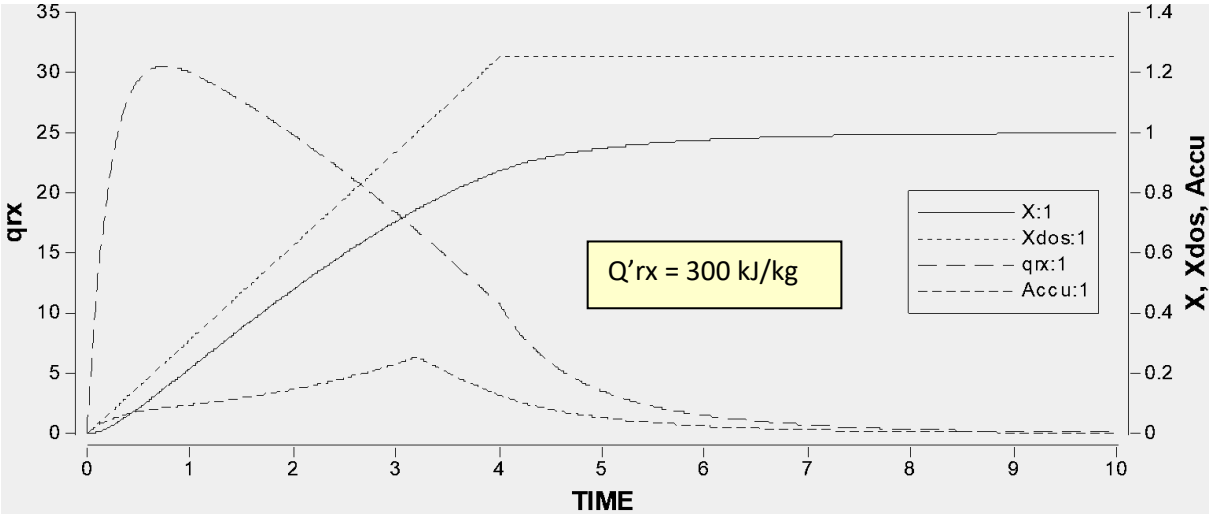

Figure 1: Reaction calorimetry experiment: qrx in W, time in hours. Xdos is the added fraction with reference to stoichiometry, X the conversion and Accu the accumulation.

The reactor characteristics are summarized in Table 1.

Table 1: Characteristics of industrial reactor

Nominal volume	$4m^3$
Heat exchange area before addition	$4,8\ m^2$
Heat exchange area after addition	$6,6\ m^2$
Overall heat transfer coefficient	$200\ W \cdot m^{-2} \cdot K^{-1}$
Minimal cooling medium temperature	+5 °C

Questions

Is the cooling capacity at industrial scale sufficient?

Calculate MTSR.

What is the criticality class? (Here the thermal stability results from DSC experiments must be taken into account).