BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: IMSC **SEMESTER : V**
BRANCH: FOOD TECH. **SESSION : MO/18**

SUBJECT: IMF5009 FOOD ENGINEERING-II HEAT AND MASS TRANSFER

TIME: 3 HOURS **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Define Fourier's law of heat conduction and write mathematical expression [2]

Q.1(b) Derive the expression for three dimensional heat conduction equation in Cartesian coordinate system. [4]

Q.1(c) A metal plate of 4 mm thick (k = 0.95.5 W/m ^{o}C) is exposed to vapour at 100 ^{o}C on one side and cooling water on 25 ^{o}C at opposite side. The Heat transfer coefficient on vapour side and water side are 14500 W/m^2 ^{o}C and 2250 W/m^2 ^{o}C, respectively. Determine, the rate of heat transfer and overall heat transfer coefficient. [6]

Q.2(a) Write the types of heat exchanger. [2]

Q.2(b) Derive the expression for overall heat transfer coefficient for plain wall. [4]

Q.2(c) A mild steel tank of wall thickness 12 mm contains water at 95 ^{o}C. the thermal conductivity of wall is 50 W/m ^{o}C, and the heat transfer coefficient inside and outside the tank are 2850 W/m^{2o}C and 10 W/m^{2o}C, respectively. If the atmospheric temperature is 15 ^{o}C, calculate heat loss per unit area and overall heat transfer coefficient. [6]

Q.3(a) Describe with sketch industrial equipment for alcohol distillation. [2]

Q.3(b) Explain Boiling point diagram and Equilibrium diagram. What is the effect of pressure on Boiling point Diagram? State Raoults Law. Define Relative volatility and derive an expression for it for Ideal Mixtures. [4]

Q.3(c) The citrus terpene d-limonene (MW =136, assume to be totally insoluble in water) is to be steam distilled at atmospheric pressure (101.3 kPa). [6]
a. Find the boiling temperature of the liquid mixture.
b. Calculate the percentage (w/w) of limonene in the vapor

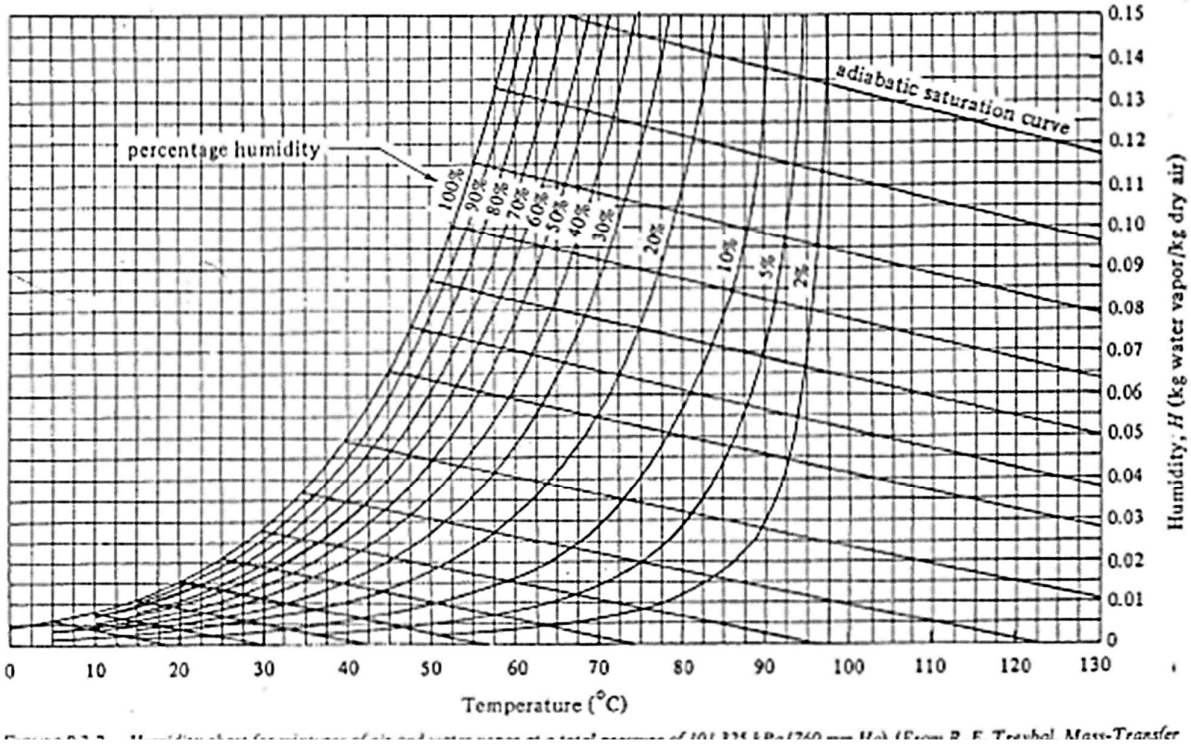
Temperature ^{o}C	Vapour Pressure Pa	
	d-limonene	Water
20	8	2339
40	34	7384
60	125	19940
80	391	47390
98	658	70140
90	984	94500
99	1033	97200
99.8	1059	99900
100	1084	101300

Q.4(a) Define Diffusivity and Mass Transfer coefficient. Derive expression relating individual and overall mass transfer coefficient. [2]

Q.4(b) Describe with sketch and compare working of Packed column and tray column for gas liquid contact operations [4]

Q.4(c) An air stream at 85^{o}C and having a humidity of 0.025 kg water/kg dry air is cooled and humidified to 90% saturation in an adiabatic saturator with water. Report (a) Initial % saturation, dew point and wet bulb temperature (b) Final Humidity and Temperature. [6]

PTO



Q.5(a) Describe with sketch working of 3 stage counter current liquid liquid extraction using Mixer Settlers. [2]

Q.5(b) Sketch a typical ternary phase equilibrium diagram. Explain tie line and Plait point. [4]
Compute selectivity of chlorobenzene for pyridine at the following tie line and comment on their value.

Pyridine	Chlorobenzene	Water	Pyridine	Chlorobenzene	Water
28.6	69.15	2.25	25.5	0.58	73.92

Q.5(c) Explain applications of Solid Liquid Extraction [Leaching] In Food Processing. Discuss pre condition of feed for extraction of vegetable oil from oil seeds. Describe any two machines for extraction of vegetable oil. [6]

Q.6(a) Explain with sketch special features of a Draft Tube Baffle Crystallizer [2]

Q.6(b) State Kelvins equation. What is the size of a nucleus of a sugar crystal in equilibrium at 20°C with mother liquor at 115% suer saturation? The surface tension at te crystal-liquid interphase is estimated to ne 0.003J/m^2. The molecular weight 342, density 1600kg/m^3. [4]

Q.6(c) State equations for different types of adsorption isotherms. Explain with flowsheet, material balance and flow sheet for single stage adsorption the procedure for determinations of concentration of solute in exit streams of the process for a system obeying Freundlich isotherm [6]

Q.7(a) What the methods of gas solid contact in dryers? Compare their performances. [2]

Q.7(b) Describe the following driers explaining working principles and applications in food processing: (a) Puff Dryer (b) Drum dryer [4]

Q.7(c) Sketch a typical Drying rate curve and explain the physical phenomena in each drying zone. [6]
The initial moisture content of a food product is 77% (wet basis), and the critical moisture content is 30% (wet basis). The equilibrium moisture content is 2%. If the constant drying rate is 0.1 kg water/(m^2s), The product has a cube shape with 5-cm sides, and the initial product density is 950 kg/m^3 . Compute the time required for the product to begin the falling rate drying period. Compute the time required for drying