RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. FOURTH SEMESTER EXAMINATION, MAY 2019

SECOND YEAR [BATCH 2017-20]

Date : 16/05/2019 **INDUSTRIAL CHEMISTRY (Honours)**

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

[Use a separate Answer Book for each group]

Group – A

Answer <u>any five</u> questions from <u>Question nos. 1 to 8</u> : (5 × 10)

1. a) i) Find the dimension of the quantity given by $h/C_p\rho u$, where h is heat transfer coefficient, C_p is specific heat, ρ is density and u is velocity.
   ii) What is Prandtl number? Show that it is dimensionless. [2]

   b) Current world production of coat is nearly 8000 million tons per year. Almost all of it is burnt as fuel. Assume that its average carbon content is 89 % by weight, and average sulphur content is about 1% by weight. How many tons of CO_2 and SO_2 per year released into atmosphere? [4]

   c) Write down Bernoulli's equation for incompressible fluids considering pump work and fluid friction. Describe physical significance of each term with units. [4]

2. a) Write down the expression for total drag force felt by a stationary solid body placed in a fluid flowing past it with a velocity u and explain the terms .

   Use the expression to find the terminal velocity of a hail stone with diameter of 1 cm as it falls through air. Assume density of hail stone to be 0.9 g/cc, density of air 0.0012 g/cc, viscosity of air to be 0.01 cP and drag coefficient to be 0.45. [2+3]

   b) The rectangular vertical door of a furnace is 1.5 m wide and 1 m in height. When the furnace is operating, the door is kept closed. Its outside surface temperature remains about 90^oC. Calculate the heat lost, if ambient air temperature is 40^oC, by natural convection and radiation.
   Assume, $\rho = 1.06$ kg/m^3 , $\mu = 2.05 \times 10^{-6}$ kgf.sec/m^2, $C_p = 0.24$ kcal/kg^oC, $K = 2.49 \times 10^{-2}$ kcal/mhr^oC , $\nu = 18.97 \times 10^{-6}$ m^2/sec, $\beta = 1/338$ per K
   The symbols have their usual significance.
   Emissivity of the door may be taken as 0.8

$$Nu_x = \frac{h_x x}{K} = 0.508\left[\frac{(\mathrm{Pr})^2 (Gr_x)}{(\mathrm{Pr} + \frac{20}{21})}\right]^{1/4}$$

$$\sigma = 5.67 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$$ [5]

3. a) A Pitot tube placed along the centre line of a 5 cm diameter horizontal tube carrying a liquid with density 0.8 g/cc and viscosity 6.5 cP, records a pressure difference of 40 dynes/cm^2. Find the average velocity, Reynolds number and volumetric flow rate for this flow. [4]

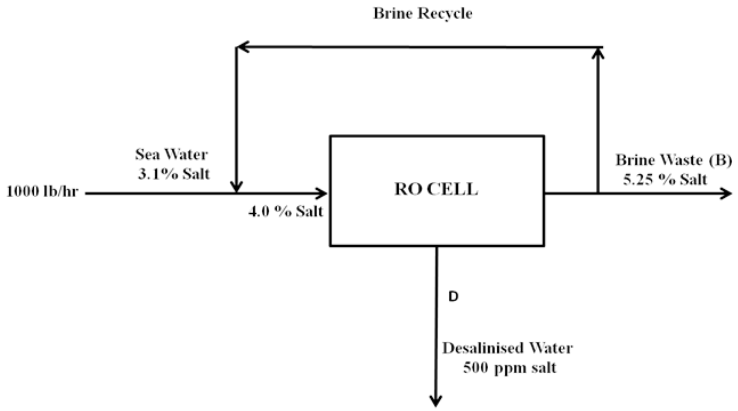
   b) In a plant an oil stream of 400 kg /hr is to be cooled from 85^oC to 55^oC by cooling water entering at 45^oC and leaving at 55^oC. A spare double pipe heat exchanger is available, with inner pipe

diameter of 4 cm, wall thickness 2.5 mm and outer pipe diameter 5.5 cm, and length 18 m. Will this exchanger be able to handle this job?
For oil Sp ht 0.55 cal /g C, viscosity 0.6 cP, density 0.84 g/cc, thermal conductivity 0.2 W/mK.
For water sp ht 1.0 cal/g C, viscosity 0.8 cP, density 0.98 g/cc, thermal conductivity 0.58 W/m K
Use Dittus Boelter expression without viscosity correction for Nusselt number calculation. Assume oil to flow inside the inner tube. Neglect metal resistance to heat transfer. [6]

4. a) i) A centrifugal pump should be used to pump water from a lake to a storage tank at 148 ft above the surface of the lake. Pumping rate is 25.0 gal/min at 60^oF. A pump in store can develop a pressure of 50 psig at the same flow rate and temperature. Frictional loss and pump efficiency are not considered.
How high (in ft) can the pump raise water under the mentioned flowrate and temperature?
Is the pump suitable for the mentioned duty? [4]

ii) What are the physical significance of Nusselt number and Schmidt number? [2]

b) Sea water is to be desalinized by reverse osmosis using the scheme indicated in the Figure below: Use the data given in the figure to determine: (Note data are given in the figure) [4]



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.

5. a) The Ergun equation is as follows:

$$\frac{\Delta P}{L} = \frac{150\mu u(1-\varepsilon)^2}{\varphi^2 D_p{}^2 \varepsilon^2} + 1.75\frac{\rho u^2(1-\varepsilon)}{\varphi D_p \varepsilon^3}$$

The symbols have their usual significance.

A vertical packed bed, 4 cm in diameter and 2 cm in height is placed under a column of water. Water level is 10 cm above the top of the bed. It is observed that water flow rate through the bed is 0.3 cc/minute. Bed porosity is estimated to be 0.45. Water density and viscosity may be taken as 1 g/cc and 1cP respectively. What will be the particle diameter assuming the particles of the bed to be spherical in shape. [5]

b) A wire of 1.5 mm diameter and 150 mm length is submerged in turbulent water at atm pr. An electric current is passed through the wire until the water boils at 100^oC. Under this condition, the heat transfer coefficient is 4500 $w/m^{2o}C$. How much electrical power has to be supplied to maintain the wire surface at 120^oC? [5]

6. a) Choose the correct one **(any six)** [6×1]

i) Solvent extraction is the name applied to
   a) Solid-liquid extraction
   b) gas-liquid transfer operation
   c) liquid-liquid extraction
   d) none of these

ii) To obtain maximum absorption efficiency
   a) gas should be distributed uniformly
   b) both liquid and gas streams should be distributed uniformly
   c) by-pass should be avoided
   d) none of these

iii) The removal of carbon dioxide from water gas is effectively achieved by
   a) absorption
   b) selective absorption
   c) simultaneous absorption and chemical reaction
   d) none of these

iv) Recovery of oil from vegetable seeds with organic solvent is an example of
   a) distillation b) leaching c) dissolution d) none of these

v) Absorption is an operation which generally involves
   a) gas-solid systems b) liquid-solid systems c) fluid-solid systems d) none of these

vi) For absorption of benzene from coal gas in wash oil, the major resistance to mass transfer comes from
   a) gas side
   b) liquid side
   c) both gas and liquid side
   d) none of these

vii) For best gas absorption the solvent should have
   a) high vapour pressure and low viscosity
   b) high vapour pressure and high viscosity
   c) low vapour pressure and low density
   d) low vapour pressure and high viscosity

b) Calculate the rate of diffusion of water vapour from a thin layer of water at the bottom of a well 6 m in depth to dry air flowing over the top of the wall. Assuming the entire system is at 298 K and atmosphere pressure. If the water well diameter is 3m, find out the total weight of water diffuse per second from the surface of the water in the well.
   Given, $D_{\text{water vapour-dry air}} = 0.256\times10^{-4}\ m^2/s$
   Partial pressure of water vapour at 298 K = 0.031 atm. [4]

7. a) Compare Diffusion coefficient and mass transfer coefficient. [2]
   b) Explain humidification and dehumidification process. [2]
   c) Ammonia and air are undergoing equimolar counter-diffusion through a cylindrical tube of 3.5 mm diameter and 25 m length. One end of the tube is connected to a large reservoir of ammonia and the other end is opened to atmosphere. Total pressure of the system is 1 atm and the temperature is 27°C. If the diffusivity is $0.3\times10^{-4} m^2/s$, calculate the rate of mass transfer of ammonia and air in kg/h through the tube.
   R = 0.08205 L.atm K^{-1} mol^{-1}. [6]

8. a) Compare Fick's law, Newton's law and Fourier's law. [4]
   b) Write the advantages and disadvantages of perforated tray, value tray and bubble cap tray. [3]
   c) Write the selection criteria of solvent used in liquid-liquid extraction unit. [3]

Group – B

Answer <u>any five</u> questions from <u>Question nos. 9 to 16</u> : (5 × 5)

9. Choose the best response among the following options for each question. [1×5]

i) What is the average degree of polymerization for a complete polycondensation reaction in a bifunctional system?

a) infinity b) 0 c) 1 d) none of these

ii) The process in which molecular weight control is achieved by using a stoichiometric imblance of the reacting functional group is —

a) chain growth process b) step growth process
c) substitution process d) none of these

iii) What is the approximate phenol formaldehyde ratio used is the preparation of casting grade phenolic resin?

a) 1:2.2 b) 2:1 c) 3:1 d) 1:2

iv) Which of the following monomer pair polymerizes to give an aramide?

a) hexamethylene diamine + sebacic acid b) terephthaloyl chloride + phenylene diamine
c) hexamethalene diamine + adipic acid d) none of these

v) Which of the following is a demerit of solution polymerization?

a) handling of inflammable solvents b) recovery of solvent
c) chain transfer to solvent d) all of the mentioned

10. a) How does degree of polymerization depends on R_p and R_t ? What do you mean by chain transfer. [2]

b) Polymerisation of polystyrene follows cationic mechanism whereas acrylonitrile follows the anionic mechasism — explain. [2]

c) Mention two commonly used initiators in cationic polymerisation. [1]

11. a) Neglecting the contribution of end groups to the polymer molar mass, calculate the percentage conversion of functional groups required to obtain a polyester with a number average molar mass of 24,000 g/mol from the monomer $HO(CH_2)_{14}COOH$. [2]

b) Derive the rate of a stand^{n} free radical polymerization using AIBN as an Initiator. [3]

12. a) Structurally distinguish between LDPE, LLDPE, VLDPE and ULDPE. [3]

b) Math column A with column B [2]

A	B
P. Polystyrene	1. Non-flammable polymer
Q. PVC	2. Contact lance
R. PAN	3. Foam
S. PMMA	4. Oil pipe

13. a) How do aromatic and aliphatic isocyanate influence the properties of a standard PU with same soft segment and chain extender? [2]

b) How epoxy resins are synthesized? Mention its uses. [2]

c) State the uses of Urea-Formaldehyde resin. [1]

14. a) Cohesive Energy density of n-hexane is 52.41 cal.cm^{-3} and that of Ethyl Acetate is 82 cal.cm^{-3}. Calculate the Hildebrand solubility parameter (δ) of the solvents. Poly(styrene) has a solubility parameter of 9.1 (cal.cm^{-3})$^{1/2}$. Which among the above two solvent will be a good solvent for Poly (styrene) and why? [3]

b) Name two rubbers having both fire and oil resistant characteristics. [1]

c) Tg of polyethylene is $-110^{o}C$ but it is not considered as rubber why? [1]

15. a) Tg of polybutadiene is recorded at $-100^{o}C$.

i) The testing temperature is a dynamic test is at $-10^{o}C$.

ii) The testing temperature in a dynamic test is at $10^{o}C$.

Calculate the shift factors in each case. Given C1 = 17.44 and C2 = 51.6K. [4]

b) Name a 'nonpolar oil' resistance rubber to be used in static applications. [1]

16. a) Your company makes oil seal out of NBR. Tg of polyacrylonitrile and polybutadiene are +95 and $-100^{o}C$ respective. If you intend to use it at $-20^{o}C$. What should be the ACN content in NBR? [3]

b) Polyethylene is a plastic and polypropylene is also a plastic. But why is EPDM a rubber? [2]

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