RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

SECOND YEAR [BATCH 2015-18]

B.A./B.Sc. FOURTH SEMESTER (January – June) 2017

Mid-Semester Examination, March 2017

Date : 15/03/2017 **INDUSTRIAL CHEMISTRY (Honours)**

Time : 11 am – 1 pm Paper : IV Full Marks : 50

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

<u>Group – A</u>

Answer <u>any two</u> questions from <u>Question nos. 1 to 3</u> : [2×5]

1. a) The equation for the flow of water through a nozzle is as follows [2]

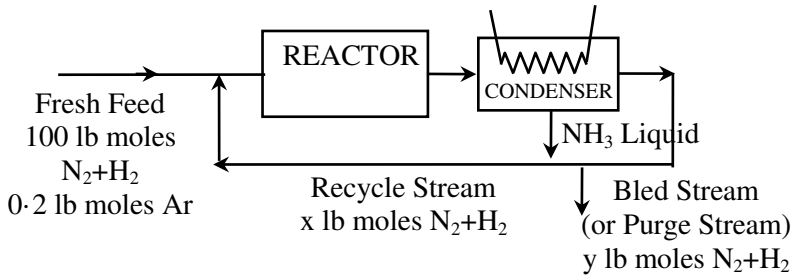
$$q = C\sqrt{\frac{2g}{1-\left(\frac{d_1}{d_2}\right)^4}}\left(A\sqrt{\frac{\Delta p}{\rho}}\right)$$

where q = volume flowing per unit time, c = dimensionless constant, g = local gravitational acceleration, d_1 = smaller nozzle diameter, d_2 = longer nozzle diameter, A = area of nozzle outlet, Δp = pressure drop across nozzle, ρ = density of fluid flowing

State whether this equation is dimensionally consistent. Show how you arrived at your conclusion.

b) When a small tube is dipped into a pool of liquid, surface tension causes a meniscus to form at the free surface, which is elevated or depressed depending on the contact angle at the liquid-solid-gas interface. Experiments indicate that the magnitude of this capillary effect, Δh, is a function of the tube diameter D, the liquid specific weight γ, and surface tension σ. Determine the number of independent π parameters that can be formed and obtain a set. [3]

2.



a) In the operation of a synthetic ammonia plant, shown diagrammatically in fig above, a 1:3 nitrogen hydrogen mixture is fed to the converter resulting in a 25% conversion to ammonia. The ammonia formed is separated by condensation, and the unconverted gases are recycled to the reactor. The initial nitrogen-hydrogen mixture contains 0·20 part of Ar to 100 parts of $N_2 - H_2$ mixture. The toleration limit of Ar entering the reactor is assumed to be 5 parts to 100 parts of N_2 and H_2 by volume. Estimate the fraction of recycle that must be continually purged. [2·5]

b) The waste acid from a nitrating process contains 23% HNO_3, 57% H_2SO_4 and 20% H_2O by weight. This acid is to be concentrated to contain 27% HNO_3 and 60% H_2SO_4 by the addition of concentrated sulfuric acid containing 93% H_2SO_4 and concentrated nitric acid containing 90% HNO_3. Calculate the weights of waste and concentrated acids that must be combined to obtain 1000 lb of the desired mixture. [2·5]

3. Propane is dehydrogenated to form propylene in a catalytic reactor :

$$C_3H_8 \rightarrow C_3H_6 + H_2$$

The process is to be designed for a 95% overall conversion of propane. The reactor products are separated into two streams : the first, which contains H_2, C_3H_6 and 0·555% of the propane that leaves the reactor, is taken off as product; the second stream, which contains the balance of the unreacted propane and 50% of the propylene in the first stream, is recycled to the reactor. Calculate the composition of the product, the ratio (moles recycled)/ (mole fresh feed) and the single pass conversion. [5]

4. Answer **any one** question : [1×4]

   a) Distinguish between (i) extraction and leaching; (ii) absorption and adsorption

   b) i) What factors the mass transfer rate between two fluid phase depends?

      ii) State and explain Fick's law of diffusion.

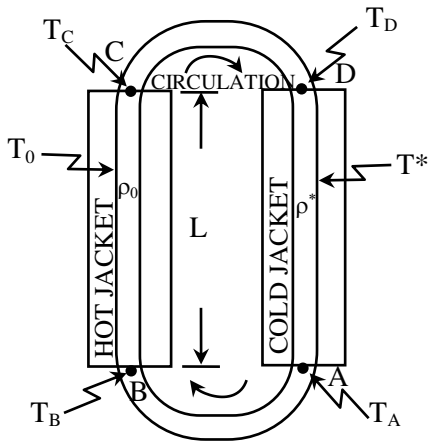
5. Answer **any one** question : [1×6]

   a) An ethanol water solution is in contact at 20°C with an organic liquid film thickness 0·4 mm in which water is insoluble. The concentration of ethanol at the interface is 6·8 wt% and at the other side of film it is 10·8 wt%.The densities are 0·9981 gm/cc and 0·9728 gm/cc respectively for 6·8 wt% and 10·8 wt%. Diffusivity of ethanol is 74×10^{-5} cm^2/s. Calculate the steady state flux $kgmol/m^2s$.

   b) 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.

Answer <u>any one</u> question from <u>Question nos. 6 & 7</u> : [1×10]

6.



Total Tube Length 3L
Tube Dia D

A simplistic model of a physical phenomena is as follows :

A tube as shown in figure is heated from B to C and cooled from D to A. It is filled with a liquid. Temperatures at points A, B, C and D are T_A, T_B, T_C & T_D. Note $T_A = T_B$ and $T_C = T_D$ Heights of the heating and cooling columns are L. Heater section tube wall temperature is T_0. Cooler section tube wall temperature is T*. Liquid gets hot in BC section, its density decreases and gets cooled in DA section, where its density increases, the differences in densities causes a differential pressure, which drives a flow as shown by circulation arrows in figure. Assume average density in AD region tube ρ^* and in BC region to be ρ_0. Assume tube diameter to be D total length of tube = 3L. Liquid used in water. Assume $\rho_0 = 0{\cdot}9776 \frac{g}{cc}$ $\rho^* = 0{\cdot}9955 \frac{g}{cc}$. Liquid viscosity η = 0·56 cP. D = 4mm, L = 30 cm, T_0 = 95° C, T* = 15°C , $k = 0{\cdot}642 \frac{w}{mK}$ $C_p = 4{\cdot}182$ J/gk T_B = 30°C, T_D = 70°C.

Take ρ for Re calculation as $\frac{(\rho_0 + \rho^*)}{2}$.

[Note : $T_A = T_B = 30°C$, $T_C = T_D = 70°C$, $\eta = 0{\cdot}56$ cP, $k = 0{\cdot}642 \ \frac{w}{mK}$, $C_p = 4{\cdot}182 \ {}^{J}\!/_{gk}$, L = 30 cm, D = 4mm, $T_0 = 95°C$]

Other Correlations

Laminar Flow $N_u = 1{\cdot}86 \left(R_e P_r \frac{D}{L} \right)^{1/3}$

Turbulent flow $N_u = {\cdot}023 \ Re^{0{\cdot}8} \ P_r^{0{\cdot}4}$

a) Calculate the recirculation rate and average linear velocity. [5]

b) Calculate the water side heat transfer coefficient in BC portion and the amount of heat transferred (Rate) [5]

7. An oil is being cooled in a double pipe heat exchanger from 80°C to 40°C by cooling water entering at 30°C and leaving at 45°C. Flow rate of oil is 2kg/S. Oil flows inside the central tube and cooling water flows in the annular region. Inner tube dia is 3 cm, outer tube dia is 5 cm. Neglect metal resistance and thickness properties are given in table below

Property :

	SP.Heat (J/Gk)	k (w/m K)	ρ (g/cc)	η (cP)
Oil	2·2	0·13	0·82	1·3
Water	4·2	0·6	0·98	0·6

For f use Blausius Relation $f = 0{\cdot}079 \, Re^{-1/4}$.

Other Correlations

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Turbulent flow $N_u = {\cdot}023 \ Re^{0{\cdot}8} \ P_r^{0{\cdot}4}$

a) Calculate length of the heat exchanger. [5]

b) Calculate oil side pressure Drop. [5]

Give values of all linear velocities, Reynolds, Prandtl, Nusselt No, Friction Factor.

Group – B

Answer <u>any four</u> questions from <u>Question nos. 8 to 13</u> : [4×5]

8. a) Give example of the following ; free radical polymer, step growth polymer, coordination polymer, semi-synthetic polymer, commodity plastic, emulsion polymer. [3]

b) What do you mean by functionality? [2]

9. a) What do you mean by thermal initiator? [1]

b) Name one thermal imitator. [1]

c) Write down the steps related to a FRP. [3]

10. a) Why emulsion polymerized product is not suitable for electrical insulation applications? [1]

b) Give stress vs strain plot for rubber, plastic and fibres. [2]

c) Why polystyrene shows high T_g than polybutadiene? [1]

d) What is monomer unit of natural rubber? [1]

11. a) Name a naturally occurring high molecular weight polymer obtained in latex stage. [1]

b) Write down its structures. Which form is used for making golf balls? [1·5]

c) Jot down the conditions necessary for a polymer to be called as a rubber. [1·5]

d) Write down the Tg of CR & NR. [1]

12. a) Fill in the blanks : [2]

The tensile strength of unfilled NR is _____ MPa

The tensile strength of filled SBR is _____ MPa

b) Which rubber will you select any why for making the following products : [2]

i) Football bladder

ii) Hawaii chappal

iii) Low cost oil seal for static applications

c) Choose the appropriate rubber used for the following applications : [1]

i) Roof top, car window seals (exposed to sunlight) → NR, SBR, NBR, EPDM, IIR, CR

ii) Fire retardant or insulating rubber → NR, SBR, NBR, EPDM, IIR, CR

13. a) Write down the reasons : [2]

i) PE is plastic though its Tg is much below room temperature (–120° C)

ii) Silicon rubber has both high and low temperature of applications.

b) Write down the names and structures of the three dienes used for making EPDM rubber. [1·5]

c) What will be the Tg of the polymer made by random copolymerization of 30% ACN and 70% Butadiene have individual Tg of 95°C and –90°C respectively. Can we use it as rubber at STP? [1·5]

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