

JK LAKSHMIPAT UNIVERSITY, JAIPUR

INSTITUTE OF ENGINEERING AND TECHNOLOGY

End Term Examination (Regular/Backlog), November 2016

B. Tech in Chemical Engineering, Semester V

Roll No.....

CHE504: Separation Processes

Time: 3 hours

Max. Marks: 100

Instructions to students:

1. Do not write anything other than your roll number on question paper.
2. Assume suitable data wherever required and mention it clearly.
3. Writing appropriate units, nomenclature, and drawing neat sketches/schematics/ flow chart wherever, required are an integral part of the answer.

Q.1A Objective type multiple choice questions (10 questions @ 1 mark)

10

- i. In liquid-Liquid equilibrium studies, a system is called Type-II if
 - (a) The A-C pair is immiscible
 - (b) The B-C and A-B pairs are partially miscible
 - (c) The B-C pair is completely miscible
 - (d) None of these
- ii. Which type of tower is most favoured in the chemical process industries?
 - (a) induced draft tower
 - (b) hyperbolic tower
 - (c) spray tower without a fill
 - (d) none of these
- iii. If same experiment is performed in two-stage cross-current extraction and two-stage counter current extraction under same conditions, then in which operation the fraction of solute extracted is high?
 - (a) Two-stage cross current operation
 - (b) Two-stage counter current operation
 - (c) Same in both operation
- iv. Partial recirculation of warm and humid air leaving a tower is more likely to occur in
 - (i) natural draft tower
 - (ii) forced draft tower
 - (iii) induced draft tower
 - (iv) all of above
- v. In which of the following cases is the separation of the solute (C) from the carrier (A) using solvent (B) impossible?
 - (a) A, B, and C are completely miscible.
 - (b) A-C and B-C pairs are completely miscible.
 - (c) A-B is partially miscible
 - (d) None of these
- vi. Write an equation for the calculation of enthalpy of a stream of moist air at 1 atm pressure and of humidity H and temperature T_G °C.
- vii. Give few industrial examples of drying?

- viii. What is 'critical moisture content' in drying rate curve?
- ix. Name three adsorbent used in industries.
- x. What do you understand by 'Range' and 'Approach' in cooling tower?
- Q.2 Short answer type questions (4 questions @ 2.5 marks) 10
- What is the difference between the Type-I and Type-II ternary system?
 - Two mixtures R and E, which contain both the three components A, B and C, have to mix in the ratio 1:2. This ternary system has no miscibility gap so that all compounds are completely soluble each other. The mixture R has a composition of $x_{A,R} = 0.7$ and $x_{B,R} = 0.2$; the mixture E exists of $x_{A,E} = 0.1$, $x_{B,E} = 0.5$. Determine the mixing point $x_{C,M}$.
 - How many types of cooling tower is found in industry?
 - Differentiate between dry bulb temperature and wet bulb temperature.
- Q.3A Define major types of equipment used for extraction in industry. Explain with diagram the mixer-settler equipment for extraction. 05
- Q.3B What is leaching? Explain with an industrial example. Define equilibrium stage model for leaching and washing. 05
- Q.4A Explain the drying rate curve. Derive an expression to determine the drying time from the drying rate data. 06
- Q.4B In the laboratory drying test of granular, hygroscopic wet solid, it took 8.5 hours to dry the solid from 28% to 2% moisture with a solid loading of 20 Kg/m². Given, $X_c = 0.1$, $X^* = 0.005$, and the falling rate of drying being linear in the moisture content (all moisture are on dry basis), calculate the time required for drying the material from 25% to 1.5% moisture under similar drying conditions. 04
- Q.5A Differentiate between: 01 +
- Drying and Evaporation 02 +
 - Extraction and Distillation 02 =
 - Adsorption and Absorption 05
- Q.5B Determine the following psychrometric properties of a moist air sample having a dry-bulb temperature 27°C and a humidity of 0.015 kg/(kg dry air) using psychrometric chart. 05
- Dew point
 - Wet bulb temperature
 - Relative Humidity
 - Humid heat
 - Enthalpy
- [Note: Psychrometric chart is attached at the end of the paper. Attached the chart with your answer sheet after solving the paper]
- Q.6A What is adiabatic saturation temperature? Show that adiabatic saturation temperature and wet bulb temperature are same for air-water system. 05
- Q.6B What is adsorption? Define the terms 'adsorbent' and adsorbate' giving suitable examples. Distinguish between physical adsorption and chemical adsorption. 01+01
+03=
05

OR

Q.6B What is an adsorption isotherm? Deduce Langmuir's adsorption isotherm 05

Q.7A A finely divided solids feed, F , of 150 kg/h, containing $1/3$ water-soluble Na_2CO_3 and $2/3$ insoluble ash is to be leached and washed at 30°C in a three-stage (1 leaching and 2 washing stages), countercurrent system with 400 kg/h of water. The leaching stage consists of an agitated vessel that discharges slurry into a thickener. The washing stage consists of a second thickener. Experiments show that the sludge underflow from each thickener will contain 2 kg of liquid (water and carbonate) per kg of insoluble ash. Assuming ideal stages. Calculate the % recovery of carbonate in the final extract. 10

Q.7B Explain the principles of Crystallization. Also develop the material balance equations of the crystallizer. 05

OR

Q.7B A 2000 kg hot solution at 330 K (57°C) containing 30 weight % MgSO_4 is cooled to 293 K (30°C) and $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ crystals are removed from it. The solubility at 293 K (30°C) is 35.5 kg MgSO_4 per 100 kg water. Calculate the yield of crystals. Assume that no water is evaporated. 05

At. Wt. : $\text{Mg} = 24, \text{S} = 32, \text{O} = 16, \text{H} = 1$

Q.8A How do you determine the number of stages in multistage cross-current extraction? Explain by plotting equilateral triangular diagram. 10

Q.9 1000 kg of an aqueous solution containing 35 mass% trimethyl amine (TMA) and 65% water is to be extracted using benzene as the solvent. A three stage cross current extraction scheme is suggested. The amounts of solvent (98% benzene, 2% TMA) to be used in successive stages are 815 kg, 950 kg and 2625 kg. The solute concentration in Raffinate and extract phases in stage 1, stage 2 and stage 3 are 0.24 and 0.166, 0.15 and 0.105, 0.0596 and 0.0506 respectively. Determine the fraction of the solute removed if the stages are ideal. 15

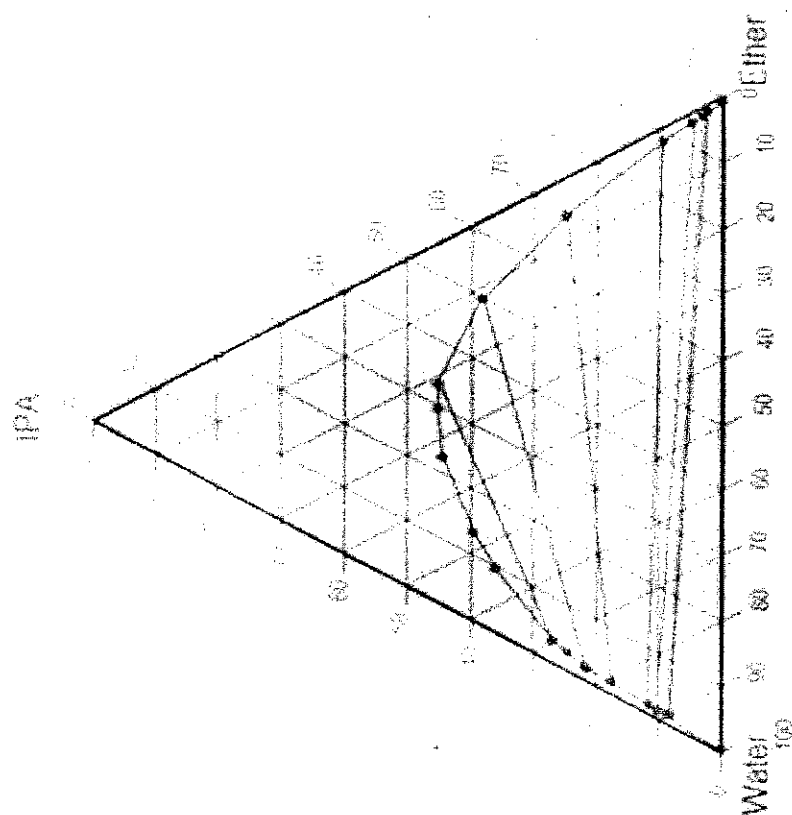
OR

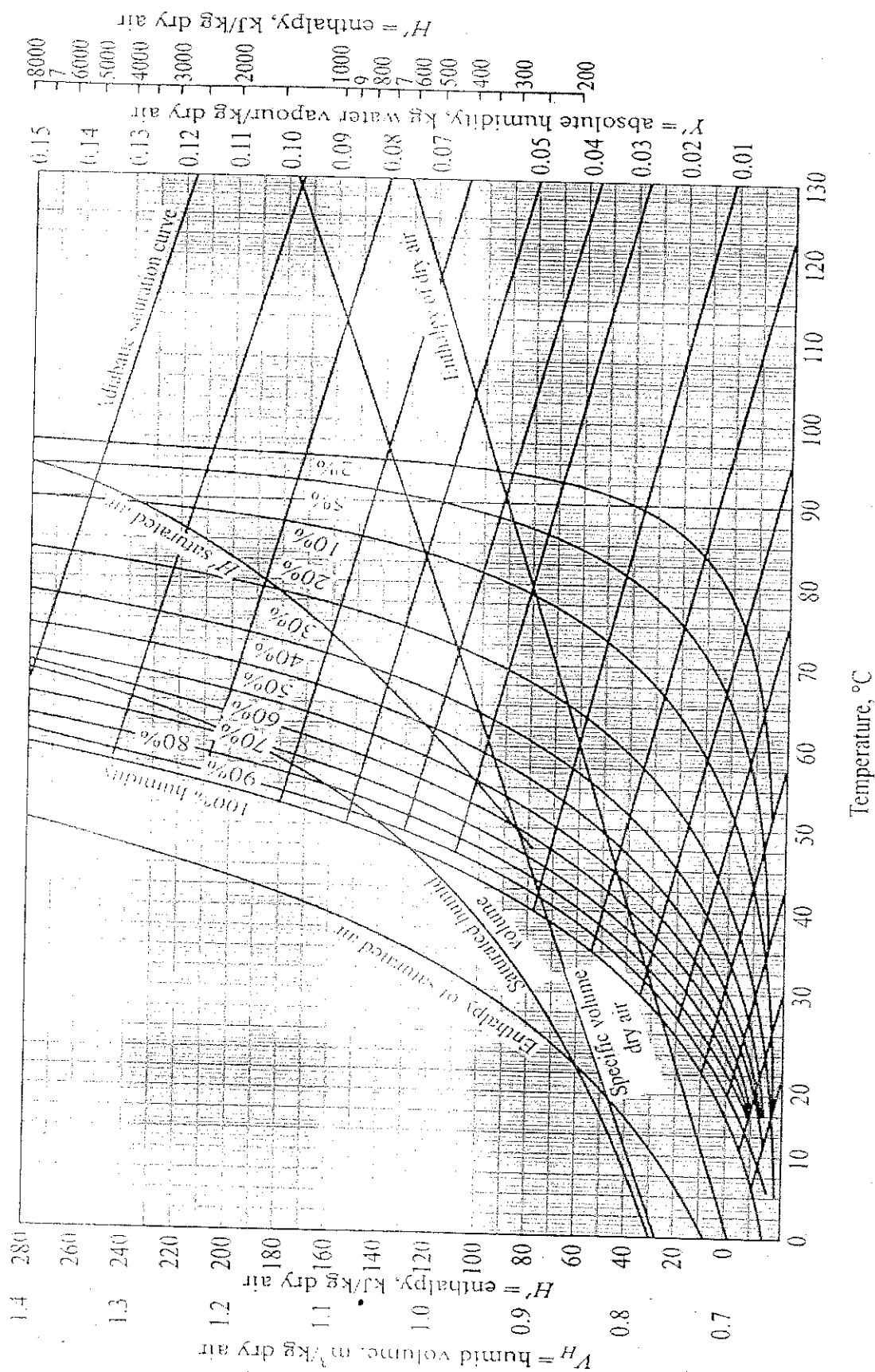
Q.9 A feed of 40 wt% isopropyl alcohol, 55 wt% diisopropyl ether, 5 wt% water is mixed with pure water, the solvent, in a LLE cascade to recover the ether. The solvent enters the top and feed enters the bottom, so as to produce an ether containing less than 3 wt% alcohol and an extracted alcohol of at least 20 wt%. The system will operate at 1 atm and 25°C . How many stages are required for this extraction? 15

[Note: Use Figure 1 and attached with your answer sheet after solving the paper]

Figure 1

Student ID: _____





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