AD

INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Mid-Spring Semester Examination, 2016-2017

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

Date: 15.02.2017 (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)** Air saturated with water vapor at 30°C is heated to 50°C at constant pressure. How do its humidity, dew point and humid heat change as a result?

   (b) What is Lewis relation? Why does the Lewis relation apply to air-water system?

   (c) In a plant for the recovery of acetone which has been used as a solvent, it is evaporated into a stream of nitrogen gas. A mixture of acetone vapor and nitrogen flows through a duct 0.4 m x 0.4 m cross-section. The pressure and temperature at one point in the duct are 850 mm Hg, 40°C and at this point, the average velocity is 3.5 m/s. A wet-bulb thermometer (wick wet with acetone) indicates a temperature at this point as 27°C. Calculate the kilograms of acetone carried by the duct per second.

   DATA: Latent heat of vaporization of acetone at 27°C = 546 J/gm;
   Saturation humidity at 27°C = 0.946 gm acetone/gm dry nitrogen;
   Psychrometric ratio = 2.0 J/(gm) (°C).

   [1+2+4]

2. **(a)** Explain the process of non-adiabatic evaporative cooling.

   (b) A once-through cooling tower is to cool hot process water at the rate of 4.0×10^5 kg/h by air coming from a blower at a rate of 3.5×10^5 kg/h. The air enters the tower at a dry-bulb temperature of 25°C and humidity of 0.005 kg water/kg dry air. It leaves the tower at a dry-bulb temperature of 40°C with 0.035 kg water/kg dry air. The hot process water enters the tower 45°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 vapor = 1.884 kJ/(kg)(°C)
   Latent heat of vaporization of water at 0°C = 2500 kJ/kg

   OR

   (b) A process requires 8256 kg air/h at 20% humidity and 60°C. This air is to be obtained by conditioning air at 20% humidity and 30°C by first heating, then humidifying adiabatically to the desired humidity and finally reheating the humidified air to 60°C. The humidification step is to be conducted in a spray chamber. Assuming that the air leaving the spray chamber is 80% saturated, to what temperature the air be preheated, at what temperature it will leave the spray chamber, how much heat will be required for preheat and reheat? What is the dew point of the final air? What is its relative humidity?

   [2+6]

P.T.O.

PART – B

1. **(a)** What are the criteria, based on which a solvent is selected for extraction?

   (b) A 100 kg solution of acetic acid and water containing 30% acid is to be extracted in three stages with pure isopropyl ether at 20°C and 1 atm. pressure, using 40 kg of solvent in each stage.
   (i) Determine the quantities and compositions of extract and raffinate phases for each stage.
   (ii) How much solvent would be required if the same final raffinate concentration is to be obtained with one stage?
   (iii) Determine the minimum amount of solvent required for original feed mixture.
   The equilibrium data at 20°C are given in the following Table.

Equilibrium data for Water-Acetic acid-Isopropyl ether at 20 °C and 1 atm					
Water Layer, wt %			**Isopropyl Ether, wt %**		
Acetic acid	**Water**	**Isopropyl Ether**	**Acetic Acid**	**Water**	**Isopropyl Ether**
0.69	98.1	1.2	0.18	0.5	99.3
1.41	97.1	1.5	0.37	0.7	98.9
2.89	95.5	1.6	0.79	0.8	98.4
6.42	91.7	1.9	1.93	1.0	97.1
13.30	84.4	2.3	4.82	1.9	93.3
25.50	71.1	3.4	11.40	3.9	84.7
36.70	58.9	4.4	21.60	6.9	71.5
44.30	45.1	10.6	31.10	10.8	58.1
46.40	37.1	16.5	36.20	15.1	48.7

[2 + 10]

2. **(a)** What are the types of adsorption and basic mechanism of adsorption behind it?

   (b) Explain the adsorption and desorption hysteresis with the help of a diagram.

[2 + 1]

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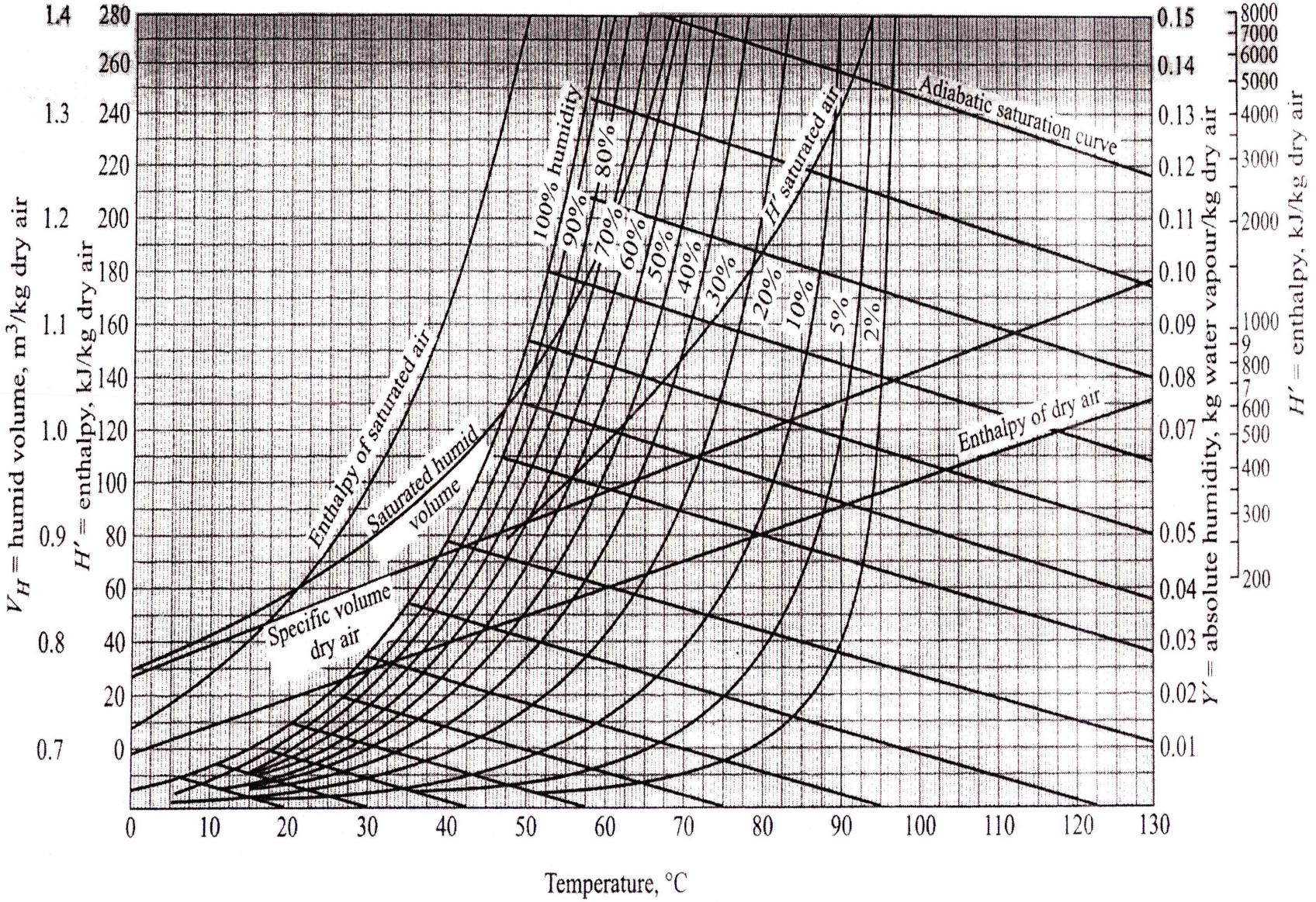
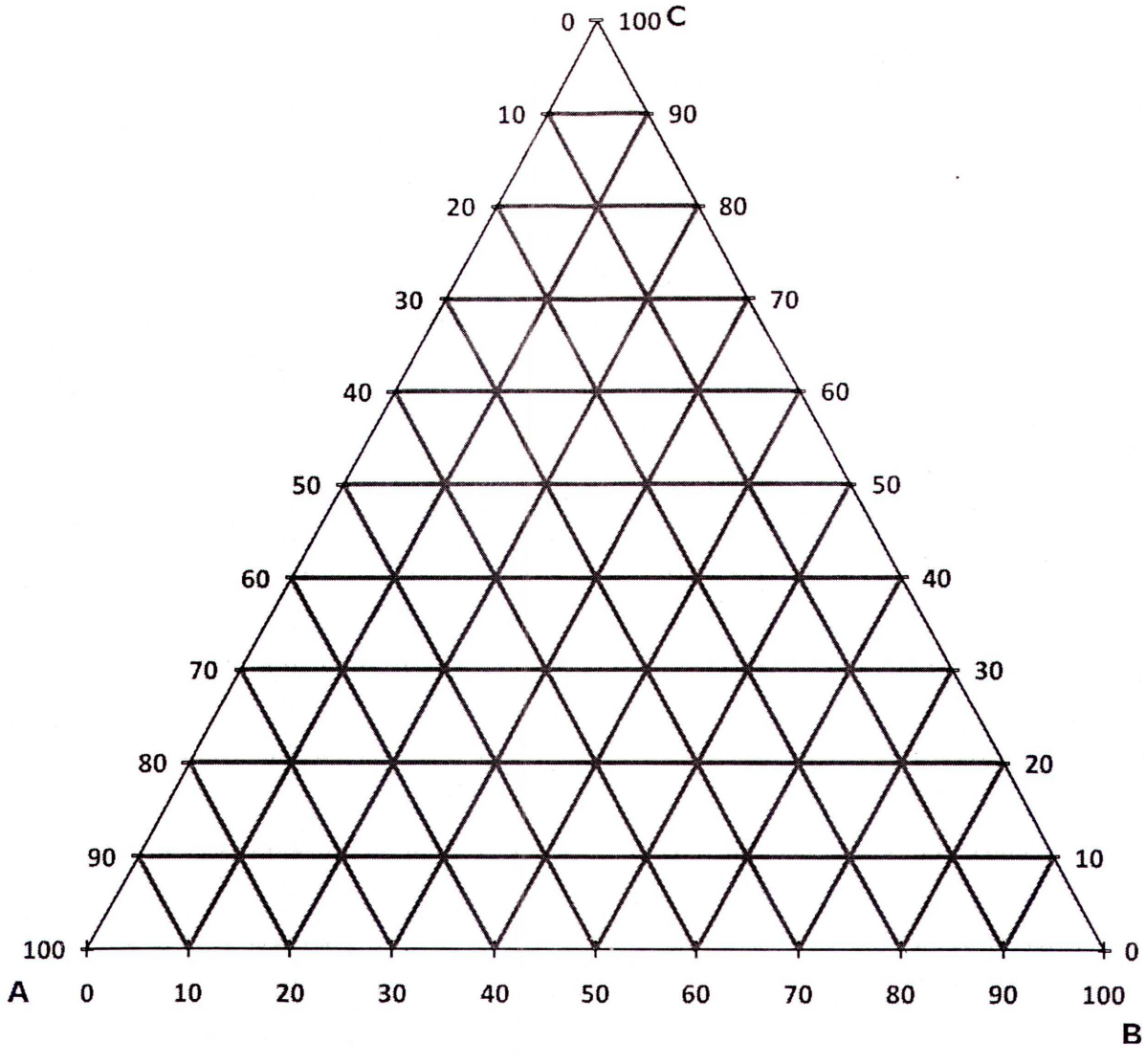


Psychrometric chart for the air–water system at 1 atm total pressure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