BITS, PILANI, GOA CAMPUS, FIRST SEMESTER 2022 – 2023
MID SEMESTER EXAMINATION: KINETICS AND REACTOR DESIGN (CLOSED BOOK)
COURSE CODE: CHE F311

DATE: 1/11/2022 **TIME: 90 MINUTES** **MAX. MARKS: 30**

(ALL QUESTIONS ARE COMPULSORY. MAKE SUITABLE ASSUMPTIONS WHEREVER NECESSARY)

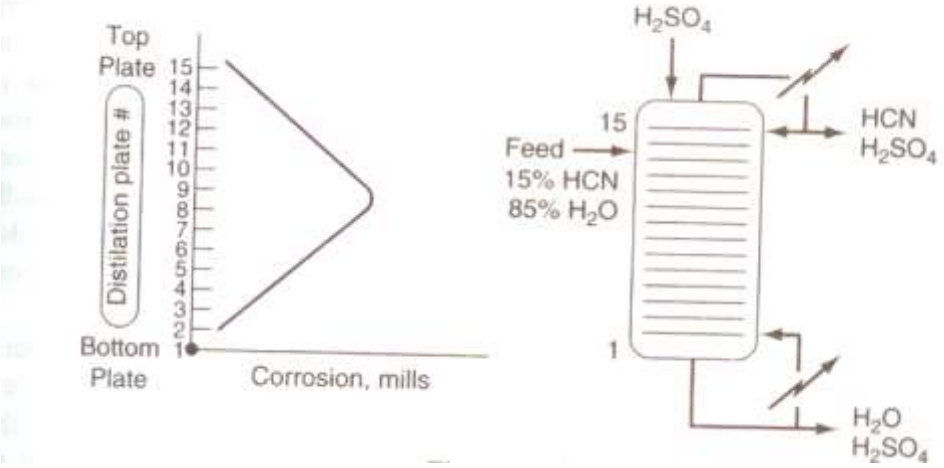
Question 1 **[4 + 4 = 8 marks]**

a. Starting with the standard definition of rate and for a constant pressure reaction A $\rightarrow$ M + H + C carried out in a constant volume batch reactor, derive an expression for rate expression in terms of concentration. How does this differ from the rate expression for a constant pressure (volume not constant) batch reactor?

b. Milk is pasteurized if it is heated to 63 ^{o}C for 30 min, but if it is heated to 74 ^{o}C, it only needs 15 s for the same result. Find the activation energy of the sterilization process. Note rate of a reaction is inversely proportional to time. **Note: The rate is inversely proportional to time**

Question 2 **[3 marks]**

Corrosion of high nickel stainless steel plates were found to occur in a distillation column used at Du Pont to separate HCN and water. Sulphuric acid is always added at the top of the column to prevent polymerization of HCN. Water collects at the bottom of the column and HCN at the top. The amount of corrosion on each tray is shown in Figure as a function of plate location in the column. The bottom-most temperature of the column is approximately 125 ^{o}C and the topmost is at 100 ^{o}C. The Engineer handling this suspected that the HCN – H_2SO_4 complex had a strong role to play in the corrosion **<u>rate</u>** and was one of the possible **two culprits**. Assuming his assumption to be true, suggest an explanation for the observed corrosion plate profile.



Question 3 **[8 marks]**

Large central power stations (about 1000 MW electrical) using fluidized bed combustors may be built someday. The giants would be fed 240 tons of coal per hour (90% C and 10% H_2), 50 % of which would burn within the battery of primary fluidized beds, the other 50% elsewhere in the system. One suggested design would use a primary battery of 10 fluidized beds, each bed is 20 m long, 4 m wide and containing solids to a depth of 1m. Find the rate of reaction within the beds based on the oxygen used in ton-moles/m^3.hr. All 10 beds are used for combustion.

Question 4 **[6 marks]**

There were 820 million pounds of phthalic anhydride (C) produced in the United States in 1995. One of the end uses of phthalic anhydride is in the fiberglass of sailboat hulls. Phthalic anhydride can be produced by the partial oxidation of naphthalene (A) in either a fixed or a fluidized catalytic bed. The reaction is carried out in a fixed-bed reactor with a vanadium pentoxide catalyst packed in 25-mm-diameter tubes. A production rate of 31,000 tons per year would require 15,000 tubes. Set up a stoichiometric table for this reaction for an initial mixture of 3.5% naphthalene (A) and 96.5% oxygen (B) (mol %). The reaction is

$$2A + 9B \text{ ------ } 2C + 4D + 4E$$

The reaction is gas phase and that needs to be taken into account. D and E denoted CO_2 and water respectively.

Question 5 **[5 marks]**

Enzyme E catalyzes the fermentation of reactant A to product S. Estimate the size of the mixed flow reactor required for 95% conversion of reactant A in a feed stream of 25 l/min of reactant A with C_{Ao} = 2 mol/litre and enzyme. The kinetics of fermentation is given by

$$A \xrightarrow{E} S \text{ and } -r_A = 0.1C_A / (1+0.5\, C_A) \text{ mol/l.min}$$

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