RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2017

SECOND YEAR [BATCH 2015-18]

Date : 18/05/2017 **INDUSTRIAL CHEMISTRY (Honours)**

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

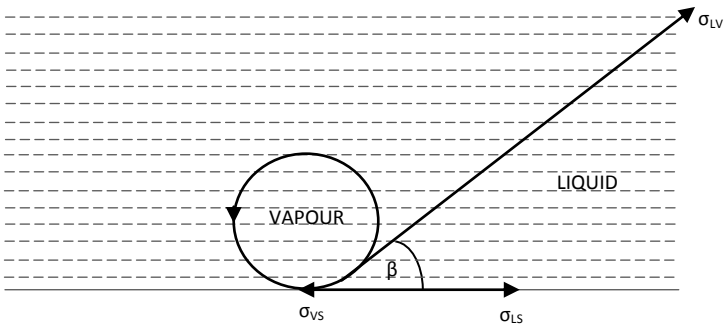
[Use a separate Answer Book for <u>each group</u>]

<u>Group – A</u>

<u>Unit-I</u>

(***Answer <u>any four</u>***) [4×5]

1. a) Dimension of Kinematic viscosity is 1
   (i) MLT^{-1} (ii) L^2T^{-1} (iii) L^2T (iv) L^2T^{-2}
   b) During nucleate pool boiling bubbles form on the surface of the submerged heating coil. The bubbles grow in size and at a particular critical diameter it get detached from the heating surface. The maximum diameter of the bubble formed on the heating surface is shown schematically in the following fig.: 4



where

σ_{LV} = surface tension between liquid and vapour

σ_{LS} = surface tension between liquid and solid surface

σ_{VS} = surface tension between vapour and solid surface

β =angle formed by the bubble as shown in figures

d_c = maximum diameter of the bubble

2. a) For the rotational speeds of similar wheels in a fluid, the power dissipated in windage is dependent upon the diameter *D*, speed *N* of the wheel and density ρ and viscosity μ of the fluid. Using the principle of dimensional analysis, show that the power *P* is given by

$$\frac{P}{\rho N^3 D^5} = f\left(\frac{\mu}{\rho N D^2}\right)$$ 4

   b) Weber number is the ratio of inertial force to ……. force. 1
   (i) surface tension (ii) gravity (iii) viscous (iv) elastic.

3. a) Ar gas in an insulated plasma deposition chamber with a volume of 2L is to be heated by an electric resistance heater. Initially the gas, which can be treated as an ideal gas, is at 1.5 Pa and 300 K. The 1000 ohm heater draws current at 40 V for 5 mins. (i.e. 480 J of work is done on the system by its surroundings). What is the final gas temperature and pressure in the chamber? The mass of the heater is 12g and its heat capacity is 0.35 J/(g)·(K). Assume that the

heat transfer through the walls of the chamber from the gas at this low pressure and in the short time period considered in negligible. 2·5

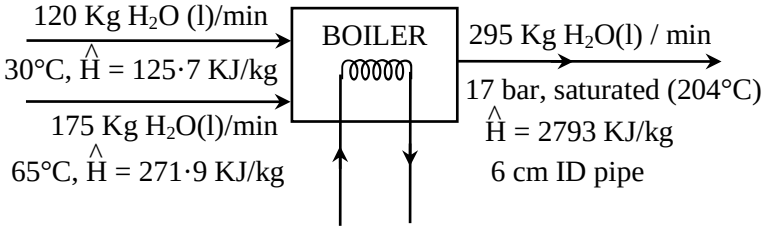
b) Two streams of water are mixed to form the feed to a boiler. Process data are as follows :

Feed stream 1 120 kg/min @ 30^0 C

Feed stream 2 175 kg/min @ 65^0C

Boiler pressure 17 bar (absolute)

The exiting stream energies from the boiler through a 6-cm ID pipe. Calculate the required heat input to the boiler in kilojoules per min if the emerging steam is saturated at the boiler pressure. Neglect the kinetic energies of the liquid inlet streams.

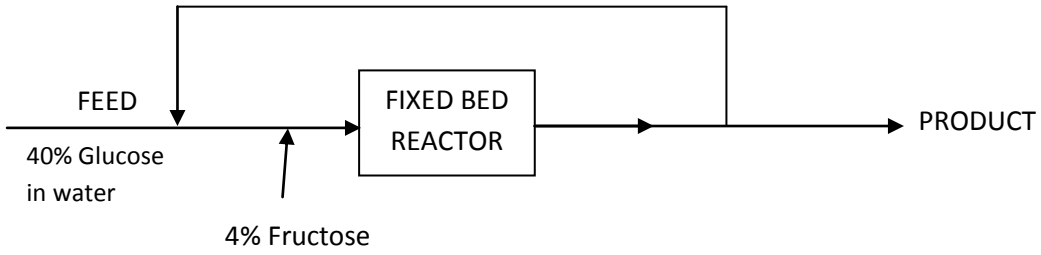


Sp. volume of saturated steam at 17 bar is 0.1166 m^3/kg. 2·5

4. a) Immobilised glucose isomerase is used as a catalyst in producing fructose from glucose in a fixed bed reactor (water is the solvent). For this system shown in Fig. given below: what percent conversion of glucose results on one pass through the reactor when the exit stream/recycle ratio in moles is equal to 8.33? The reaction is 4

$$C_6H_{12}O_6 \longrightarrow C_6H_{12}O_6$$

d-glucose d-fructose



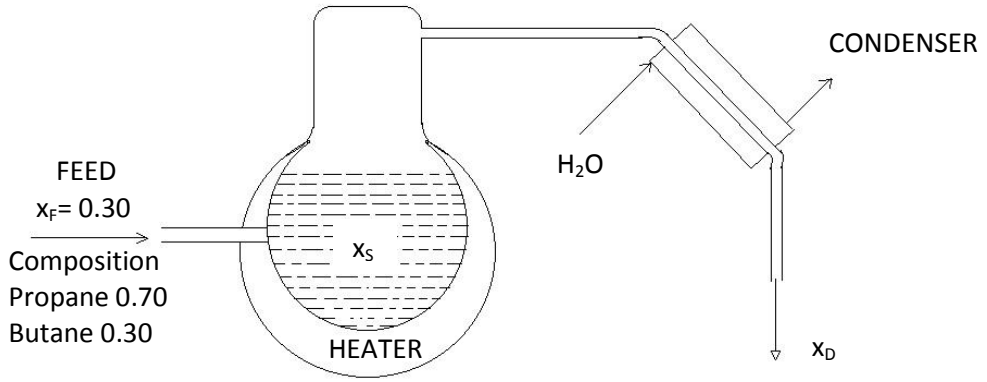
b) The unit of g_c is

(a) $\frac{lbm}{lbf}\frac{ft}{\sec^2}$ (b) $\frac{lbf}{lbm}\frac{ft}{\sec^2}$ (c) $\frac{ft}{\sec^2}$ (d) $\frac{lbm}{lbf}\frac{\sec^2}{ft}$. 1

5. a) A small still is separating propane and butane at 135°C and initially contains 10 Kg moles of a mixture whose composition is x = 0.30 (x = mole fraction Butane). Additional mixture $(x_F = 0.30)$ is fed at the rate of 5 Kg mol/hr. If the total volume of the liquid in the still is constant, and the concentration of the vapour from the still (x_0) is related to (x_s) as follows:

$$x_D = \frac{x_s}{1+x_s}$$

how long will it take for the value of x_s to change from 0.30 to 0.47? What is the steady state ("equilibrium") value of x_s in the still (i.e.; when x_s becomes constant)? 4



b) Kopp's Rule is helpful in finding: 1
(i) heat capacities of solids
(ii) heat capacities of gases
(iii) molal heat capacities of gases
(iv) activation energies.

6. A distillation column separates 10,000 Kg/hr of a 80% benzene – 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 90% 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 with drawn for use elsewhere. Assume that the compositions of the streams at the top of the column (*v*), product with drawn (I) and the reflux (R) are identical, because their steam is condensed completely. Find the ratio of the amount refluxed R to the product with drawn (D). 5

Unit-II

(***Answer <u>any seven</u>***) [7×5]

7. a) Distinguish between (i) extraction and leaching; (ii) adsorption and desorption. 2
b) Alcohol vapour is diffusing through a layer of water vapour under equimolar counter diffusion at 35^{o}C and 1 atm. Pressure. The concentration of alcohol on the two sides of the gas film (water vapour) 0.3 mm thick are 80% and 10% respectively. Assuming the diffusivity of alcohol-water vapour to be 0.18 cm^2/s, (i) calculate the rate of diffusion of alcohol and water vapour in kg/hr through an area 100 cm^2 (ii) if the water vapour layer is stagnant, estimate the rate of diffusion of alcohol vapour. 3

8. a) State and explain the Fick's law of diffusion. 1
b) Show that $D_{AB} = D_{BA}$. 1
c) A spherical water drop evaporates in stagnant air. Derive an expression to calculate the time required to evaporate the water drop. Assume the evaporation takes place only due to diffusion. 3

9. Answer ***<u>any five</u>*** questions: 5 x 1
(a) Distinguish between molecular diffusion and eddy diffusion.
(b) For packed bed write the basic requirements needed.
(c) Name the common types of packing used in process industry.
(d) For gas-liquid contacting device with foaming packed bed is preferred. Explain why?

(e) For gas-liquid contacting device with high fluctuation of temperature and pressure plate column is preferred over the packed column. Explain why?

(f) Write the advantages of structured packing over the random packing in packed bed.

(g) Write the comparison between bubble cup tray, value tray and packed column.

10. Answer ***any five*** questions: 5 x 1

a) Write the force/forces used to reduce the size.

b) Write a note on different aspects of energy consumed in size reduction process.

c) Write the advantages of wet grinding over the dry grinding.

d) Discuss the factors that influence the product size in a ball mill.

e) Draw closed circuit dry grinding milling and mention the factors which control the grinding process.

f) State Bond's law of crushing.

11. State the following:

a) (i) Kick's Law (ii) Rittinges's Law 1+1

b) Calculate the energy required to crush 100 tons per hour of limestone if 80% of the feed passes through a screen 3.75 cm aperture and 80% of the product passes through a screen with 0.03 cm aperture. The work index for limestone is 12.74, when the capacity is expressed in tonnes per minute, calculate energy required in horsepower and size of the product in feet and size of the feed in feet. 3

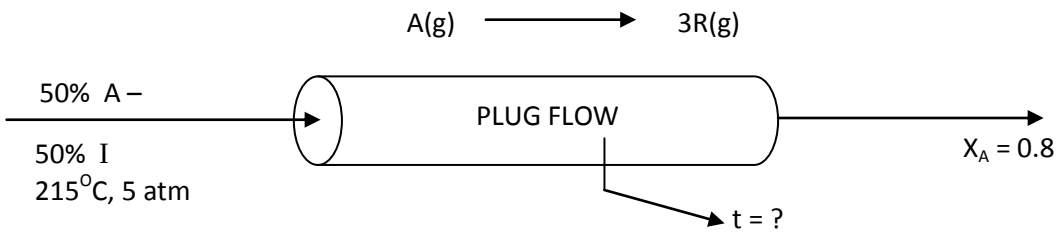
12. a) A specific enzyme acts as catalyst in the fermentation of reactant A. At a given enzyme concentration in the aqueous feed streams (25 liter/min) find the volume of the plug flow reactor needed for 95% conversion of reactant A (C_{Ao} = 2 mol/liter). The Kinetics of the fermentation at the enzyme concentration is given by

$$A \xrightarrow{enzyme} R,\ -r_A = \frac{0.1C_A}{1+0.5C_A}\ \frac{mol}{liter.\min}.$$ 2½

b) A homogeneous gas reaction $A \rightarrow 3R$ has a reported rate at 215°C. 2½

$$-r_A = 10^{-2} C_A^{1/2},\ [\text{mol/liter.sec}]$$

Find the space-time needed for 80% conversion of a 50% A – 50% inert feed to a plug flow reactor operating at 215°C and 5 atm (C_{A_0} = 0.0625 mol/liter).



TABLE

X_A	$\frac{1+X_A}{1-X_A}$	$\left(\frac{1+X_A}{1-X_A}\right)^{1/2}$
0	1	1
0.2	$\frac{1.2}{0.8}=1.5$	1.227
0.4	2.3	1.528
0.6	4.0	2
0.8	9.0	3

Use Simpson's Rule with the help of data's from above mentioned table.

13. In a CSTR operating at steady state, a solution containing reactant A with concentration C_A^o is being fed. Inside the reactor two simultaneous reactions takes place $A \rightarrow B$, rate constant k_1, first order, $A \rightarrow C$, 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 equation for determining concentrations of the reactants and products in the stream having the reactor. 5

14. a) A metal wire of length 30 cm, dia 1 mm with resistance of 2Ω is placed in a pool of non-conducting (electrical) liquid, and a current of 10 amp is passed through it. At steady state the liquid starts to boil.
Calculate heat flux – assume nucleate boiling, use appropriate expression for heat flux / heat transfer coefficient.
Calculate expected temperature of wire surface.
(i) First calculate wire surface area, electrical heat generated and hence heat flux. 1½
(ii) Now calculate the temperature difference from appropriate correlation. Note liquid is at boiling point. 2½

b) Write down the expression usually used for calculating frictional pressure loss for a fluid flowing through a pipe line using Fanning's friction factor. Explain the symbols used. 1

15. a) State Fourier's law. 1

b) Crude oil flows at the rate of 2000 kg/hr through the inside pipe of a double pipe heat exchanges and is heated from 30°C to 90°C. The heat is supplied by Kerosene initially at 200°C flowing through annular space. If the temperature of approach (minimum temperature difference) is 10°C determine the heat transfer area for co-current flow and Kerosene flow rate
C_P for crude oil = 0.5 Kcal/Kg°C
C_P for Kerosene = 0.6 Kcal/Kg°C
U_0 = 400 Kcal/hr m^2 °c. 4

16. a) What is NPSH, and why is it considered an important selection and operation parameter for a centrifugal pump. 1½

b) (i) Write down the equation that gives the total thermal radiation emitted by a surface. Explain the terms used. 1

(ii) A pan of diameter 150 mm was kept on a horizontal surface in the open on a winter night, containing water to a depth of 5 mm. Initial temperature of water is 4°C. Water looses heat

by radiation. Assume no convective heat transfer between air and water, no evaporation and no heat exchange with pan.

Find out if radiation cooling will cause the water to freeze, if so what amount will freeze if the pan remains under open sky for 6 hrs. Assume radiation temperature of sky to be too low to make any significant contribution. Assume normal values for properties of water, latent heat of fusion 350 J/gm. Assume water surface to radiate as a grey body with emissivity of 0.1. 2½

Group – B

(*Answer any four*) [4×5]

17. a) Give examples of the following: (i) semi-synthetic polymer (ii) coordination polymer (iii) thermoset polymer (iv) plastic with very low Tg (v) anionic polymer (vi) biodegradable plastic. 3
    b) What is 'back biting'? 1
    c) Name one polymer where backbiting is a common phenomenon. 1

18. a) What do you mean by 'hot tack' property of LLDPE? 1
    b) How product from a free radically made polymer will affect if the disproportionation reaction dominates over combination? 1
    c) What is the monomer of Nylon 6? Name a product made from HDPE. 1
    d) What properties will affect if acrylonitrile content will be increased for styrene acrylonitrile plastic (SAN)? 2

19. a) What do you mean by PDI? How PDI normally affects processing of a polymer? 2
    b) In what purpose z-average molecular weight is being estimated? 1
    c) In between emulsion and solution SBR, which one gives better processability and why? 2

20. a) Draw molecular weight distribution plot and point out the M_n, M_w, M_z, M_V. 2
    b) What do you mean by vulcanization? 1
    c) Why accelerator is used with sulphur at the time of vulcanization? 2

21. a) Polystyrene has higher Tg than PVC. Explain why? 2
    b) Why emulsion polymers are not suitable to apply in electrical purposes? 1
    c) Write short notes on synthesis, properties and application (end use) of Polymethyl Methacrylate. 2

22. a) Calculate the content of Acrylonibile and butadiene that is present in NBR supplied to you. Data supplied are Tg of ACN 95^{o}C, Tg of Butadiene – 90^{o}C and Tg of the copolymer is – 57.5^{o}C. 2½
    b) Calculate the degree of polymerization if 6, 6-nylon has a molecular weight of 120,000 g/mol. 2½

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