UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
DEHRADUN
End Semester Examination - June, 2021

Program/Course : M. Tech Chemical (Spl. in Process Design)
Subject: Process, Modelling and Simulation
Code: CHPD 7009
No. of pages: 2

Semester: II
Max. Marks: 100
Duration: 3 hrs

NOTE:

(A) **OPEN BOOK and OPEN NOTES EXAMINATION**

(B) Assume all missing data. **State your assumptions clearly.** Sketch wherever necessary.

Section A: ANSWER ALL QUESTIONS - 30 x 2 = 60

1. Typically, air is heated in a hair dryer by blowing it across a coiled wire through which an electric current is passed. Thermal energy is generated by electric resistance heating within the wire and is transferred by convection from the surface of the wire to the air. Consider conditions for which the wire is initially at room temperature, T_i, and resistance heating is concurrently initiated with air flow at t = 0.

   (a) For a wire radius r_0, an air tempertuare T_∞ and a convection coefficient h, derive heat equation and state the boundary/initial conditions that govern the transient thermal response, T(r,t), of the wire.
   (OR)

   (b) Write MATLAB code to sketch the variation of the heat flux with the time for locations at r = 0 and r = r_0 on q''_r - t coordinates.

   [30 marks]

2. Some of the condensation reactions that take place when formaldehyde (F) is added to sodium paraphenolsulfonate (M) in an alkaline-aqueous solution have been studied. It was found that the reactions could be represented by the following equations:

$$
\begin{array}{ll}
F + M \rightarrow MA, & k_1 = 0.15 \text{ L/gmol min} \\
F + MA \rightarrow MDA, & k_2 = 0.49 \\
MA + MDA \rightarrow DDA, & k_3 = 0.14 \\
M + MDA \rightarrow DA, & k_4 = 0.14 \\
MA + MA \rightarrow DA, & k_5 = 0.04 \\
MA + M \rightarrow D, & k_6 = 0.056 \\
F + D \rightarrow DA, & k_7 = 0.50 \\
F + DA \rightarrow DDA, & k_8 = 0.50
\end{array}
$$

where M, MA, and MDA are monomers and D, DA, and DDA are dimers. The process continues to form trimers. The rate constants were evaluated using the assumption that the molecularity of each reaction was identical to its stoichiometry. Derive a dynamic model for these reactions taking place in a single, isothermal CSTR. Carefully define your terms and list your assumptions. [30 marks]

Section B: ANSWER THE QUESTION - 40 x 1 = 40

1. Fast pyrolysis, the rapid heating of biomass in the oxygen-free atmosphere, has been considered as a promising technology for the production of transportation fuels, speciality and fine chemicals, and furnace and boiler fuel. Catalytic fast pyrolysis (CFP) has a potential option for improving the quality of organic products from fast pyrolysis of biomass. The lab-scale reactor of pyrolysis vapours upgrading was performed in either a fixed bed or fluidised bed reactors. In comparison with fixed bed reactor, fluidised bed operations could be preferred because it produces relatively lesser coke and thus reduces catalyst deactivation. The pyrolysis vapours upgrading in fluidised bed follows a similar procedure in the petroleum industry with the reactor concept of fluid catalytic cracking (FCC). In a typical FCC unit, catalyst from the regenerator enters at the bottom of the riser where it reacts with the feed in the riser and is separated from the gaseous products by the cyclone. The catalyst flows back to the regenerator where the air is injected to burn off the coke that is deposited on the active surface of the catalyst.

   Deduce from the first principles, the model equations representing the prediction of catalyst residence time in the riser is performed for studying the contact time of vapours with the catalyst. This is examined by the effect of catalyst feed rate and gas flow rate on the hydrodynamic behaviour and catalyst residence time distribution (RTD).

   [40 marks]