Q1. Consider the following isomerisation reaction of n-butane to i-butane in a PFR as

$$\text{n-}C_4H_{10} \rightleftharpoons \text{i-}C_4H_{10}$$

The reaction is to be carried out adiabatically in the liquid phase under high pressure using essentially trace amounts of a liquid catalyst which gives a specific reaction rate of 31.1 h^{-1}at 360 K. Calculate the PFR and CSTR volumes necessary to process 100,000 gal/day (163 kmol/h) at 70% conversion of a mixture 90 mol % n-butane and 10 mol % i-pentane, which is considered an inert. The feed enters at 330 K.

Additional information:

ΔH_{Rx} = - 6900 J/mol.butane

Activation energy = 65.7 kJ/mol

K_c = 3.03 at 60^{o}C

C_{Ao} = 9.3 g-mol/dm^3

n-butane	i-butane	i-pentane
C_p = 141 J/ mol.K	C_p = 141 J/ mol.K	C_p = 161 J/ mol.K

Isobutane is a valuable product that is used in the manufacture of gasoline additives. e.g., isobutane can be further reacted to form iso-octane. The 2004 selling price of n-butane was 72 cents per gallon, while the price of iso-butane was 89 cents per gallon.

Q2. Vapour-phase cracking of acetone to ketene and methane is one of the key steps in the design of an acetic anhydride manufacturing facility, the reaction is given as:

$$CH_3COCH_3 \longrightarrow CH_2CO + CH_4$$

It is stated further that this reaction is first-order with respect to acetone and that the specific reaction rate can be expressed by

$$\ln k = (34.34 - (34.222/T))$$

where k is in reciprocal seconds and T is in kelvin. In this design it is desired to feed 8000 kg of acetone per hour to a tubular reactor. The reactor consists of a bank of 1000 1-inch schedule 40 tubes. Consider the two cases:

1. The reactor is operated adiabatically.

2. The reactor is surrounded by a heat exchanger where the heat-transfer coefficient is 110 W/m^2-K, and the ambient temperature is 1150 K.

The inlet temperature and pressure are the same for both cases at 1035 K and 162 kPa (1.6 atm), respectively. Plot the conversion and temperature along the length of the reactor in both cases.