Extra

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Spring Semester Examination, 2013-2014

Subject : Mass Transfer – II *Subject No.*: CH31010

Date: 18.02.2014 (AN) *Time*: 2 Hrs *Full Marks*: 30

Instructions: Answer **all Questions**. Assume any missing data suitably.

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1. Derive the equation of the wet-bulb lines of the psychrometric chart. Discuss the procedure for humidity measurement with the help of a wet-bulb thermometer.

[3]

2. Ethyl alcohol is removed from a crystallized pharmaceutical material by evaporation into a nitrogen stream. At 30°C and 1 std. atm, the resulting nitrogen-alcohol vapour mixture has a relative humidity of 70%. It is required to remove 95% of the alcohol present by cooling to 10°C and compressing to a suitable pressure. What should this pressure be? Given the vapour pressure of ethyl alcohol at 30°C as 78 mm Hg and at 10°C as 23 mm Hg.

[4]

3. (a) What is "approach" of a cooling tower? What do you mean by "5% wet-bulb temperature"?
(b) A once-through cooling tower operation is done by supplying air by a blower having a capacity of 254880 m^3/h. The air enters the tower at a dry-bulb temperature of 24°C and humidity of 0.007 kg water/kg dry air. It leaves the tower at a dry-bulb temperature of 32.5°C with 0.0255 kg water/kg dry air. The hot process water enters the tower 54.5°C. The return water to the process operation must be at a temperature of 32.5°C. How much water can be cooled by this operation?

DATA: Heat capacity of air = 0.24 kcal/(kg)(°C)
Heat capacity of water vapour = 0.45 kcal/(kg)(°C)
Latent heat of vaporization of water at 0°C = 597 kcal/kg.

[2+6]

OR

A cooling tower operates in counter-current mode with entering air of humidity 0.013 kg/kg dry air at a dry bulb temperature of 27°C. Hot process water enters the tower at 48°C and cold water leaves at 27°C. The cross sectional area of the tower is 63.6 m^2. Determine the height of the tower required to meet the process requirements. Air is supplied to the tower by a blower having a capacity of 4.2×10^5 m^3/h and the water loading is 7244 kg/m^2 h.

DATA: Heat capacity of air = 0.24 kcal/(kg)(°C)
Heat capacity of water vapour = 0.45 kcal/(kg)(°C)
Latent heat of vaporization of water at 0°C = 597 kcal/kg
$K_Y a$ = 2.28 kg/m^3 s ($\Delta Y'$)

[8]

P.T.O.

4. 1000 kg/h of a 45wt% acetone-in-water solution is to be extracted at 25°C in a continuous, countercurrent system with pure 1,1,2-trichloroethane to obtain a raffinate containing 10wt% acetone. Using the following equilibrium data, determine: (a) the minimum flow rate of the solvent; (b) the number of theoretical stages required for a solvent rate equal to 1.5 times the minimum.

[6]

Wt. fraction	Extract						Raffinate					
Acetone	0.6	0.5	0.4	0.3	0.2	0.1	0.55	0.5	0.4	0.3	0.2	0.1
Water	0.13	0.04	0.03	0.02	0.015	0.01	0.35	0.43	0.57	0.68	0.79	0.895
$C_2H_3Cl_3$	0.27	0.46	0.57	0.68	0.785	0.89	0.1	0.07	0.03	0.02	0.01	0.005

5. Liquids A and C (1000 lb), which have nearly identical boiling points, are to be separated by liquid–liquid extraction with solvent B. The following data represent the phase equilibrium. Determine the number of theoretical stages on both sides of the feed to produce an extract containing 83% C and 17% A (compositions are on a solvent-free basis) and a raffinate of 10% C and 90% A with a reflux rate of 1,644lb/h. The feed contains 35% C and 65% A.

[7]

Wt %	**Extract**									
C	0.0	1.0	1.8	3.7	6.2	9.2	13.0	18.3	24.5	31.2
A	7.0	6.1	5.5	4.4	3.3	2.4	1.8	1.8	3.0	5.6
B	93.0	92.9	92.7	91.9	90.5	88.4	85.2	79.9	72.5	63.2
Wt %	**Raffinate**									
C	0.0	9.0	14.9	25.3	35.0	42.0	48.1	52.0	47.1	PLAIT POINT
A	92.0	81.7	75.0	63.0	51.5	41.0	29.3	20.0	12.9	
B	8.0	9.3	10.1	11.7	13.5	17.0	22.6	28.0	40.0	

6. Answer the following questions: [2]

(a) Briefly explain: Selectivity and Distribution coefficient.
(b) What is a conjugate curve and how is it obtained on an equilateral triangle?

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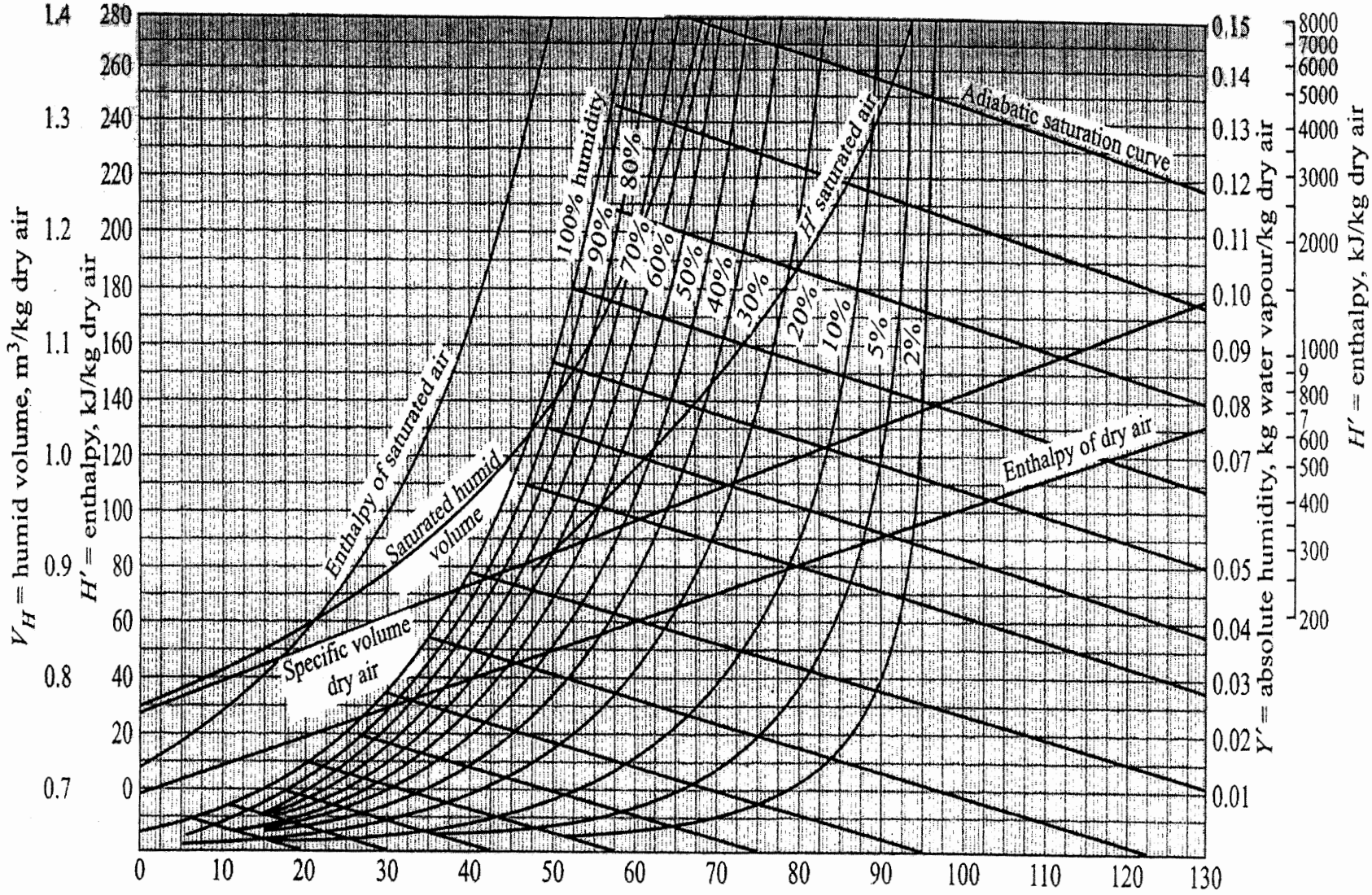

Psychrometric chart for the air–water system at 1 atm total pressure