* R N - 6 7 2 9 / 2 0 0 *

RN-6729

B. E. - III (Sem. V) (Chemical) Examination

May / June – 2010

Heat Transfer

Time : **3** Hours] [Total Marks : **100**

Instructions :

(1)

નીચે દર્શાવેલ ☛ નિશાનીવાળી વિગતો ઉત્તરવહી પર અવશ્ય લખવી.
Fillup strictly the details of ☛ signs on your answer book.

Name of the Examination :

☛ **B. E. - 3 (Sem. 5) (Chemical)**

Name of the Subject :

☛ **Heat Transfer**

☛ Subject Code No. : **6 7 2 9** ☛ Section No. (1, 2,.....) : **1&2**

Seat No. :

Student's Signature

(2) Answer each section in **separate** answer books.

(3) Assume suitable data, when necessary. Graph, data sheets etc. will be provided wherever necessary.

(4) Draw a neat sketch wherever necessary.

(5) Figures to the right indicate full marks.

SECTION - I

1 (a) Answer the following : **10**

(i) The unit of overall heat transfer coefficient is Btu/ .hr. $Ft^2.R^4$. - True/False.

(ii) Fouriers later applies to _____ surfaces.

(a) Isothermal

(b) Non isothermal

(c) Both (a) and (b)

(d) None

(iii) Maximum heat transfer is obtained in _____ flow.

(a) Laminar

(b) Turbulent

(c) Transition

(iv) What is heat flux? Give unit of heat flux.

(v) Prandlt number is given by _____.

(vi) Thermal conductivity of liquids vary from _____ to _____ W/m.k.

(vii) What is unsteady state heat transfer?

(viii) State Wien's displacement law.

(ix) For heat flow through very thick walled cylinder use _____ mean radius.

(a) Arithmetic

(b) Logarithmic

(c) Geometric

(d) either a or c.

(x) Define : Emissivity.

(b) Explain modes of heat transfer in detail. **4**

(c) Derive Fouriers general equation for one-dimensional unsteady state heat conduction. **6**

2 Attempt any **two** : **16**

(a) A flat furnace wall is constructed of a 4.5 - in (114 mm) layer of sil-o-cel brick. With a thermal conductivity of 0.08 Btu/ft.h. ^{o}F (0.138 W/m.^{o}C) backed by a g-in (299 mm) layer of common brick of conductivity 0.8 Btu/ft.u. ^{o}F (1.38 W/m ^{o}C). The temperature of the inner face of the wall is 1400 ^{o}F (760^{o}C), and that of the outer pace is 170^{o} F (76.6 ^{o}C).

(i) What is the heat loss through the wall?

(ii) What is the temperature of the interface between the refractory brick and the common brick?

(iii) Supposing that the contact between the two brick layers is poor and that g 'contact resistance' of 0.50 ^{o}F h.ft^{2}/Btu (0.088 ^{o}C m^{2}/w) is present; what would be the heat loss?

(b) A steel pipe with an outside diameter of 115 mm and a wall thickness of 5mm is covered with 50 mm thickness of 85% magnesia. The surface temperature on the inside of the pipe is 423 K (150°C) and that on the outside of insulation is 305 K (32°C). Calculate :

(i) The heat flow per metre of length

(ii) The temperature at the outer surface of the steel pipe and

(iii) The conductance of the pipe and insulation based on its inside surface arch.

k for steel = 43.03 W/(m.k) and k for insulation = 0.07 W/(m.k)

(c) A steam pipe with 100 mm I.D, and 110 mm O.D. is covered with an insulating material having thermal conductivity of 1.0 $W/m^2.K$. The steam temperature is 473 k (220°C) and ambient temperature is 293 K(20°C). Taking the convective heat transfer coefficient between the insulation surface and air as 8.0 $W/cm^2.k$), find the critical radius of insulation. For this value (r_c), calculate the heat loss per metre of pipe and outer surface temperature. Neglect the resistance of pipe wall.

3 Attempt any **two** : **14**

(a) A chamber for heat curing large aluminium sheets, lacquered black on both sides, operates by passing the sheets vertically between two steel plates 150 mm apart. One of the plates is at 300°C and the other, exposed to the atmosphere, is at 25°C.

(i) What is the temperature of the lacquered sheet?

(ii) What is the heat transferred between the walls when equilibrium has been reached? Neglect convection effects. Emissivity of steel is 0.56, emissivity of lacquered sheets is 1.0.

(b) Derive that the net radiant heat between two elementary black surfaces is given by $q_{12} = 6AF\left(T_1u - T_2u\right)$ where A is the surface area and F is the view factor between two surfaces and T_1 and T_2 are the corresponding surface temperatures.

(c) Write Planks' law, derive the Stefan Boltzmann law from the planks law equation.

SECTION - II

4 (a) Answer the following : 8

(i) What characteritsics of fluid are to be considered while deciding its route in heat exchanger?

(ii) What are the factors on which the thickness of the condensate layer in film wise condensation depend?

(iii) Why vacuum is maintained in vapour space of an evaporator?

(iv) What is the significance of Prandtl Number?

(v) Give the equation of forced convection which gives effect of liquid viscosity on heat transfer coefficient.

(vi) Why baffles are used in heat exchanger?

(vii) Define effectiveness of Heat Exchanger.

(viii) What is the advantage of square pitch over triangular pitch in heat exchanger tube?

(b) Answer the following : **10**

(i) What do you mean by subcooled boiling?

(ii) Explain fouling factor.

(iii) Discuss Durhing's law.

(iv) What is free and forced convection?

(v) Discuss hydrodynamic and thermal boundary layer.

5 (a) Discuss Reynold's analogy. **3**

(b) Derive equation of LMTD for parallel flow heat exchanger. **5**

(c) A single effect evaporator is to concentrate 10000 kg/hr of 20% solution of sodium hydroxide to 50%. The gauge pressure of steam is to be 1.37 atmosphere. The absolute pressure in the vapour space is to be 100 mm Hg. The overall heat transfer coefficient is 1400 $W/m^2\,^oC$. The feed temperature is 38°C. Calculate the amount of steam consumed, the economy and the heating surface required.

OR

5 (a) Discuss multipass heat exchangers. **6**

(b) Discuss nucleation. **4**

(c) Freon -12 at 60°C condenses on the outer surface of vertical tube 90 cm long and 2.5 cm in diameter held at 57°C. Calculate the rate of condensation per hr. assuming following properties of Freon-12. **6**

$$\rho = 1280 \text{ kg/m}^3, \quad \mu = 0.9 \frac{\text{kg}}{\text{m. hr}}$$

Latent heat $\lambda = 130$ kJ/kg, $K = 0.072 \frac{\text{W}}{\text{mK}}$

6 Answer any **two** : **2×8=16**

(a) List various types of condensors and discuss any one in detail.

(b) Discuss Multieffect evaporator.

(c) 8000 kg/hr of air at 105°C is cooled by passing through a counter flow heat exchanger. Find the exit temperature of air using NTU effectiveness method, if water enters at 15°C and flows at rate of 7500 kg/hr. The overall heat transfer co-efficient is 145 W/m^2K and surface area is 20 m^2.

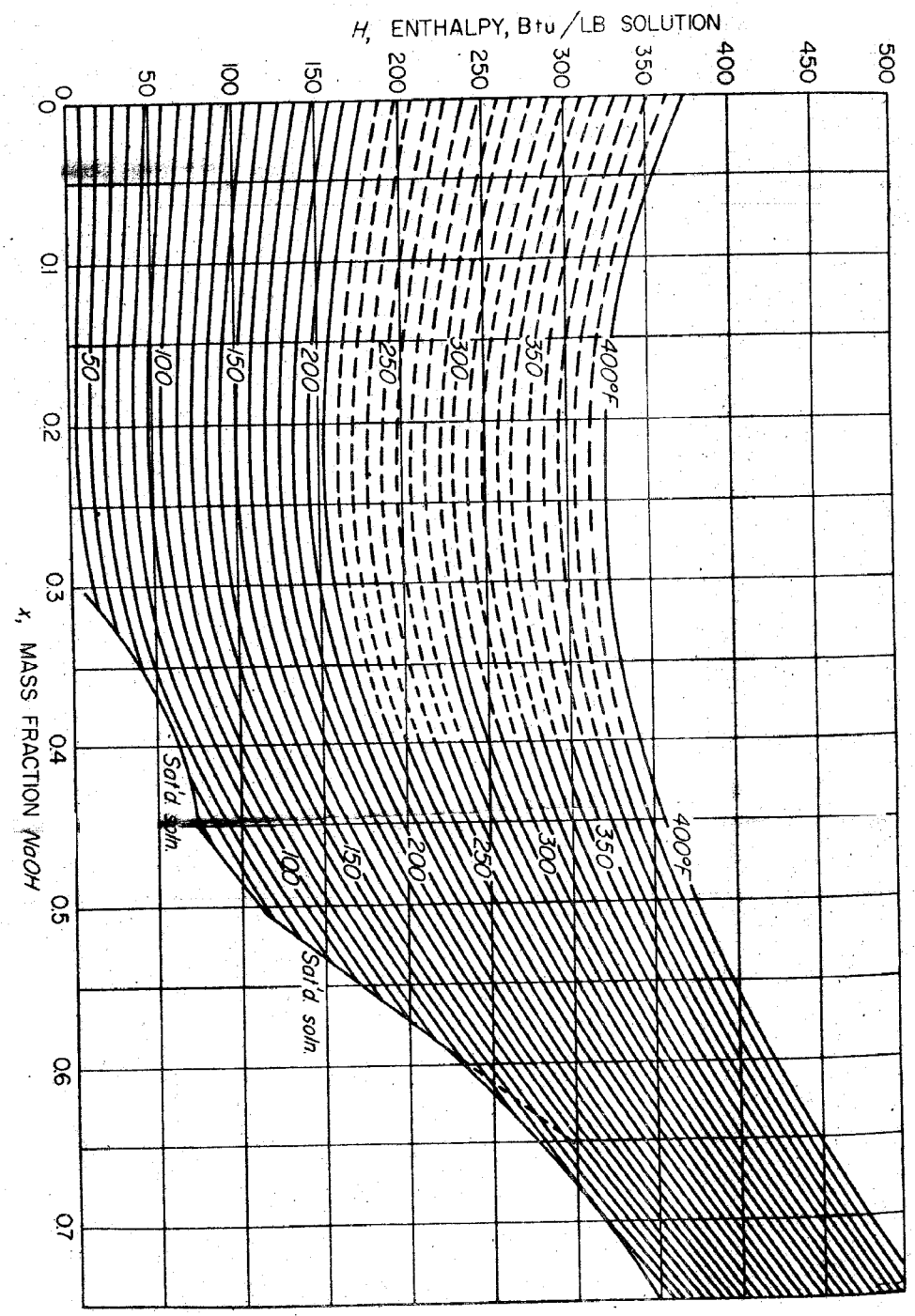

FIGURE 16.8
Enthalpy-concentration diagram, system sodium hydroxide—water. Dashed lines represent extrapolated data. (*After McCabe*[6].)

Temperature T, °F	*Vapor* pressure p_A, $lb_f/in.^2$	Specific volume, ft^3/lb		Enthalpy, Btu/lb		
		Liquid v_x	Saturated vapor v_y	Liquid H_x	Vaporization λ	Saturated vapor H_y
32	0.08859	0.016022	3305	0	1075.4	1075.4
35	0.09992	0.016021	2948	3.00	1073.7	1076.7
40	0.12166	0.016020	2445	8.02	1070.9	1078.9
45	0.14748	0.016021	2037	13.04	1068.1	1081.1
50	0.17803	0.016024	1704.2	18.06	1065.2	1083.3
55	0.2140	0.016029	1431.4	23.07	1062.4	1085.5
60	0.2563	0.016035	1206.9	28.08	1059.6	1087.7
65	0.3057	0.016042	1021.5	33.09	1056.8	1089.9
70	0.3632	0.016051	867.7	38.09	1054.0	1092.0
75	0.4300	0.016061	739.7	43.09	1051.1	1094.2
80	0.5073	0.016073	632.8	48.09	1048.3	1096.4
85	0.5964	0.016085	543.1	53.08	1045.5	1098.6
90	0.6988	0.016099	467.7	58.07	1042.7	1100.7
95	0.8162	0.016114	404.0	63.06	1039.8	1102.9
100	0.9503	0.016130	350.0	68.05	1037.0	1105.0
110	1.2763	0.016166	265.1	78.02	1031.4	1109.3
120	1.6945	0.016205	203.0	88.00	1025.5	1113.5
130	2.225	0.016247	157.17	97.98	1019.8	1117.8
140	2.892	0.016293	122.88	107.96	1014.0	1121.9
150	3.722	0.016343	96.99	117.96	1008.1	1126.1
160	4.745	0.016395	77.23	127.96	1002.2	1130.1
170	5.996	0.016450	62.02	137.97	996.2	1134.2
180	7.515	0.016509	50.20	147.99	990.2	1138.2
190	9.343	0.016570	40.95	158.03	984.1	1142.1
200	11.529	0.016634	33.63	168.07	977.9	1145.9
210	14.125	0.016702	27.82	178.14	971.6	1149.7
212	14.698	0.016716	26.80	180.16	970.3	1150.5
220	17.188	0.016772	23.15	188.22	965.3	1153.5
230	20.78	0.016845	19.386	198.32	958.8	1157.1
240	24.97	0.016922	16.327	208.44	952.3	1160.7
250	29.82	0.017001	13.826	218.59	945.6	1164.2
260	35.42	0.017084	11.768	228.76	938.8	1167.6
270	41.85	0.017170	10.066	238.95	932.0	1170.9
280	49.18	0.017259	8.650	249.18	924.9	1174.1
290	57.53	0.017352	7.467	259.44	917.8	1177.2
300	66.98	0.017448	6.472	269.73	910.4	1180.2
310	77.64	0.017548	5.632	280.06	903.0	1183.0
320	89.60	0.017652	4.919	290.43	895.3	1185.8
340	117.93	0.017872	3.792	311.30	879.5	1190.8
350	134.53	0.017988	3.346	321.80	871.3	1193.1
360	152.92	0.018108	2.961	332.35	862.9	1195.2
370	173.23	0.018233	2.628	342.96	854.2	1197.2
380	195.60	0.018363	2.339	353.62	845.4	1199.0
390	220.2	0.018498	2.087	364.34	836.2	1200.6
400	247.1	0.018638	1.8661	375.12	826.8	1202.0
410	276.5	0.018784	1.6726	385.97	817.2	1203.1
420	308.5	0.018936	1.5024	396.89	807.2	1204.1
430	343.3	0.019094	1.3521	407.89	796.9	1204.8
440	381.2	0.019260	1.2192	418.98	786.3	1205.3
450	422.1	0.019433	1.1011	430.2	775.4	1205.6

† Abstracted from *Steam Tables*, by Joseph H. Keenan, Frederick G. Keyes, Philip G. Hill, and Joan G. Moore, John Wiley & Sons, New York, 1969, with the permission of the publisher.