INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Spring Semester Examination, 2012-2013

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

Date: **19.02.2013 (AN)** *Time*: **2 Hrs** *Full Marks*: **30**

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

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1. Answer the following questions: **[5]**

(a) Air saturated with water vapour at 25°C is heated to 40°C at constant pressure. How does its humidity, dew point and humid heat change as a result?

(b) For air-water system, the wet-bulb and adiabatic saturation temperatures are nearly equal – Why?

(c) Enthalpy of a moist gas is a function of its adiabatic saturation temperature – Explain.

(d) How is it possible to cool water in a cooling tower to a temperature below the dry-bulb temperature of the incoming air used for cooling the water?

(e) How does the height of a packed cooling tower vary with approach?

2. An air (B) - water vapour (A) mixture has a dry-bulb temperature of 52.5°C and an absolute humidity of 0.040 kg water vapour/kg dry air at 1 std atm pressure. The vapour pressure of water under these conditions is 92 mm Hg. Calculate the percentage relative humidity and humid volume of the mixture. If 100 m^3 of the above moist air is heated to 120°C, how much heat is required?

DATA: Specific heat of air = 1.005 kJ/(kg)(°C)

Specific heat of water vapour = 1.884 kJ/(kg)(°C)

[4]

3. A cooling tower operation is designed without any recycle stream. Approximately 320,000 kg/h of hot process water at 60°C is to be cooled and returned to the process operation. Moist air is used as the cooling medium and is fed at the rate of 1.56×10^5 kg/h. The dry- and wet-bulb temperatures of the incoming air are 26.6°C and 15.5°C, respectively. The air leaves the tower with an estimated wet-bulb temperature of 35°C and a dry-bulb temperature of 38°C. Estimate the temperature of the water returned to the process operation.

DATA: Heat capacity of air = 1.005 kJ/(kg)(°C)

Heat capacity of water vapour = 1.884 kJ/(kg)(°C)

Latent heat of vaporization of water at 0°C = 2495 kJ/kg

OR

It is planned to cool warm water at 43°C in a packed water cooling tower using air at a dry-bulb temperature of 31°C and a humidity of 0.01516 kg/kg dry air. A cooling range of 13°C is to be achieved by the counter-current contact with air. The water flow rate is 7000 kg/m^2 h and the air flow rate is 4200 kg/m^2 h. Calculate the height of the tower needed for the water cooling operation. The overall volumetric mass transfer coefficient ($K_Y a$) is given as 2500 kg/m^3 h ($\Delta Y'$)

[6]

P.T.O.

4. Answer the following questions: [3]
(a) What is the controlling factor for the rate of extraction if the solids to be leached should be of small size?
(b) What is meant by constant underflow condition for leaching?
(c) What is meant by practical equilibrium condition in a solid-liquid extraction?

5. A quantity of 100 kg/h of 50-50 acetone-water solution is to be reduced to 10% acetone using 30 kg/h of 1, 1, 2-trichloroethylene in a multi stage counter current extraction operation. If the rate at which the mixture forms is 26 times the rate at which the final raffinate exits the battery, estimate the amount of the final extract and its solute concentration. [2]

6. A solute is recovered from an aqueous solution containing 20% of the solute by weight using kerosene as the solvent. The distribution of the solute in the two immiscible phases (water and kerosene) may be described by **x' = 6.45 y'** where, x' is the kg of solute per kg of water and y' is the kg of solute per kg of kerosene. Calculate the solute concentration in the final raffinate if the extraction is done in 3 simple equilibrium stages using 5 kg of solvent per kg of initial solution in each stage.

OR

1950 kg/m^2 h of pure isopropyl ether is used to extract 975 kg/m^2 h of dilute aqueous solution containing 4% acetic acid by weight. The two immiscible phases are passed counter-currently through a packed column. If the ether phase leaves the column with a concentration of 1% acid by weight, estimate the acid concentration in the raffinate.

[5]

7. 1,000 kg/h of a mixture of 0.80 mass fraction docosane and 0.20 mass fraction diphenyl hexane (DPH) is extracted with pure furfural to remove some diphenyl hexane from the feed. Determine (a) the compositions and flow rates of extract and raffinate streams from a single equilibrium stage for solvent rate of 1000 kg/h. Assume that the slope of the tie-line is 0. (b) Minimum and maximum solvent flow rates required to form two liquid phases.

The equilibrium data for this system is given below: [5]

Docosane (wt%)	96.0	84.0	67.0	52.5	32.6	21.3	13.2	7.7	4.4	2.6	1.5	1.0	0.7
DPH (wt%)	0.0	11.0	26.0	37.5	47.4	48.7	46.8	42.3	35.6	27.4	18.5	9.0	0.0
Furfural (wt%)	4.0	5.0	7.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	99.3

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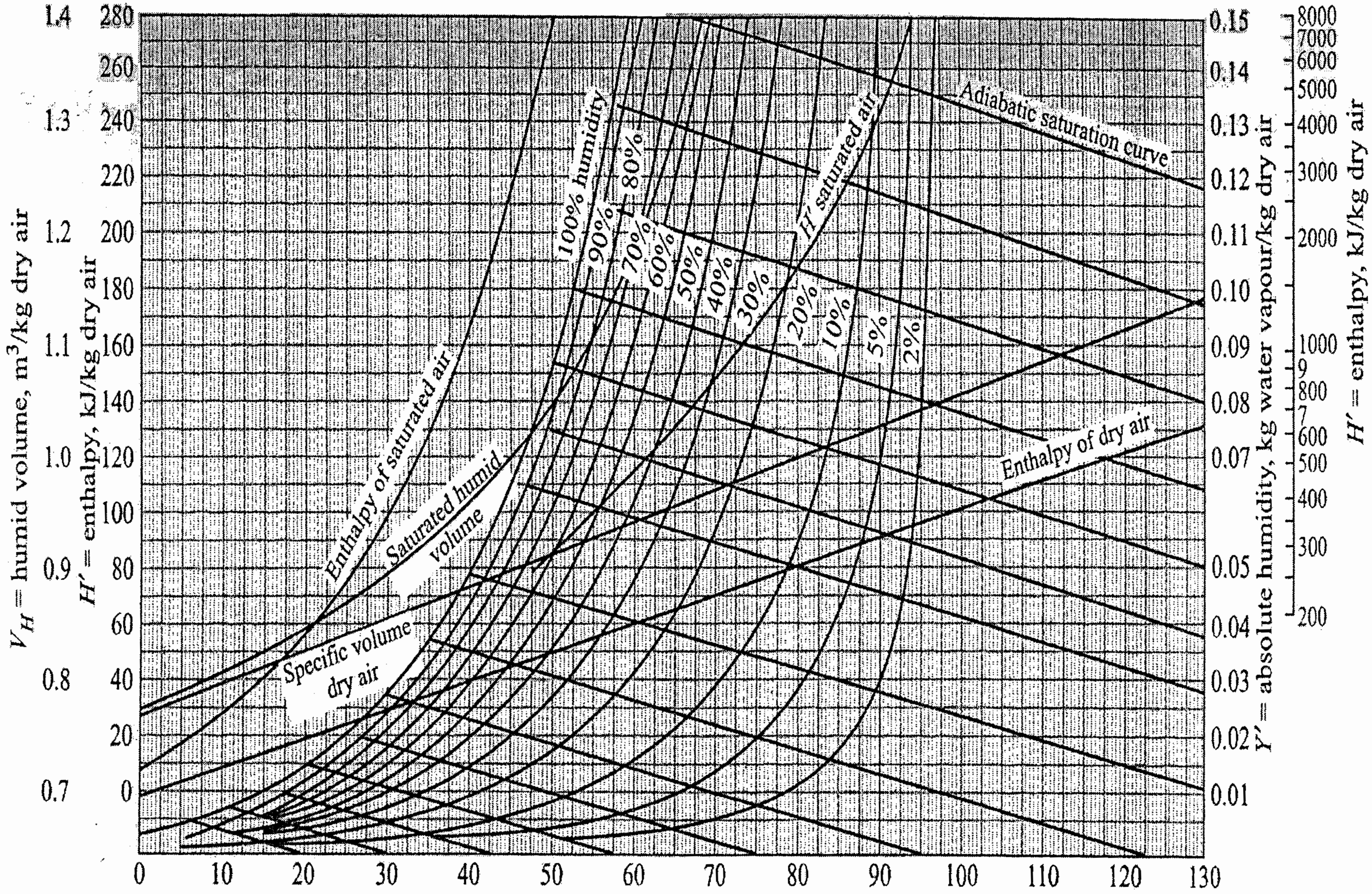

Psychrometric chart for the air–water system at 1 atm total pressure