MASS TRANSFER II
(CHEN 3202)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Lewis number is the ratio of
(a) Schmidt number and Reynolds number
(b) Prandtl number and Reynolds number
(c) Schmidt number and Prandtl number
(d) Prandtl number and Schmidt number

(ii) Temperature achieved by constant pressure cooling of air water vapour mixture is known as
(a) Adiabatic saturation temperature (b) Dew point temperature
(c) Dry bulb temperature (d) Wet bulb temperature

(iii) In cooling tower design, tie lines drawn from operating line to equilibrium curve for obtaining interfacial temperature and enthalpy have slope
(a) –h*a/k*a where h*a is the liquid phase heat transfer coefficient and k*a is the gas phase mass transfer coefficient
(b) –k*a/h*a where h*a is the liquid phase heat transfer coefficient and k*a is the gas phase mass transfer coefficient
(c) –h*a/k*a where h*a and k*a are the liquid phase heat transfer and mass transfer coefficients
(d) –k*a/h*a where h*a and k*a are the gas phase heat transfer and mass transfer coefficients

(iv) Which of the following interfacial tension value (N/m) is the most preferred for solvent to be used in liquid-liquid extraction?
(a) 0.003 (b) 0.01 (c) 0.05 (d) 0. 03

(v) While finding out the minimum solvent rate for a countercurrent extraction cascade, it was found that the line BR_Nanf the tie line through the feed point F were parallel (that is the point Δ_m lies at infinity). If it is so , which of the following relations is correct?
(a) $B_m = R_N$ (b) $F = E_1$ (c) $B_m = E_1$ (d) none of the above

(vi) Which of the following statements is correct for a supercritical extraction system?
(a) Theviscosity of a SCF is near to that of a gas than to a liquid
(b) A supercritical fluid has large surface tension.
(c) Propane has lower critical constant than ethylene.
(d) None of the above

(vii) Which of the following determine the maximum air velocity in a rotary drier for the drying of relatively fine particles?
(a) The blower horsepower (b) The diameter of the tower
(c) Dusting of the solid (d) None of the above

(viii) Constant drying conditions include
(a) Temperature constant (b) Humidity constant
(c) Velocity constant (d) All of the mentioned

(ix) An ultrafiltration membrane has a pore size range of
(a) 1-100 Aº (b) 1-100 μm
(c) 1-100 nm (d) 1-100 mm

(x) The driving force for dialysis is
(a) Temperature difference (b) Pressure difference
(c) Concentration difference (d) Electrical potential difference

Group – B

2. (a) Define the following: i. Absolute humidity
ii. Percentage humidity
iii. Humid heat
iv. Dew point temperature
v. Adiabatic saturation temperature

(b) Derive the equation of wet bulb temperature line. Obtain the condition when the adiabatic saturation line and wet bulb temperature linecoincide. Classify cooling towers.

5 + (3 + 2 + 2) = 12

3. (a) A cooling tower receives warm water at 45ºC at a mass flowrate of 7000 kg/m^2.h. A cooling range of 12ºC is to be achieved by countercurrent contact with air. The air enters at 4200 kg/m^2.h at a dry bulb temperature 32ºC and a humidity 0.015 kg/kg dry air. The overall volumetric mass transfer coefficient is K_Y'a=2500 kg/(m3)(h)ΔY'. Determine
(i) the number of overall gas phase transfer units and the height of packing.
(ii) The approach

Given: Antoinne equation for water i $\ln P_A^v\,(\text{bar}) = 11.96481 - 3984.923/(T - 39.724)$.
Here T is in K and total pressure =1 atm (mm graph required)(Humidity chart attached).

(b) In a cooling tower, if the entering and exit temperatures of the liquid are equal to the adiabatic saturation temperature of the entering gas, outline the method that is used to determine the height ofpacking in a cooling tower.

(8 + 1) + 3 = 12

Group – C

4. (a) One thousand kilograms of an aqueous solution containing 35mass % trimethyl amine (C) and 65 mass % water (A) is to be extracted using benzene (B) as the solvent. A three stage crosscurrent extraction scheme is suggested. The amounts of solvent benzene to be used in successive stages are 815 kg, 950 kg and 2526 kg. Determine the fraction of solute (C) removed if the stages are ideal. The compositions of the extract and the raffinate as well as the tie line date are given below.

Water rich phase	x_B x_C	0.004 0.05	0.006 0.10	0.010 0.15	0.020 0.20	0.030 0.35	0.036 0.30	0.07 0.35	0.130 0.40
Benzene rich phase	y_B y_C	0.95 0.06	0.90 0.10	0.84 0.15	0.78 0.20	0.71 0.25	0.63 0.30	0.50 0.35	0.26 0.40
Tie line data	x_C y_C	0.040 0.035	0.083 0.068	0.130 0.090	0.215 0.145	0.395 0.31			

(b) If 1000 kg/h of a nicotine (C)-water (A) solution containing 1 % nicotine is to be counter=currently extracted with kerosene (B) at 20^0C to reduce the nicotine content to 0,1 %, determine (a) the minimum kerosene rate and (b) the number of theoretical stages required if 1150 kg of kerosene is used per hour.
Equilibrium data:

$x' = \frac{kgC}{kgA}$	0	0.001011	0.00246	0.00502	0.00751	0.00998	0.0204
$y' = \frac{kgC}{kgB}$	0	0.000807	0.001961	0.00456	0.00686	0.00913	0.01870

5 + 2 + 5 = 12

5. (i) Discuss the different points to be considered for selection of solvent for liquid - liquid extraction.

(ii) Discuss briefly the Shanks system of leaching.

(iii) Discuss in details the extraction method using supercritical fluid.

(4 + 4 + 4) = 12

Group – D

6. (a) Define:
(i) Bound moisture
(ii) Equilibrium moisture
(iii) Free moisture
(iv) Critical moisture

(b) A batch of wet solid is to be dried from a free moisture content (X_1) of 0.38 kg water /kg dry solid to the final moisture content (X_2) 0.04 kg water /kg dry solid. If the drying area (A) equals to 18.58 m^2, calculate the time of drying.
Data; The critical moisture content = 0.195 kg water /kg dry solid
The weight of dry solid = 399 kg
The drying at constant rate period = 1.51 kg water/m^2 h
The drying rate in the falling rate period is as follows:

X, kg water/kg dry solid	0.195	0.150	0.100	0.065	0.050	0.040
Drying rate, kg water/m^2 h	1.51	1.21	0.90	0.71	0.37	0.27

4 + 8 = 12

7. (a) Describe briefly the construction and working principle of (i) circulating magma vacuum crystallizer and (ii) circulating liquid evaporator crystallizer.

(b) A hot solution containing 2000 kg of $MgSO_4$ and water at 330 K and with a concentration of 30 wt % of $MgSO_4$is cooled to 293 K and $MgSO_4$, $7H_2O$ crystal s are removed. The solubility at 293 K is 35.5 kg $MgSO_4$/100 kg total water. Calculate the yield of the crystal'
Data: Molecular weight of $MgSO_4$= 120.35.

(4 + 4) + 4 = 12

Group – E

8. (a) Explain what is meant by osmotic pressure. What is the significance of molecular weight cut off of a membrane? Classify the membrane separation processes based on driving forces.

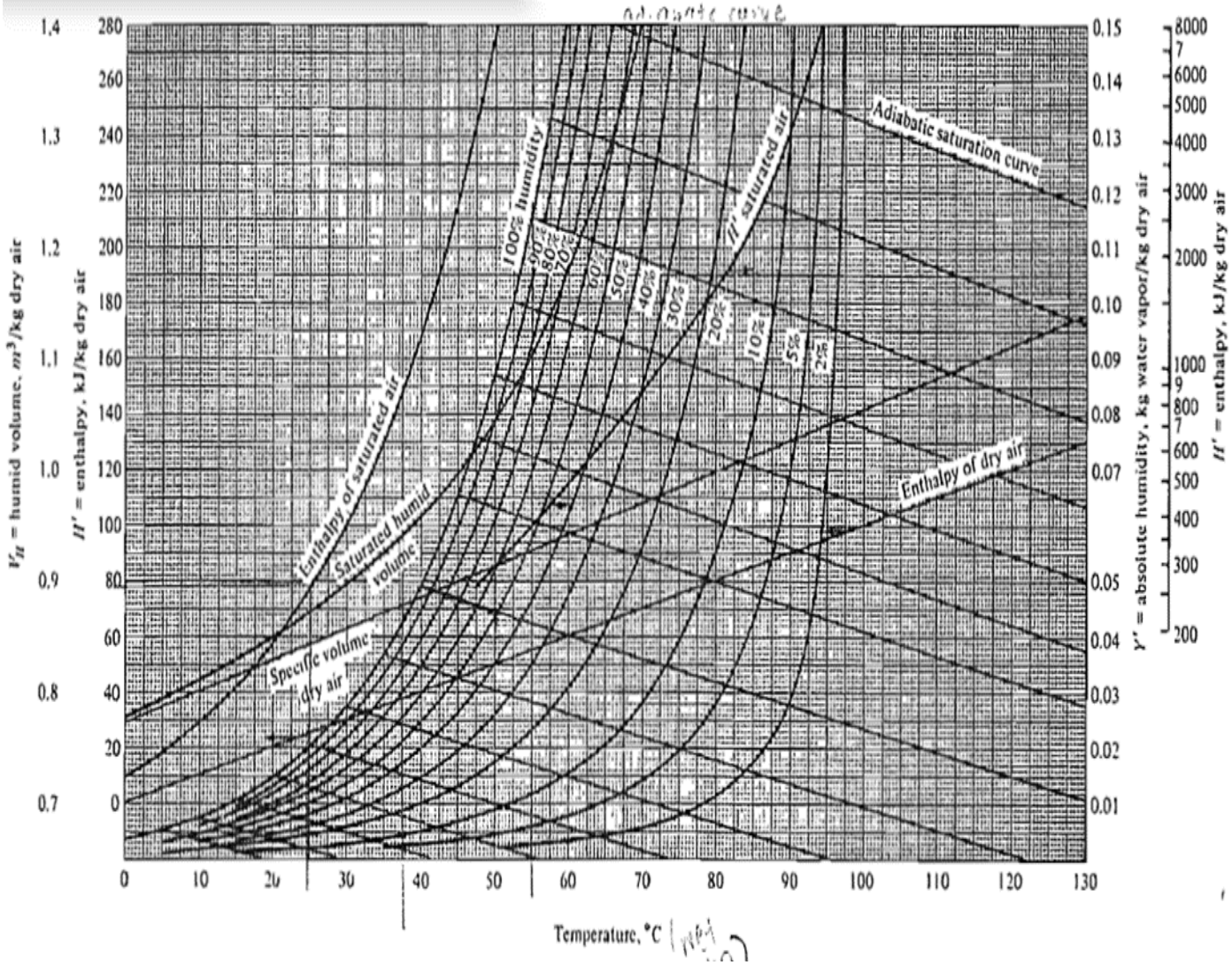
(b) Discuss with the aid of diagrams the different types of membrane modules.

(2 + 2 + 2) + 6 = 12

9. (a) Contrast concentration polarization without gel formation with concentration polarization with gel formation in ultrafiltration. A feed with glucoamylase enzyme is purified in a cross-flow ultrafiltration module. The liquid phase mass transfer coefficient at the membrane surface is estimated as 2.5×10^{-5} m/s. The bulk concentration of solute is 0.35 mass%. If the solvent water flux across the membrane is 0.38 $m^3/m^2.h$, calculate the polarization modulus and concentration of enzyme at the membrane surface. Solute rejection by the membrane is 95%. If the diffusivity of enzyme is 6.7×10^{-7} cm^2/s, calculate the film thickness.

(b) State the important applications of reverse osmosis. Explain the solution diffusion model and derive the expressions for solvent flux and water flux obtained from a reverse osmosis membrane.

(3 + 4) + (2 + 3) = 12



Humidity chart

Department & Section	Submission Link
CHE	https://classroom.google.com/c/Mjg3NDMzNTk5NzYz/a/MzY0Mjg5NjA5MjIw/details