BOM

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Spring Semester Examination, 2015-2016

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

Date: 18.02.2016 (AN) *Time*: 2 Hrs *Full Marks*: 30

Instructions: Use **separate** ANSWER BOOK for *PART* - A and *PART* - *B*.

Answer **all Questions**. Assume any missing data with proper justification.

PART – A

1. (a) Distinguish between dew point and wet-bulb temperature. When are they same?

(b) Prove that the enthalpy of a moist gas is equal to the enthalpy of the saturated gas at the adiabatic saturation temperature.

(c) At 30°C and 80% relative humidity, the water evaporates from the surface of a lake at the rate of 2.0 kg/m^2 h. What will be the relative humidity for an evaporation rate of 4.0 kg/m^2 h, with other conditions remaining the same?

[2+2+2]

2. (a) What is a spray chamber?

(b) A process requires 6650 kg air/h at 20% humidity and 55°C. This air is to be obtained by conditioning air at 20% humidity and 20°C by first heating, then humidifying adiabatically to the desired humidity and finally reheating the humidified air to 55°C. The humidification step is to be conducted in a spray chamber. Assuming that the air leaving the spray chamber is 90% saturated, (i) to what temperature the air be preheated? (ii) At what temperature it will leave the spray chamber? (iii) How much heat will be required for preheat and reheat? (iv) What should be the volume of the spray chamber?

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

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

Volumetric heat transfer coefficient ($h_G a$) = 5670 kJ/(m^3)(h)(°C).

OR

(b) It is planned to cool warm water at 45°C in a packed cooling tower using air at a dry-bulb temperature of 32°C and a humidity of 0.015 kg/kg dry air. A cooling range of 15°C is to be achieved by the counter-current contact with the air. The water flow rate is 7500 kg/m^2 h and the air flow rate is 5684 kg/m^2 h. Calculate the height of the tower required for the water cooling operation. The overall volumetric mass transfer coefficient ($K_Y a$) is given as 2642 kg/m^3 h (ΔY). Latent heat of vaporization of water at 0°C is 2500 kJ/kg.

Equilibrium Data:

Temperature (°C)	20	25	30	35	40	45	50
Enthalpy (kJ/kg)	58	76	100	130	167	213	275

[1+8]

P.T.O.

PART – B

1. It is required to extract picric acid from 10 kg of dilute aqueous solution containing 1 kg picric acid using benzene as solvent with a recovery of 80% of the picric acid originally present. Determine the quantity of benzene required per kg of aqueous solution by employing a single-stage extraction process. If the same amount of solvent is split into 2 and used in 2 cross-current stages, what will be the percentage recovery of picric acid?

   The equilibrium data is given below. **Note**: benzene is insoluble in the aqueous phase.

   [7.5]

Wt. of picric acid in 1 kg benzene	0	0.02	0.03	0.04	0.05	0.06	0.07
Wt. of picric acid in 1 kg aqueous phase	0	0.01	0.02	0.04	0.06	0.09	0.12

2. A feed entering the plant at the rate of 100 kg/h, containing 50% solute (C), is to be reduced to 10% C using 30 kg/h solvent in a multi-stage counter current extraction system operating at 25°C. Estimate the number of stages required. The equilibrium data for the system is given below. Assume that the solvent is pure.

   [7.5]

Wt. %	**Extract**						**Raffinate**					
B	91	78	61	55	40	27	0.5	0.7	1	1.1	2	7
C	9	21	37	42	54	60	6	14	26	30	41	52
A	0.3	1	2	3	6	13	94	85	73	69	57	42

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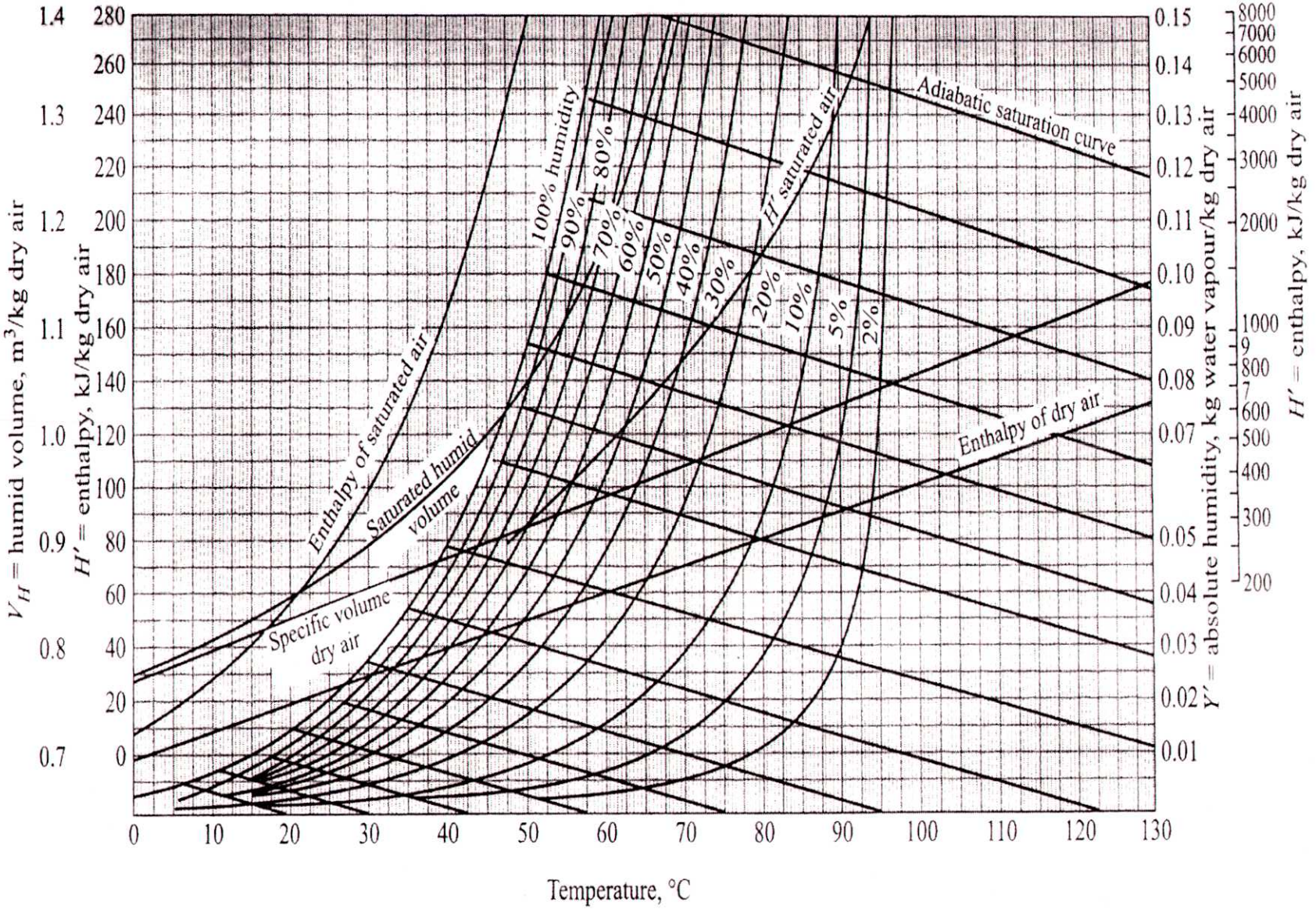

Psychrometric chart for the air–water system at 1 atm total pressure