Registration No : | | | | | | | | | | |

Total number of pages : 04 **B.Tech.**
PCE4I101

4th Semester Regular / Back Examination 2017-18
MASS TRANSFER - II
BRANCH : CHEM, PT
Time : 3 Hours
Max Marks : 100
Q.CODE : C666

Answer Part-A which is compulsory and any four from Part-B.
The figures in the right-hand margin indicate marks.
Assume suitable notations and any missing data wherever necessary.
Answer all parts of a question at a place.

Part – A (Answer all the questions)

Q1. Answer the following questions : **(2 x 10)**

(a) Consider distribution of the solute C in two partially miscible solvents A (carrier) and B (solvent). What is the selectivity of separation at the plaitpoint ?
- i. 0
- ii. 1
- iii. ∞
- iv. None of these

(b) If the interfacial tension of a carrier-solvent pair is very small, which of the following problems may appear ?
- i. Dispersion of the solvent in the carrier becomes more power-consuming
- ii. Phase separation of the liquid-liquid dispersion becomes difficult
- iii. Interfacial mass transfer resistance becomes large
- iv. Heat transfer is difficult

(c) In which of the following equipment does extraction occur by the percolation process ?
- i. Bollman extractor
- ii. Moving belt extractor
- iii. Pachuka tank
- iv. Hildebrand extractor

(d) If the solute concentrations (on solid-free basis) in the overflow and the underflow are equal, the tie lines are
- i. Horizontal
- ii. Vertical
- iii. Of varying slope
- iv. Don't exist

(e) Extraction of sugar from sugar beet is achieved using water at _____ $^{\circ}$C.
- i. 60 – 65
- ii. 70 – 75
- iii. 80 – 85
- iv. 90 – 95

(f) The solid hold-up in a rotary dryer is in the range of
- i. 05 – 15 %
- ii. 25 – 35 %
- iii. 50 – 70 %
- iv. None of these

(g) Which of the following dryers may be suitable for drying a heat-sensitive material at a rate of 100 kg/h ?

i. Vacuum tray dryer
ii. Cocurrent rotary dryer
iii. Fluidized bed dryer
iv. Drum dryer

(h) The amount of free moisture in a solid

i. Must be greater than the unbound moisture
ii. Less than the critical moisture
iii. May be more than the bound moisture
iv. None of these

(i) Entropy change for adsorption is

i. 0
ii. –ve
iii. +ve
iv. None of these

(j) An adsorption process is

i. Exothermic
ii. Endothermic
iii. Reversible
iv. Either i. or ii.

Q2. Answer the following questions : (2 x 10)

(a) Give a few examples of applications of solvent extraction for wastewater treatment.

(b) Can two tie lines intersect within the two-phase region of an LLE diagram ? Justify your answer.

(c) What are the advantages and problems of carrying out extraction of a solid at an elevated temperature ?

(d) Mention the factors influencing the fraction of liquid retained in the underflow in leaching operation.

(e) What kind of diffusional phenomenon occurs within broken seeds during oil extraction ?

(f) Draw the typical gas and solid temperature profiles for drying of a non-hygroscopic solid in a cocurrent rotary dryer.

(g) Can the moisture content of a solid on dry basis be above 100% ? Justify of answer.

(h) What kind of flow strategy is preferred for drying a heat-sensitive substance in a continuous dryer ?

(i) Why adsorbents of a small particle size are preferred for liquid separation compared to gas separation ?

(j) What is the size range of meso-pores ?

Part – B (Answer any four questions)

Q3. (a) With suitable plots explain the equilateral triangular diagram for presenting the liquid-liquid equilibrium data. **(6)**

(b) Graphically explain the effect of temperature on liquid-liquid equillibria. **(4)**

(c) Critically discuss the important criteria for solvent selection for liquid-liquid equillibria. **(5)**

Q4. **(a)** 1000 kg of an aqueous solution containing 30 mass % trimethyl amine (C) and 70 % water (A) is to be extracted using benzene (B) as the solvent. A 3-stage crosscurrent extractor is used. The amounts of solvent (95 % B and 5 % C) to be used in successive stages are 800, 1000, and 2700 kg. Determine the fraction of the solute removed if the stages are ideal. The compositions of the raffinate and the extract (two phases) as well as the tie line data are givenbelow. **(12)**

A rich phase	x_B	0.004	0.006	0.01	0.02	0.03	0.05	0.07	0.13
	x_C	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40
B rich phase	y_B	0.95	0.90	0.84	0.78	0.71	0.63	0.50	0.26
	y_C	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40
Tie line data	x_C	0.04	0.06	0.13	0.225	0.39			
	y_C	0.04	0.07	0.09	0.15	0.31			

(b) Mention the important factors that govern the selection of a liquid-liquid extractor. **(3)**

Q5. **(a)** Discuss the important factors affecting the rate of leaching of a solute from a solid substance. **(5)**

(b) Oil seeds containing 25 mass % oil, is to be extracted with hexane to reduce the oil content to 0.8 % in the underflow. 1 kg of the solvent is used per kg of the feed. Using the extraction equilibrium data given below, determine the number of stages required. **(10)**

Overflow (100 kg), solution			Underflow (100 kg), slurry		
W_A (kg)	W_B (kg)	W_C (kg)	W'_A (kg)	W'_B (kg)	W'_C (kg)
0.3	99.7	0.0	67.2	32.8	0.0
0.45	90.6	8.95	67.1	29.94	2.96
0.54	84.54	14.92	66.93	28.11	4.96
0.70	74.47	24.83	66.58	25.06	8.36
0.77	69.46	29.77	66.26	23.62	10.12
0.91	60.44	38.65	65.75	20.90	13.35
0.99	54.45	44.56	65.33	19.07	15.60
1.19	44.46	54.35	64.39	16.02	19.59
1.28	38.50	60.22	63.77	14.13	22.10
1.38	34.55	64.17	63.23	12.87	23.90
1.48	24.63	73.89	61.54	9.61	28.85

Q6. **(a)** Graphically explain different types of moisture in a wet solid. **(5)**

(b) Derive the equation for total drying time. **(10)**

Q7. **(a)** A wet solid of 30 % moisture is to be dried to 1.0 % moisture in a dryer. A laboratory test shows that it requires 8 hours to reduce the moisture content of the same solid to 2.0 %. The critical moisture content is 7 % and the equilibrium moisture is 0.3 %. The falling rate of drying is linear in the free moisture content. Calculate the drying time of the solid if the drying conditions similar to those in the laboratory test are maintained. All moistures are expressed as % of bone dry-mass of solid. **(10)**

(b) Discuss the basis of classification of industrial dryers. **(5)**

Q8. **(a)** Discuss the construction and operation of a spray dryer with a neat diagram. **(7)**

(b) A sample of wet solid is taken on a tray (1 x 0.6 m^2) and dried in a stream of hot air (120^0C, 0.02 kg water/kg dry air, 4.5 m/s). The initial moisture content of 28 % (dry basis) is to be reduced to 0.5 %. It is known that the critical moisture content is 12 % and the equilibrium moisture is negligible. The falling rate of drying is linear in the moisture content. If the solid loading (dry basis) is 35 kg/m^2, calculate the drying time. Assume that the air flow is large and its temperature drop across the tray is low. **(8)**

Q9. **(a)** Discuss the selection criteria of a good adsorbent. **(5)**

(b) The adsorption equilibrium data for the decolourization of an oil with a clay is given by: $Y = 4.5 \times 10^{-4} X^*$, where Y = number of colour units/kg oil and X^* = number of colour units/kg clay in equilibrium. 1000 kg of oil having an initial colour concentration of 50 units has to be treated to reduce the concentration to 1 colour unit. The adsorbent has an effective specific surface area of 30 m^2/kg and the surface mass transfer coefficient is $k_L = 5.0 \times 10^{-6}$ m/s (on the solid phase concentration basis). The density of oil is 900 kg/m^3. Calculate the minimum quantity of adsorbent required. Also calculate the required contact time if 1.1 times the minimum amount of adsorbent is used. **(10)**