Reg. No.										

Manipal Institute of Technology, Manipal

(A Constituent Institute of Manipal University)

V SEMESTER B.TECH (CHEMICAL ENGINEERING)
END SEMESTER EXAMINATIONS, NOV/DEC 2015
SUBJECT: SIMULTANEOUS HEAT & MASS TRANSFER (CHE 303)

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 100

Instructions to Candidates:

- Answer **ANY FIVE FULL** the questions.
- Missing data may be suitably assumed.
- Use of psychrometric chart and steam table are permitted.

1A.	What is the mechanism of crystallization process? Also derive the equation for crystal growth rate with necessary assumptions.	**10**
1B.	Write the possible Material and Energy Balance equations for triple effect evaporator arranged under backward feed conditions.	**06**
1C.	Explain in detail the effect of liquid head and boiling point elevation in multiple effect evaporators.	**04**
2A.	14.4 tones per hour (4kg/s) of a liquor containing 10% solids is fed at 294K (21^0C) to the first effect of a triple effect unit, thick liquor containing 50% solids is to be withdrawn from the third effect, which is at a pressure of 13.172 kPa(abs) , the liquor will be assumed no B.P.E. Dry saturated steam at pressure of 205kN/m^2 is fed to a heating element of the first effect, assume the overall heat transfer co-efficient of 3.1, 2.0 , & 1.1 kW/m^2.K for the first, second and third effect respectively, if the three units are to have equal areas, find the heat transfer area of each effect, steam consumption and steam economy. Assume. ΔT_1 = 18K ΔT_2=17K ΔT_3=34K forward-feed arrangement is to be used.	**12**
2B.	Explain the importance of vapor recompression and write short notes on thermal recompression evaporator with neat sketch.	**08**
3A.	A non-hygroscopic filter cake is to be dried in a continuous countercurrent dryer from 30% moisture to 2% moisture (wet basis) at a rate of 1000 kg per hour. The material enters the dryer at 27^{o}C and leaves at 52^{o}C. Fresh air is mixed with a part of the moist air leaving the dryer and heated to a temperature of 120^{o}C in a finned air heater using low pressure steam (4 kg/cm^2 gauge). Calculate (a) the rate of flow of fresh air, (b) the fraction of the air leaving the dryer that recycled, (c) the theoretical steam requirement and (d) the heat loss from the dryer, if any. The following data and information are given : temperature of fresh air = 29^{o}C; humidity=0.018 kg/(kg dry air); humidity of the air leaving the heater = 0.03 kg/(kg dry air); humidity and temperature of the air leaving the dryer = 0.05 kg/(kg dry air), 70^{o}C; specific heat of the dry solid = 920 J/kg.K	**12**
3B.	Derive the equation for the time of drying required to reduce the moisture content of a solid to the desired extent from drying rate data.	**08**

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<tr><td>4A.</td><td>Explain the importance of natural draft cooling towers and write a short note on mechanical draft cooling towers with neat sketch.</td><td>10</td></tr>
<tr><td>4B.</td><td>Determine the following psychrometric properties of a moist air sample having a dry-bulb temperature 27^{o}C and a humidity of 0.015 kg/(kg dry air) using the psychrometric chart and/ or the vapor pressure equation for water
(a) Relative humidity (b) Dew point
(c) Adiabatic saturation temperature (d) Wet-bulb temperature
(e) Enthalpy (f) Humid volume
(g) Humid heat
The Antoine equation for water is $\ln P_A^v$(bar)= 11.96481-3984.923/(T-39.724). The total pressure is 1 atm.</td><td>10</td></tr>
<tr><td>5A.</td><td>A Swenson-walker crystallizer is used to produce 1000 kg/hr of copperas ($FeSO_4.7H_2O$) crystals by the cooling of a saturated solution which enters the crystallizer at 50^{o}C and slurry is leaving at 26.6^{o}C, cooling water enters the crystallizer jacket at 15^{o}C and leaves at 25^{o}C.
a) Estimate heat removed
b) cooling water and total heat transfer area required.
Assume: U for crystallizer = 6.61 w/m^2.k
X_L' at 50^{o}C= 140 kg of copperas / 100kg of excess water
X_L' at 26.6^{o}C = 74 kg of copperas / 100kg of excess water
(At. Mass: Fe:55.85, S:32.065, O:16)</td><td>10</td></tr>
<tr><td>5B.</td><td>Explain the importance of super-saturation in crystallization process and explain working principle of vacuum crystallizer with neat sketch.</td><td>10</td></tr>
<tr><td>6A.</td><td>1500kg of granuler solid is to be dried under the constant drying conditions from a moisture content of 18% to a final moisture content of 2%, the drying surface is given as 0.055 m^2/kg , under the same conditions , the following rates were previously known, calculate the time required for drying.
<table>
<tr><td>X (kg of water / kg of dry solid)</td><td>0.32</td><td>0.219</td><td>0.12</td><td>0.096</td><td>0.056</td><td>0.046</td><td>0.02</td><td>0.016</td></tr>
<tr><td>N(kg/m^2.h)</td><td>1.8</td><td>1.8</td><td>1.8</td><td>1.46</td><td>1.29</td><td>0.88</td><td>0.54</td><td>0.376</td></tr>
</table></td><td>10</td></tr>
<tr><td>6B.</td><td>A single effect evaporator is to be designed to concentrate 8000 kg/hr of a chemical solution from 10% to 20% by weight, feed enters at 25^{o}C, saturated steam at 110^{o}C (latent heat 532 Kcal /kg) is available, condensate leaves at saturation temperature, the solution boils at 45^{o}C (latent heat is 570 Kcal/kg), specific heat of all the solution may be taken as 1 Kcal/kg and overall heat transfer co-efficient is 1800 Kcal/hr.m^2.^{o}C . Find (a) Steam economy (b) Heat transfer area.</td><td>10</td></tr>
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