RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2016

SECOND YEAR [BATCH 2014-17]

Date : 20/05/2016 **INDUSTRIAL CHEMISTRY (Honours)**

Time : 11 am – 3 pm **Paper :** IV Full Marks : 75

[Use a separate Answer Book for each group]

Group - A

Answer any four questions from question nos. 1 to 6 : [4×5]

1. a) In Fourier's law, the proportionality constant is called— [1]
   i) heat transfer co-efficient ii) thermal conductivity
   iii) thermal diffusivity iv) Stefan-Boltzman constant
   b) State and explain Stefan-Boltzman law. [2]
   c) Explain the limitations of Bernoulli's equation. [2]

2. a) Choose the correct set of dimensions of viscosity that are equivalent
   i) $FL^{-2}T, ML^{-1}T^{-1}$ ii) $FL^{-2}T, ML^{-1}T^{-1}$ iii) $ML^{-1}T^{-3}, F^{-1}L^{2}T$ iv) $F^{-1}L^{2}T^{-1}, MLT^{-3}$
   where F, M, L and T are dimensions for force, mass, length and time respectively. [1]
   b) Which of the following denotes the effect of compressibility in fluid flow
   i) Weber number ii) Mach number iii) Euler number iv) Reynold's number [1]
   c) 1000 kg of cheese at 15°C is pumped per hour through a tube of 75 mm in diameter. The temperature of the tube is maintained at 90°C.
   i) Find the heat transfer coefficient using the following correlation

$$Nu = 3\cdot65 + \frac{0\cdot067\left(\frac{d}{L}\right)(Re\,Pr)}{1+0\cdot04\left[\left(\frac{d}{L}\right)(Re\,Pr)\right]^{0\cdot67}}$$

   Length of the tube = 1·2 m

   Take the following properties for the cheese at mean temp. $\rho = 1100\,kg/m^3$; $\mu = 24\,kg/ms$;

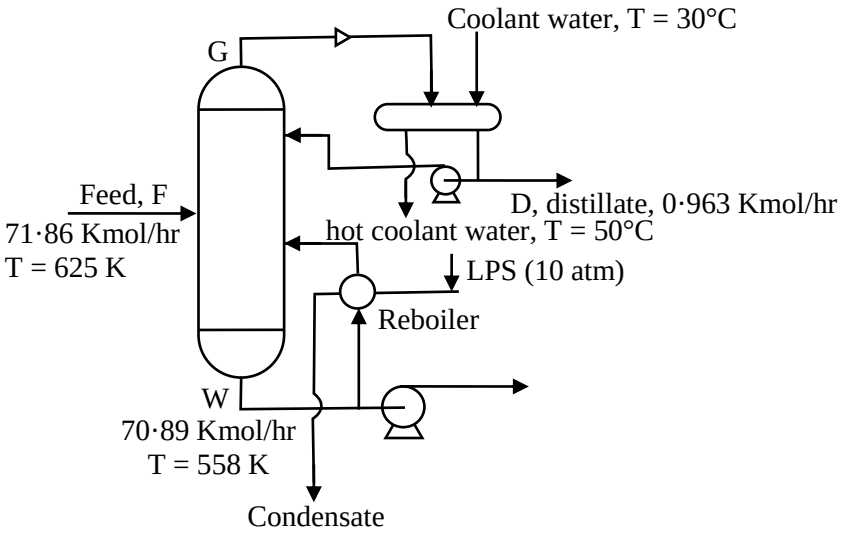
   $C_p = 2800\,J/KgK$; K = 0·43 W/mK. [1·5]

   ii) Also find the rise in temperature of the cheese. [1·5]

3. A distillation column separates 10,000 kg/hr of a 80% bz – 20% toluene mixture. The product D recovered from the condenser at the top of the column contains 95% benzene and the bottom W from the column contains 96% toluene. The vapour stream V entering the condenser from the top of the column is 8000 kg/hr. A portion of the product from the condenser is returned to the column as reflux, and the rest is withdrawn for use elsewhere. Assume that the compositions of the streams at the top of the column (v), product withdrawn (D) and the reflux (R) are identical because the V steam is condensed completely. Find the ratio of the amount refluxed R to the product withdrawn D. [5]

4. a) Which are used in case of heat flow by conduction through a cylinder. [1]
   i) Logarithmic mean area ii) Arithmetic mean area iii) Geometric mean area iv) None of these
   b) State and explain Stefan Boltzman law for radiation heat transfer. [2]
   c) What is meant by overall heat transfer co-efficient? Write the design equation of a heat exchanger equipment. Explain briefly the importance of overall heat transfer co-efficient. Give its unit. [2]

5. A feed of a mixture of phthalic anhydride (PAN), Maleic Anhydride (MA), Benzoic acid (BA) and Toluic acid (TA) in saturated liquid condition at a temperature of 625 K is fed to a distillation column. Bottom product is mainly PAN. Minimum reflux ratio is 1·35. Latent heat of vapourisation of PAN is 15·6 KCal/gmol. Calculate the LPS requirement in the reboiler. [5]



Data Given :

Feed Component	Mole fraction	Sp. heat (KJ/ K mole K)
PAN	0·98	184·195
MA	0·002	159·796
BA	0·003	112·729
TA	0·015	321·180

R_{min} = 1·35.

6. a) In calculating the mass fraction and mole fraction of Ce and O in the catalyst CeO used in dehydrogenation of lower alkanes the basis will be [1]

   i) 1 Kg ii) 100 Kg iii) 1 Kg mole iv) 50·0 gram v) all of these

   b) Poise is converted into stoke by [1]

   i) multiplying with density (gm /cc) ii) dividing with density (gm/cc)

   iii) multiplying with specific gravity iv) dividing with specific gravity

   c) Fuels for motor vehicles other than gasoline are being eyed because they generate lower levels of pollutants than does gasoline Compressed propane has been suggested as a source of economic power for vehicles. Suppose that in a test 20 Kg of C_3H_8 is turned with 400 Kg of air. What was the present excess air? $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$ [3]

Answer <u>any seven</u> questions from question nos. <u>7 to 15</u> : [7×5]

7. Water is flowing through a pipeline of dia 4 cm at a rate of about 2·5 ℓ/S. It is proposed to measure the exact flow rate by installing a venturimeter. What should be the throat diamter if the reading in a differntial manometer be 20 cm for the above flow rate. The differential manometer uses water and another immiscible liquid with density 1·2 g/ml.Assume venturi co-efficient to be 0·98. [5]

8. Water is to be pumped to a height of 20m through a pipeline of diameter 4 cm, and effective length 100m. Find the frictional head loss and power required to pump water at the rates 2 l/s, 3 l/s and 4 l/s. For friction factor use $f = 0 \cdot 079\, N_{Re}^{-0 \cdot 25}$. Use density 1 g/cc and viscosity 1 cP for water. [5]

9. a) Define the term "sphericity" of a particle. [1]

   b) A mixture of spherical particles contains 200 particles of diameter 0·5 mm, 100 particles of dia 1 mm and 50 particles of dia 2 mm.

   Find the following average diameter of this particle mixture

   i) Number average diameter, ii) Volume average diameter. [4]

10. A vertical packed bed has dia 4 cm and depth 10 cm. Water flows through it at a rate of 0·5 cc/s, when the water height over the bed is 35 cm. The bed porosity is 0·45. Assume the particle shape factor to be 0·8. Calculate the average particle size assuming Kozeny-Carman equation to be valid $\Delta p = 150\mu vL(1-\varepsilon)^2 / \phi^2 dp^2 \varepsilon^3$. The symbols have their usual meanings. [5]

11. a) The diffusivity (D) in a binary gas mixture is related to pressure (P) as— [1]

i) $D \propto P^{0.5}$ ii) $D \propto \frac{1}{P^{0.5}}$ iii) $D \propto \frac{1}{P}$ iv) $D \propto \frac{1}{P^{1.5}}$

b) Ammonia gas (A) diffuses through nitrogen gas (B) under steady state conditions with nitrogen non diffusing. The total pressure of gas is $1{\cdot}013 \times 10^5$ Pa and temperature is 298K. The diffusion path is 0·15 m and the partial pressure of ammonia at one point is $1{\cdot}5 \times 10^4$ Pa and at the other point is 5×10^3 Pa. Calculate the flux of ammonia. [4]

12. Air containing 17mol% acetone is being scrubbed by an oil sprayed from the top of a counter current absorber column. Oil flow rate is 2·5 moles per mole of acetone free air. 99% of the acetone is being removed. Assume that no oil evaporates and no air dissolves in oil and also that oil sprayed at top contains no acetone. The equilibrium relation is given by $y_e = 1{\cdot}6\ x_e$. where y_e and x_e are the equilibrium mole fractions of acetone in air and oil phases. Plot the equilibrium line in X-Y diagram (X and Y are mole ratios not mol fractions in liquid and vapor phases)

Find the bottom composition (mole fraction of acetone in the oil leaving) by material balance. Find the slope of the operating line and plot the operating line. Use supplied graph paper. [5]

13. In a CSTR operating at steady state, a solution containing reactant A with concentration C_A^0 is being fed. Inside the reactor two simultaneous reactions take place A--> B, rate constant k_1, first order,

A --> C, rate constant k_2, second order,

Volumetric flow rate is Q, and reactor volume is V Assume that there is not change in density.

Use material balance principle to deduce the governing equations for determining the concentration of the reactants and products in the stream leaving the reactor. [5]

14. a) Maximum heat transfer rate is achieved in _____ flow. [1]

i) Co-current ii) Counter current iii) Turbulent iv) Laminar

b) Crude oil flows at the rate of 1000Kg/hr through the inside pipe of a double pipe heat exchanger and heated from 30°C to 90°C. The heat is supplied by kerosene initially at 200°C flowing through the annular space. If the outlet temperature of kerosene is 100°C, calculate the heat transfer area required for co-current flow and kerosene flowrate.

[Given, C_P for crude oil = 0·5 Kcal/kg°C, C_P for kerosene = 0·6 Kcal/kg°C,

U = 400 Kcal/hr m^2 °C] [4]

15. Use Buckingham π theorem to find the frictional head loss in the pipe through which fluid is flowing. Frictional head loss depends on the following factors :

a) $\frac{\Delta P}{L}$ = pressure drop per unit length ($ML^{-2}T^{-2}$)

b) ρ = density of the fluid (ML^{-3})

c) D = dimeter of the pipe (L)

d) V = velocity of the pipe (LT^{-1})

e) μ = dynamic viscosity of the fluid [$ML^{-1}T^{-1}$) [5]

Group - B

Answer <u>any four</u> questions from question nos. <u>16 to 21</u> : [4×5]

16. a) Write down 2 differences between condensation polymerization and addition polymerization. [2]

b) Name one condensation polymer with their monomer precursors. [1·5]

c) Draw the structure of Nylon-6, 6. [1·5]

17. a) What do you mean by glass transition temperature? [1]
    b) Polystyrene has higher T_g than PVC. Explain why? [2]
    c) Write the full forms of UHMWHDPE, PET. [2]

18. a) What is inhibitor? What do you mean by vulcanization? [1+1]
    b) Why accelerator is used with sulfur at the time of vulcanization? [2]
    c) Draw stress vs strain diagram for a gum rubber and vulcanized rubber. [1]

19. a) Draw molecular weight distribution plot and point out the M_n, M_w, M_z and M_v. [2]
    b) What do you mean by monodisperse and polydisperse polymer? [2]
    c) Name two methods/ materials used for curing of rubber other than sulfur. [1]

20. a) Calculate the degree of polymerization if 6,6–nylon has a molecular weight of 120,000 g/mol. [2]
    b) Why MFI cannot be calculated for PVC? [1·5]
    c) Why emulsion polymers are not suitable to apply in electrical purposes? [1·5]

21. What are the differences between sulfur cured product and peroxide cured product. Draw stress-strain plot for pseudoplastic, dilatant, Bingham body and Newtonian fluid. [5]

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