**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI**
**First Semester 2015-2016**
**CHE F313 Separation Processes – II**
**Mid-Semester Test**

**Date: 05.10.2015** **Maximum Marks: 90**

***Note*:** The question paper consists of two parts: Part A (Closed-Book) and Part B (Open Book). Part B question paper can be collected only after submission of Part A answer sheet.

## PART – A

**Time: 08.00 – 08.45 A.M.** **(Closed-Book)** **Marks: 45**

**1.** Fresh air at 21.2$^{o}$C in which partial pressure of water vapor is 9 mm Hg is blown through a pre-heater. Determine humidity, saturation humidity, percentage humidity, relative humidity, humid volume, humid heat and wet-bulb temperature. Given: total pressure =76 cm Hg, Vapor pressure of water at 21.2$^{o}$C = 21 mm Hg. Latent heat of vaporization of water at the adiabatic saturation temperature = 625.47 kJ/kg water, Specific heat of air = 1.005 kJ/kg.$^{o}$C and Specific heat of water = 1.88 kJ/kg.$^{o}$C. [15]

**2.** Answer the following questions briefly. [2x5=10]

a) Define dew point.
b) Explain why wet-bulb temperature is equal to the adiabatic saturation temperature for air-water system.
c) Differentiate between breakthrough time and equilibrium time.
d) What is ion exchange? Classify the synthetic ion-exchange resins.
e) Explain the mechanism of transport of gas through dense polymeric membrane.

**3.** Obtain an expression for total time taken for drying assuming a straight line fall till equilibrium moisture content. [10]

**4.** (a) In a chromatographic analysis peak time and peak width for a particular component is 8 and 2 minutes, respectively. What is the length of column required, if HETP = 0.1 cm?

(b) Calculate the flux at steady state in g/h.m$^2$ from blood in a cellophane membrane dialyzer at 37$^{o}$C. The membrane is 0.025 mm thick and has an area of 2 m$^2$. The mass transfer coefficient on the blood side is estimated as 1.25 x 10$^{-5}$ m/s and that on the aqueous side is 3.33 x 10$^{-5}$ m/s. The effective diffusivity is 2.18 x 10$^{-10}$ m$^2$/s. The concentration of urea in the blood is 0.02 g urea per 100 mL and that in the dialyzing fluid will be assumed as zero. [5+5 = 10]

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**Time: 8.45 – 9.30 A.M.** **PART – B** **Marks: 45**

**(OPEN BOOK)**

***Note:*** 1.Answer in separate answer book.
2. Only Text Book and Hand-written Class-Notes are allowed.
3. Photocopy (Xerox) of Class-Notes is not allowed.

**1.** Wet salt is to be dried from 6 to 0.1% moisture (dry basis) in a counter-current adiabatic rotary dryer at a rate of 20,000 kg/h of wet solids. The heating air enters at $147^oC$ with a humidity of 0.05 and a wet-bulb temperature of $50^oC$. The salt having specific heat of 0.88 kJ/kg.$^oC$ enters the dryer at $25^oC$ and leaves at $93^oC$. The mass velocity of air is 5000 kg/$m^2$.h and it leaves the dryer at $72^oC$. Calculate the length and diameter of the dryer required. Given: $\lambda_w$ =2383 kJ/kg; Cpv = 1.88 kJ/kg.$^oC$ ; $Cp_L$ = 1 kJ/kg.$^oC$; $Cp_{Air}$ = 1.005 kJ/kg.$^oC$.

[25]

**2.** The equilibrium adsorption of benzene vapor from a mixture of benzene vapor and nitrogen on a certain activated charcoal at $33.3^oC$ is reported as follows:

| | | | | | | |
|---|---|---|---|---|---|---|
| X = kg benzene/ kg charcoal | ( S Phase) | 0 | 0.2262 | 0.2785 | 0.3136 | 0.3479 |
| Y = kg benzene/ kg nitrogen | (G Phase) | 0 | 0.0009 | 0.0037 | 0.0103 | 0.0289 |

A nitrogen-benzene vapor mixture containing 1.0% benzene by volume is to be passed counter-currently at the rate of 1.8767 g mol/s to a moving stream of activated charcoal so as to remove 90% of the benzene from the gas in a continuous process. The entering charcoal contains 2.9 g mole benzene vapor adsorbed per kg charcoal. The temperature and total pressure are to be maintained at $33.3^oC$ and 1 std. atm, respectively, throughout. Nitrogen is not adsorbed. If charcoal used (on solute-free basis) is 0.0132 kg/s, what will be the concentration of benzene adsorbed upon the charcoal leaving? To how many equilibrium stages will the process be equivalent? Molecular weight of benzene and nitrogen are 78 and 28, respectively.

[20]

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