महाराष्ट्र वनसेवा मुख्य परीक्षा - २०१२

JOO

2012

CHEMICAL ENGINEERING (Optional)

100101

रासायनिक अभियांत्रिकी (वैकल्पिक)

Time : 3 hours **Maximum Marks : 200**

Note :

(i) *Answers must be written in English only.*

(ii) *Question **No. 1** is **compulsory**. Of the remaining questions, attempt **any four** selecting one question from **each section**.*

(iii) *Figure to the **RIGHT** indicates marks of the respective question.*

(iv) *Number of optional questions upto the prescribed number in the order in which they have been solved will only be assessed. Excess answers will not be assessed.*

(v) *Candidates should not write roll number, any name (including their own), signature, address or any indication of their identity anywhere inside the answer book otherwise they will be penalised.*

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1. Answer ***any four*** of the following :

(a) Air is flowing in a 50 mm ID tube. There is a venturimeter in the line, and the manometric fluid is water. Calculate the volumetric flow rate of air for the following conditions : **10**

Manometric reading = 100 mm water
Density of water = 1000 kg/m^3
Density of air = 1.185 kg/m^3
Coefficient of discharge = 0.98
Diameter of venturi throat = 25 mm
Pressure of air = 1 atm.

(b) A homogenous gas phase decomposition reaction : $4A \rightarrow B + 7S$ takes place in an isothermal PFR. The reaction rate is, $-r_A = KC_A$ with $K = 0.17\ sec^{-1}$; feed concentration of A $(C_{AO}) = 0.1\ mole/m^3$; feed flow rate $(F_{AO}) = 0.17\ \frac{mole}{sec}$. Determine the size of the reactor in order to achieve 50% conversion. **10**

(c) The wall of a cold storage unit comprises a brick layer (thickness $\delta_B = 0.1$ m, thermal conductivity $K_B = 1.4$ W/m.K.) and an inner layer of polyurethane foam (thickness $\delta_P = 0.05$ m, thermal conductivity $K_P = 0.015$ W/m.K). Assume one dimensional heat transfer by conduction through the composite wall, and that the inner surface of polyurethane layer is at a temperature T_c and the outer surface of the brick layer is at temperature T_h. The surface area for heat transfer is 260 m^2. **10**

(i) Derive an expression for the heat flux through wall.

(ii) Calculate the rate of heat gain when $T_c = -10°C$, and $T_h = 40°C$.

(d) Describe the catalytic reforming process for the naphtha feed with neat process flow sheet. **10**

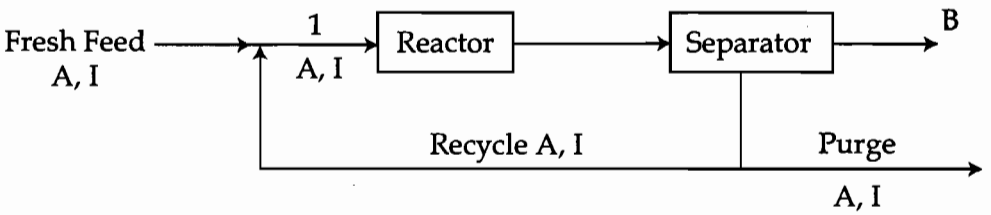
(e) Describe the methods employed for flow measurement in open channels. **10**

P.T.O.

SECTION - A

2. (a) Derive the Hagen - Poiseuillie equation by the application of Navier - stokes equation. **10**

(b) For the reaction A → B, the process flow diagram is as shown in figure. The fresh feed of A consists of 0.5% of inerts by volume. 60% conversion per pass of A fed to the reactor is obtained. The concentration of inerts going into the reactor at (1) must be held at 2% by volume. All streams are ideal gases and the process is at steady state. How many moles need to be recycled per mole of total feed to the reactor (1). **20**



(c) Classify screening equipment with the help of neat sketches. Compare between ideal and actual screens. **10**

3. (a) Derive the equation for diffusion through a stagnant gas film. **10**

(b) The analysis of 15000 liter of gas mixture at standard condition is as follows : $CO_2 = 9.5\%$; $SO_2 = 0.5\%$; $O_2 = 12.5\%$; $N_2 = 78\%$. How much heat must be added to this gas to change its temperature from 25°C to 700°C ? **20**

Data : Specific heat values in kcal/(kmol °K)

Gas →	CO_2	SO_2	O_2	N_2
C_P at 25°C →	8.884	9.54	7.017	6.961
C_P at 700°C →	11.303	11.66	7.707	7.298

(c) A filtration was carried out for 10 minutes at a constant rate in a leaf filter and thereafter it is continued at constant pressure. The pressure was that attained at the end of the constant rate period. If one quarter of the total volume of the filtrate was collected during the constant rate period, estimate the total filtration time. Assume that the cake is incompressible and the filter medium resistance was neglected. **10**

SECTION - B

4. (a) Discuss various types of cooling towers employed in cooling hot water from process plants. **20**

(b) A first order reaction is to be treated in a series of two mixed reactors. Show that total volume of the two reactors is minimum when the reactors are equal in size. **10**

(c) In a vapour - compression refrigeration system, designed to maintain an enclosure at $-3°C$; the equilibrium is so sized that all heat transfer units realize an approach of 5°C. Cooling water is available at 32°C. **10**

Given that :

Enthalpy of saturated refrigerant vapour = 180 kJ/kg

Enthalpy of refrigerant vapour leaving the compressor = 206 kJ/kg.

Enthalpy of saturated liquid leaving the throttle valve = 61 kJ/kg

Estimate the following :

(i) The maximum possible C.O.P.

(ii) The C.O.P. obtained in the cycle.

5. (a) Indicate how the use of the enthalpy - concentration - diagram and McCabe - Thiele diagram could be utilized for the design of distillation columns. Specify the applications of each method. Explain by means of McCabe-Thiele method to determine : **20**

(i) Minimum Reflux

(ii) The number of plates at total reflux

(b) Explain the different models for gas - solid non - catalytic reaction of the type : **10**

$A(g) + bB(s) \rightarrow E(g) + F(s)$

(c) An experimental determination of a VLE state of - ether (1) and acetone (2) binary system gave the following result. **10**

$x_1 = 0.3$; $T = 40°C$

$y_2 = 0.42$; $P = 10^5$ Pa

The saturation vapour - pressure of the pure components at 40°C are :

Ether (1) $= 1.21 \times 10^5$ Pa

Acetone (2) $= 0.56 \times 10^5$ Pa

The vapour phase can be assumed ideal.

(i) Calculate the liquid phase activity coefficients.

(ii) What is the value of excess Gibbs free energy G^E/RT, for the liquid phase ?

SECTION - C

6. (a) Discuss briefly the phenomenon of nucleate and film boiling. Explain with neat diagram the various zones of boiling curve. **10**

(b) Draw the instrumentation flow diagram for a shell and tube heat exchanger. State the importance of such diagrams. **20**

(c) Write short notes on the following : **10**

(i) Galvanic protection

(ii) Crevice corrosion

7. (a) Discuss with neat diagram Direct and Indirect contact type heat exchangers. **10**

(b) Classify flow meters. Explain with a neat sketch the principle, construction and working of the reciprocating piston type flow meters. **20**

(c) Explain different mechanisms of electrochemical corrosion. **10**

SECTION - D

8. (a) An equipment costs Rs. 1,70,000 and will have a scrap value of Rs. 25,000 at the end of its useful life of 10 years. If the interest is compounded at 10% per year, what is the cost of replacement, the present worth and the capitalised cost ? **10**

(b) Explain the salient features of industrial process for manufacture of Soda Ash by solvay process. **20**

(c) Discuss the occupational hazards with suitable examples. **10**

9. (a) Discuss the utility of PERT and CPM network techniques for Chemical Engineering project analysis. **10**

(b) Discuss in brief various polymerisation procedures. Briefly outline the process for manufacture of Nylon 66 and likely major engineering problems in this process. **20**

(c) Write short notes on the following : **10**

(i) Ozone depletion and its effects

(ii) Sludge treatment and disposal

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