# RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

SECOND YEAR [2017-20] B.A. /B.Sc. FOURTH SEMESTER (January – June) 2019 Mid-Semester Examination, March 2019

Date : 25/03/2019 Time : 11 am - 1 pm **INDUSTRIAL CHEMISTRY (Honours)** 

Paper: IV

Full Marks: 50

[6×5]

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## (Use a separate Answer Book for <u>each group</u>)

### Group - A

Answer **any six** from the following questions:

1. a) A nonvolatile oil contains 1.5 mol% of Benzene. It is proposed to strip this solution of benzene by passing steam at 60°C and 200 mm Hg pressure. The oil is fed to a vessel and steam is bubbled through it. What will be the mole fraction and weight fraction of benzene in the gas / vapour stream leaving the stripper. Assume the oil leaving the stripper vessel has benzene content 0.2 mol% and the gas stream leaving the stripper is in equilibrium with this and no steam condenses.

Assume benzene solution follows Raoult's law and the vapour phase is ideal. Vapour pressure of pure benzene at  $60^{\circ}$ C is 397 mm Hg.

b) A petroleum oil with density  $\rho$ , viscosity  $\mu$  is pumped through a pipe line of effective length *L*, diameter *D*, at a volumetric flow rate of *Q*. The frictional pressure loss is  $\Delta P_{f}$ . If it is required to pump the same fluid through the same line at a volumetric flow rate of 1.2Q, what will be the pressure drop (express in terms of  $\Delta P_{f}$ ).

Assume flow is turbulent enough for friction factor to remain constant.

- 2. a) Write down Bernoulli's equation, and explain the terms.
  - b) In a double pipe heat exchanger, the internal diameter of the inner tube is 2.0 cm, wall thickness is 0.2 cm. The inside and outside heat transfer coefficients are 0.05 cals/cm<sup>2</sup>sec and 0.2 cal/cm<sup>2</sup>sec respectively. What is the overall heat transfer coefficient based on outside area. Neglect metal resistance.
- 3. a) High pressure steam is passing through a pipeline a internal diameter 7.5 cm and outer diameter 9.0 cm. Inside wall temperature of the pipe is 150°C. Thermal conductivity of the pipe material is 20 W/mk. There is an insulation on the outside of the tube with thickness 2 cm and thermal conductivity of 0.1 W/mK. Outside surface temperature of insulation is 60°C. What is the heat loss per meter length of pipe line?
  - b) Calculate the dimension of the quantities v and  $\alpha$ , where

$$\upsilon = \frac{\mu}{\rho}$$
 and  $\alpha = \frac{k}{\rho C_P}$ 

Where  $\mu$  is viscosity,  $\rho$  is density, K is thermal conductivity and  $C_p$  is specific heat.

Express Prandtl number in terms of v and  $\alpha$ .

4. a) Sulfur is burnt in a furnace with dry air to produce a gas which contain 8% of SO<sub>2</sub>. Calculate the composition of the gas. This gas is passed through a converter, which converts the SO<sub>2</sub> to SO<sub>3</sub>, and all the SO<sub>3</sub> is then absorbed in concentrated sulphuric acid. If the gas after absorption is to contain a maximum of 10 ppm SO<sub>2</sub> what must be the conversion of SO<sub>2</sub> to

 $SO_3$  in the converter. Assume for simplicity, all  $SO_3$  produced is absorbed, but all unconverted  $SO_2$  escapes.

- b) A liquid process stream is being pumped through a pipeline. Frictional pressure drop increases as velocity of fluid is increased. Will the Friction Factor increase with increase in fluid velocity?
- 5. a) i) The two ends of a metal piece of length *L* are maintained at temperature  $T_1$  and  $T_2$   $(T_1 > T_2)$  as shown in the figure below. The cross-section of the metal piece is a section of a circle of radius *r* and included angle of  $\theta$ . Assuming the conductivity of the metal varies with temperature as given by the following equation:

$$K = K_0 \left( 1 - \alpha T \right)$$

Find the expression for the heat flow in Z-direction through the metal piece per hour. Assume  $\frac{\delta T}{\delta \theta} = 0$  and  $\frac{\delta T}{\delta r} = 0$  and outer surfaces of the slab except the end surfaces are fully insulated.

ii) If the given data is L = 50 cm, r = 10 cm,  $\theta = 90^{\circ}$ ,  $T_1 = 100^{\circ}$ C,  $T_2 = 20^{\circ}$ C and  $K_0 = 100$  kcal/m-hr-°C and  $\alpha - 10^{-4}$ /C, then find the value of heat conducted at steady state. [1]



- b) Flow of a liquid through a pipeline is being measured by a venture meter installed in the pipeline. The pressure drop is read by a manometer. The manometer shows a reading of 15 cm when the volumetric flow rate is  $3 \text{ m}^3$  / hr. What will be the volumetric flow rate if the manometer shows a reading of 20.2 cm?
- 6. a) Sea water is to be desalinized by reverses osmosis using the scheme indicated in the Figure below: Use the data given in the figure to determine:
  - i) The rate of waste brine removal (B).
  - ii) The rate of desalinized water (called potable water) production (D).
  - iii) The fraction of the brine leaving the reverse osmosis cell (which acts in essence as a separator) that is recycled.



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[1]

b) A liquid stream containing 60.0 wt% ethane and 40.0 wt% n-Butane is to be heated from 100K to 200K at a pressure of 5 bar as shown in the Figure. Calculate the required heat input per kilogram of the mixture, neglecting potential and kinetic energy changes, using given enthalpy data for  $C_2H_6$  and  $C_4H_{10}$  and assuming that the mixture to be ideal liquid mixture. Enthalpy at 200K and 5 bar : for  $C_2H_6$  434.5 KJ/kg and for  $C_4H_{10}$  130.2 KJ/Kg

Enthalpy at 100K and 5 bar : for  $C_2H_6$  314.3 KJ/kg and for  $C_4H_{10}$  30.0 KJ/Kg



- a) State and explain Fick's law of diffusion. 7.
  - b) What is molecular diffusion and eddy diffusion?
  - c) Differentiate between (i) extraction and leaching; (ii) absorption and adsorption.
  - d) Identify the correct answer:
    - (i) The breathing process within the lungs involves
      - (a) diffusion of A through non-diffusion B
      - (b) equimolar counter diffusion
      - (c) multicomponent non-equimolar counter diffusion

(ii) The diffusion of Ar in N<sub>2</sub> at 20<sup>o</sup>C and 1 atm. pressure is 0.194 cm<sup>2</sup>/s. What would the diffusivity of N<sub>2</sub> in Ar at same temperature and pressure?

(a) 
$$0.194 \text{ cm}^2/\text{s}$$
 (b)  $1.94 \text{ cm}^2/\text{s}$  (c)  $0.0194 \text{ cm}^2/\text{s}$   $[1+1\frac{1}{2}+1\frac{1}{2}+1]$ 

In an oxygen-nitrogen gas mixture at 1 atm. 25°C, the conc. of oxygen at two planes 0.2 cm apart 8. are 10% and 20% (by volume) respectively. Calculate the fluxt of oxygen when (i) nitrogen is non-diffusion and (ii) there is equimolar counter diffusion.

Given,  $D_{oxygen-nitrogen} = 0.215 \text{ cm}^2/\text{s}$ 

A drop of water is placed in a stagnant air and it is gradually evaporating. Derive and expression 9. to determine the time required for complete evaporation of the drop. [5]

#### Group - B

#### Answer any four from the following question:

10. Choose the best response among the following options of each question. [1×5]

- i. Which of the following kind of polymers are known for their high crystallinity?
  - a) Isotactic
  - b) Syndiotactic
  - c) Atactic
  - d) none of the mentioned

[5]

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 $[4 \times 5]$ 

- ii. How is the extent of reaction, p, of a polycondensation reaction related to the average functionality, f, of the system?
  - a) proportional to f
  - b) proportional to 1/f
  - c) proportional to  $f^2$
  - d) proportional to  $1/f^2$
- iii. Which of the following is a thermosetting polymer?
  - a) polystyrene
  - b) polyolefins
  - c) nylons
  - d) phenolic resins
- iv. What kind of substituent groups should be attached to the monomer, readily undergoing cationic polymerization?
  - a) electron accepting
  - b) electron releasing
  - c) all of the mentioned
  - d) none of the mentioned
- v. Which of the following is correct regarding the alternate copolymerization?
  - a)  $r_1r_2=1$
  - b)  $r_1 = r_2 = 1$
  - c)  $r_1r_2=0$
  - d)  $r_1r_2>1$
- 11. a) What is degree of polymerisation? What is the relation between functionality and it? What is the Functionality of resorcinol?
  - b) A polymer formed from Caprolactum has molecular weight of 120000 gmol<sup>-1</sup>. What will be its degree of polymerisation? [1+1+1+2]
- 12. a) The average functionality of a polyfunctional system is 2.4. What will be the average degree of polymerization for 80% completion of reaction?
  - b) What is "gel effect"?
  - c) How can we introduce carboxylic group and alcohol in polymer chain? [2+1+2]
- 13. a) What will be the nature of copolymers in following conditions (state with explanation)
  - I.  $r_1 r_2 > 1$
  - II.  $r_1r_2 < 1$
  - III.  $r_1r_2=1$
  - b) "BF<sub>3</sub> is ineffective to induce cationic polymerization in isobutylene when the reactants are moisture free" –justify the statement. [3+2]
- 14. a) Provide the differences between step growth and chain growth polymerisation.

	b)	What is CMC?	[3+2]
15.	a)	What is the role of inorganic stabilizers in suspension polymerisation? Give one example of them	

b) Explain the advantages and disadvantages of bulk polymerisation. [2+3]

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