L-3/T-1/CHE **Date : 14/02/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2010-2011

Sub : **CHE 409** (Corrosion Engineering)

Full Marks: 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **EIGHT** questions in this Section. Answer any **SIX**.

1. (a) How do crystal imperfections and defects cause corrosion? Will you choose high purity metals for corrosion resistance? Give reasons for your answer. **(10+5+10=25)**

   (b) An austenitic iron-carbon alloy has been quenched. What changes will occur in its corrosion behaviour? How can its corrosion resistance be improved? **(5+5=10)**

2. (a) What is the real reason behind the higher rate of corrosion due to cold working? **(5)**

   (b) Justify the introduction of Stress Sorption theory to explain Stress Corrosion Cracking. **(5)**

   (c) How does Dry Fatigue differ from Corrosion Fatigue? **(5)**

   (d) Show with the help of diagrams how corrosion can be prevented by design improvement (give 5(Five) examples) **(20)**

3. (a) Why cathodic protection is more popular than anodic protection? **(10)**

   (b) Explain the importance of "critical concentration" in the use of Passivators. **(5)**

   (c) How do dissolved gases cause corrosion in high pressure boilers? Suggest ways to remove dissolved gases and neutralize boiler water. **(5+10=15)**

   (d) How does intergranular corrosion occur? Can it happen in (wrought) iron? Give reasons. **(5)**

4. (a) "When in doubt, use lead " --- can this be justified today? Give reasons. **(10)**

   (b) Explain why and how oxide layer grows after formation of a monomolecular layer. **(15)**

   (c) Select and justify a "natural law" for oxidation at high temperature. **(10)**

SECTION – B

There are **FIFTEEN (15)** questions in this Section. Answer any **TWELVE (12)**.

The questions are of equal value.

5. Why do we need to understand different aspects of corrosion phenomenon?

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6. What are Pourbaix diagrams? How useful are they in corrosion studies?

7. What is a Galvanic series? How useful it is in corrosion studies?

8. What is polarization? How does it reduce corrosion?

9. With appropriate equations of O_2 electrodes show how a differential aeration cell works?

10. What are passivators? How do they function?

11. What is a potentiostatic anodic polarization curve? Draw the same for an active-passive metal and explain its different zones.

12. For pH range of 4 to 10, the corrosion rate of iron in aerated water is independent of pH – Explain.

13. Corrosion rate of iron in NaCl solution initially increases with increase in concentration – Explain.

14. What are the methods available for corrosion control of steel in concrete?

15. Why galvanized steel sheets last longer in rural atmosphere What is $RH_{critical}$ for atmospheric corrosion?

16. What is stray current corrosion? How would you detect a case of stray current corrosion?

17. What are the factors affecting soil corrosion? How is soil corrosion prevented?

18. What is hydrogen over voltage? What role does it play in corrosion of metals?

19. Direct exposure of metallic materials to rain may be beneficial compared to partial exposure in polluted air. Explain with an example.

L-3/T-1/IPE **Date : 16/02/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2010-2011

Sub : **CHE 303** (Mass Transfer-I)

Full Marks: 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) What are the assumptions made for washing and leaching operations to simplify the calculations? Explain. **(10)**

(b) As the system becomes dilute $L/G \rightarrow L/V$, $Y \rightarrow y$ and $X \rightarrow x$. At what concentration levels could you safely work in terms of fractions and total flows instead of ratios and flows of solvent and carrier gas? **(2)**

(c) You are testing out a system to leach caffeine, $C_8H_{10}N_4O_2$, out of coffee beans using a new solvent. Over the range of concentrations studied, the concentration of caffeine in the beans (measured as 'gm' caffeine per 'kg' insoluble solid) is related to the weight ratio in the liquid by Y = 0.8 X, where Y = 'gm' caffeine/kg solvent; and X = 'gm' caffeine/kg insoluble solid. The solvent you are studying appears to be unique in that only caffeine dissolves in it and none of the other water –soluble components in coffee dissolve. The solvent does not adsorb or crystallize onto the solids. The system uses three mixer-centrifuges, each of which acts as an equilibrium stage. The mixer-centrifuges are arranged so that the solid and fluid phases move counter currently to each other. Solvent entering the system is pure. You desire the final value of X to be 0.05 $X_{initial}$. How many kilograms of solvent are required for each kilogram of fresh coffee? **(23)**

2. A complete gas treatment plant often consists of both an absorber to remove solute and a stripper to regenerate the solvent Some of the treated gas is heated and used in the stripper. In a particular application we wish to remove obnoxious impurity 'A' from the inlet gas. The absorber operates at 1.5 atm and 24°C where equilibrium is given as y = 0.5 x (units are mole fractions). The stripper operates at 1.0 atm and 95°C where equilibrium is y = 3.0 x *units are mole fractions). The total gas flow rate is 1400 moles/day, and the gas is 15 mole % A. The nonsoluble cannier is air. We desine a treated gas concentration of 0.5 mole% A. The liquid flow rate into the absorber is 800 moles/day and the liquid is 0.5 mole % A. **(35)**

(a) Calculate the number of stages in the absorber and the liquid concentration leaving the absorber.

(b) If the stripper is an already existing column with four stages (equilibrium), calculate the inlet gas flow rate (concentration is 0.5 mol% A) to the stripper and the outlet gas concentration from the stripper.

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3. (a) Write down the steps to determine the minimum solvent rate for the extraction of partially miscible system when 'E' is greater than 'R'. **(10)**

(b) A solution of acetic acid (A) in water (D) is to be extracted using isopropyl ether as the solvent (s). The feed is 1000 kg/hr of a solution containing 30 wt% acid and 70 wt% water. The solvent used comes from a solvent recovery plant which contains 1wt% acetic acid but no water. Inlet solvent flow rate is 1500 kg/hr. The exiting naffinate stream should contain 10 wt% acetic acid. Operation is at 20°C and f atm. **(25)**

Find the outlet concentrations and the number of equilibrium stages required for this separation.

Equilibrium data are given in table-1.

Table 1. Equilibrium data for water – acetic acid – isopropyl ether at 20°C and 1 atm.

water layer (wt%)		Isopropyl ether layer (wt%)	
x_A	x_D	y_A	y_D
0.69	98.1	0.18	0.5
2.89	95.5	0.79	0.8
6.42	91.7	1.93	1.0
13.30	84.4	4.82	1.9
25.50	71.1	11.40	3.9
36.70	58.9	21.60	6.9
44.30	45.1	31.10	10.8
46.40	37.1	36.20	15.1

4. (a) Which diameter will you consider as the column diameter in case of designing a stripping column and an absorption column? Why? **(5)**

(b) What are the chief advantages of valve trays over bubble cap and sieve trays? **(5)**

(c) Distinguish between froth and spray regimes. **(5)**

(d) Draw the schematic diagrams of different types of down comers and weirs. **(5)**

(e) Show sieve tray geometry with a neat sketch. **(5)**

(f) Show different pressure heads on a sieve tray with a neat sketch. **(5)**

(g) Explain Murphree efficiency model with a neat sketch with respect to its shortcomings. **(5)**

Contd P/3

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SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) The constants in the Antoine equation are: **(10+10=20)**

	A	B	C
For benzene:	6.90565	1211.033	220.79
For toluene :	6.95334	1343.943	219.377

where, P° is in mm Hg, T is in °C and $\log_{10}$ is used instead of ln.

(i) Determine the vapour phase composition of a mixture in equilibrium with a liquid mixture of 0.5 mole fraction benzene and 0.5 mole fraction of toluene at 65°C. Will the liquid vaporize at a pressure of 101.325 kN/m^2?

(ii) What is the boiling point of a equimolar mixture of benzene and toluene at 101.325 kN/m^2?

(b) One thousand Kmol/h of a feed containing 30 mol% n-hexane and 70% n-octane is to be distilled in a column consisting of a partial reboiler, one equilibrium plate and a partial condenser, all operating at 1 atm. The feed, a bubble-point liquid, is fed to the reboiler, from which a liquid bottoms product is continuously withdrawn. Bubble-point reflux is returned from the partial condenser to the plate. The vapour distillate, in equilibrium with the reflux, contains 80 mol% hexane, and the reflux ratio, L/D, is 2. If the relative volatility ∞ is assumed constant at a value of 5 over the composition range, Calculate the bottoms composition analytically. **(15)**

6. A continuous fractionating column is to be designed to separate 2.5 Kg/s of a mixture of 60% toluene and 40% benzene (weight%), so as to give an overhead of 97% benzene and a bottom product containing 98% toluene by mass. A reflux ratio of 3.5 Kmol of reflux /Kmol of product is to be used and the molar latent heat of benzene and toluene may be taken as 30 MJ/Kmol. The boiling-points of benzene and toluene are 353.3 and 383.8 K respectively. q can be calculate from the following equation. **(35)**

$$q = \frac{\lambda + H_{fs} - H_f}{\lambda}$$

where, λ is the molar latent heat of vaporization, H_{fs} is the molar enthalpy of the feed at its boiling-point, and H_f is the molar enthalpy of the feed.

Equilibrium data for benzene at 1 atm:

x_B	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y_B	0.22	0.38	0.51	0.63	0.7	0.78	0.85	0.91	0.96

Calculate:

(i) The mass of top and bottom products per hour.

(ii) The number of theoretical plates and position of feed if the feed in liquid at 295 K, of specific heat capacity 1.84 kJ/kg. K.

(iii) How much steam at 240 kN/m^2 is required in the reboiler of the still. The latent heat of steam at 240 kN/m^2 is 2186 kJ/kg.

(iv) The minimum number of plates for a feed entering at its boiling-point.

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7. (a) A liquid mixture cotaining 40 mole % n-heptane and 60 mole % n-octane ($\alpha = 2.16$) is subjected to batch distillation of atmospheric pressure. If 60 mole % of the feed is distilled then. Compute the composition of the composite distillate and the residue. **(15)**

(b) A mixture of water and ethanol containing 0.16 mole fraction alcohol in continuously distilled in a plate distillation column to give a product containing 0.77 mole fraction alcohol and a waste of 0.02 mole fraction alcohol. It is proposed to withdraw 25% of the alcohol in the entering stream as a side stream containing 0.50 mole fraction of alcohol. Equilibrium data for ethanol at 1 atm. **(20)**

x_E	0.02	0.1	0.24	0.33	0.4	0.51	0.57	0.74	0.89
y_E	0.17	0.44	0.55	0.58	0.6	0.66	0.68	0.78	0.89

Determine the number of theoretical plates required and the plate from which the side stream should be withdrawn if the fed is liquid at its boiling point and a reflux ratio of 2 is used.

8. (a) A continuous fractionating column is required to separate a mixture containing 0.695 mole fraction n-heptane and 0.305 mde fraction n-otane into products of 99 mole percent purity. The column is to operate at 101.3 kN/m^2 with a vapour velocity of 0.6 m/s. The feed is all liquid at its boiling-point, and this is supplied to the column at 1.25 kg/s. The boiling-point at the top of the column may be taken as 372 as K, and the equilibrium data for heptane at 101.3 kN/m^2 are: **(13+10=23)**

x	0.92	0.82	0.69	0.57	0.46	0.32	0.22	0.13
y	0.96	0.91	0.83	0.74	0.65	0.50	0.37	0.24

(i) Determine the minimum reflux ratio, and the minimum number of plates:

(ii) What column diameter would be required if the reflux used were twice the minimum possible?

(b) A feed of 50 mole % hexane and 50 mole % octane is flashed in to a chamber. The vapour and liquid leaving the chamber are assumed to be in equilibrium. If the fraction of the feed converted to vapour is 0.5, find the compositions of the top and bottom products. Equilibrium data for hexane are: **(12)**

x_h	1.00	0.69	0.40	0.192	0.045	0.00
y_h	1.00	0.932	0.78	0.538	0.1775	0.00

L-3/T-1/ChE **Date : 9/2/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B.Sc. Engineering Examinations 2010-2011

Sub : **CHE 301** (Heat Transfer)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

1. (a) Describe the thermal boundary layer formation for forced convection on an isothermal flat plate. Indicate the relative thickness of hydrodynamic and thermal boundary layers for common fluids. **(10)**

(b) Discuss the industrial applications of heat transfer with phase change (boiling and condensation). **(10)**

(c) Define bulk temperature in the case of forced convection in tubes. What is "Mixing cup" temperature? **(10)**

(d) What are the usual heat transfer coefficient values for the following fluids and associated modes of heat transfer? **(5)**

(i) AIR : Free convection and forced convection

(ii) WATER : Forced convection

(iii) STEAM : Filmwsie condensation

(iv) STEAM : Dropwise condensation

?

2. (a) A furnace wall is to be constructed with a 6 cm layer of fire brick (k = 1.0 W/m°C) on the inside. This is covered on the exterior with a layer of block insulation (k = 1.0 W/m°C). The interior of the furnace is at 800°C and the exterior surface 70°C. Determine the thickness of block insulation necessary to maintain the firebrick-block insulation interface temperature at 700°C. **(20)**

(b) For a cylinder or wire with internal heat generation the temperature distribution is given by the expression: $T - T_w = \frac{\dot{q}}{4k}(R^2 - r^2)$

A 5 mm diameter wire generates heat uniformly at the rate of 500 MW/m3. The outside surface temperature of the wire is 150°C, and the thermal conductivity is 20 W/m°C. Calculate the temperature at the center of the wire. **(15)**

3. (a) Draw a typical pool boiling curve and discuss the heat transfer behavior in different regimes. Explain the "burnout" phenomenon. **(15)**

(b) Discuss the influence of Gra-shoff number on the type of flow in natural convection. **(5)**

Contd P/2

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Contd ... Q. No. 3

(c) A horizontal pipe 20 cm outside diameter carrying steam is in ambient are at 32°C. The outside surface temperature of pipe is 220.C. Calculate the natural convection coefficient and the heat loss per meter length of pipe. Table for properties of air is supplied. **(15)**

The correlation for natural convection:

$Nu_f = C(Gr_f \;\; Pr_f)^m$

Values of C and m for use with the correlation are:

$Gr_f Pr_f = 10^4 - 10^9$, C = 0.53, M = 0.25

$Gr_f Pr_f = 10^9 - 10^{12}$, C = 0.13, M = 0.33

4. (a) Reynold's analogy is given by the relation St = f/8. What does this analogy relate? Derive Reynolds analogy for turbulent heat transfer in tubes. **(25)**

Given:

Heat transfer : $\dfrac{q}{\rho C_p A} = -(\alpha + t_M)\dfrac{dT}{dy}$

Shear stress : $\dfrac{\tau}{\rho} = (\nu + t_M)\dfrac{du}{dy}$

Shear stress : $\dfrac{\tau}{\rho} = \dfrac{f}{8}\rho u_m^2$

Assume, $\dfrac{q/A}{\tau} = cons\tan t = \dfrac{q_w}{A\tau_w}$

(b) Write short notes on the following terms: **(10)**

(i) Prandtl mixing length (ii) Eddy diffusivity of heat

SECTION – B

There are **FOUR** questions in this Section. Answer any **TWO** with Question No. 5. Question No. 5 is compulsory. Students must attain the TEMA sheet with their answer script.

5. (a) 25,000 lb/hr of a 30% K_3PO_4 solution is to be cooled from 150°F to 90°F, using underground water. The water stream was heated up simultaneously from 68°F to 95°F. Pressure drops of 10 psi are allowable for both the streams, and total dirt factor of 0.003 is required.

A 1-2 shell and tube heat exchanger is being used for this process.

Shell Site	Tube Side
ID = 10.02 inch	Tube no. = 52
$a_s = 0.0347$ ft^2	Tube Length = 16 ft OD = 0.75 inch
Baffle Spacing = 2 inch	Pitch = 1 inch (square) ID = 0.62 inch
	16 BWG

Contd P/3

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Contd ... Q. No. 5

Physical Properties at average temperature - for Phosphate :

(i) Viscosity = 2.90 lb/ft. hr

(ii) Thermal Conductivity = 0.33 Btu/hr.ft.°F

(iii) Specific Heat Capacity = 0.757 Btu/lb°F

for Water :

(i) Viscocity = 2.20 lb/ft.hr

(ii) Thermal Conductivity = 0.386 Btu/hr.ft.°F

(iii) Specific Heat Capacity = 1.0023 Btu/lb.°F

(a) Which liquid would you place in the tube side and why? **(2)**

(b) Draw a temperature profile along the heat exchanger length, and find the logmean temperature difference. **(5)**

(c) Determine the tube side heat transfer coefficient, h_i use Fig. for Q. No. 5. **(10)**

(d) If the shell side heat transfer coefficient is 565 But/hr.ft^2. find the clean overall coefficient for the exchanger. **(4)**

(e) Calculate Design Overall Coefficient. Make all the necessary calculations and check if the exchanger is suitable for use. **(7)**

(f) Fill in the attached TEMA sheet and Attach it to your answer script. **(7)**

6. (a) The outer surface of a vertical tube, which is 1 m long and has an outer diameter of 85 mm, is exposed to saturated steam at atmospheric pressure. The tube is maintained at 50°C by the flow of cold water through the tube.

Determine -

(i) the rate of heat transfer to the coolant. **(19)**

(ii) the rate at which stream is condensed at the surface. **(5)**

Available Data : Nusselt correlation:

$$h = 1.13\left[\frac{\rho(\rho-\rho_v)gh_{fg}k_f^3}{\mu_f(T_{sat}-T_w)L}\right]^{1/4}$$

ρ_v is negligible

h_{fg} (at T_{sat} = 100) 2400 kJ/kg

For properties of water see the attached Table.

(b) Write down the physical significance of Nu, St, Pe and Re. Which one is better between Nu and St and why? **(8+3=11)**

Contd P/4

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7. (a) A cross flow heat exchanger with both fluids unmixed is used to heat water (c_p = 4.181 kJ/kg.K) from 40°C to 80°C. The flow rate of water is 1.1 kg/s. What is the overall heat transfer coefficient, if the hot engine oil (c_p = 1.9 kJ/kg.K) is flowing at the rate of 2.6 kg/s? The hot fluid enters at 100°C, and heat transfer area is 20 m^2. (See figure for Q-7) **(17)**

(b) Write short note on- **(6× 3 =18)**

(i) Thermal Expansion

(ii) Impingement Baffles

(iii) Recommended Velocity

(iv) Plate and Frame heat exchanger

(v) Finned tube heat exchanger

(vi) Scrapped surface heat exchanger

8 (a) Write down the assumptions for deriving the expression of LMTD. **(5)**

(b) Draw the schematic diagram and temperature profile for a 2.4 shell and tube heat exchanger. **(8)**

(c) Give the outline for designing a shell and tube heat exchanger when process conditions are given. **(12)**

(d) Write down the names of some commonly employed codes and standards for design and construction of heat transfer equipment. **(5)**

(e) Why counter flow is preferred than parallel flow? **(5)**

Table A-9 Properties of Water (Saturated Liquid)†

Note: $Gr_x Pr = \left(\frac{g\beta\rho^2 c_p}{\mu k}\right)x^3\Delta T$

°C	c_p, kJ/kg·°C	ρ, kg/m³	μ, kg/m·s	k, W/m·°C	Pr	$\frac{g\beta\rho^2 c_p}{\mu k}$, 1/m³·°C
0	4.225	999.8	1.79×10^{-3}	0.566	13.25	1.91×10^9
4.44	4.208	999.8	1.55	0.575	11.35	6.34×10^9
10	4.195	999.2	1.31	0.585	9.40	1.08×10^{10}
15.56	4.186	998.6	1.12	0.595	7.88	1.46×10^{10}
21.11	4.179	997.4	9.8×10^{-4}	0.604	6.78	1.91×10^{10}
26.67	4.179	995.8	8.6	0.614	5.85	2.48×10^{10}
32.22	4.174	994.9	7.65	0.623	5.12	3.3×10^{10}
37.78	4.174	993.0	6.82	0.630	4.53	4.19×10^{10}
43.33	4.174	990.6	6.16	0.637	4.04	4.89×10^{10}
48.89	4.174	988.8	5.62	0.644	3.64	5.66×10^{10}
54.44	4.179	985.7	5.13	0.649	3.30	6.48×10^{10}
60	4.179	983.3	4.71	0.654	3.01	7.62×10^{10}
65.55	4.183	980.3	4.3	0.659	2.73	8.84×10^{10}
71.11	4.186	977.3	4.01	0.665	2.55	9.85×10^{10}
76.67	4.191	973.7	3.72	0.668	2.33	1.09×10^{11}
82.22	4.195	970.2	3.47	0.673	2.16	
87.78	4.199	966.7	3.27	0.675	2.03	
93.33	4.204	963.2	3.06	0.678	1.90	
104.4	4.216	955.1	2.67	0.684	1.66	
115.6	4.229	946.7	2.44	0.685	1.51	
126.7	4.250	937.2	2.19	0.685	1.36	
137.8	4.271	928.1	1.98	0.685	1.24	
148.9	4.296	918.0	1.86	0.684	1.17	
176.7	4.371	890.4	1.57	0.677	1.02	
204.4	4.467	859.4	1.36	0.665	1.00	
232.2	4.585	825.7	1.20	0.646	0.85	
260	4.731	785.2	1.07	0.616	0.83	
287.7	5.024	735.5	9.51×10^{-5}			
315.6	5.703	678.7	8.68			

†Adapted from A. I. Brown and S. M. Marco, "Introduction to Heat Transfer," 3d ed., McGraw-Hill Book Company, New York, 1958.

Properties of Water for Question No. 6(a) ~~and (a)~~

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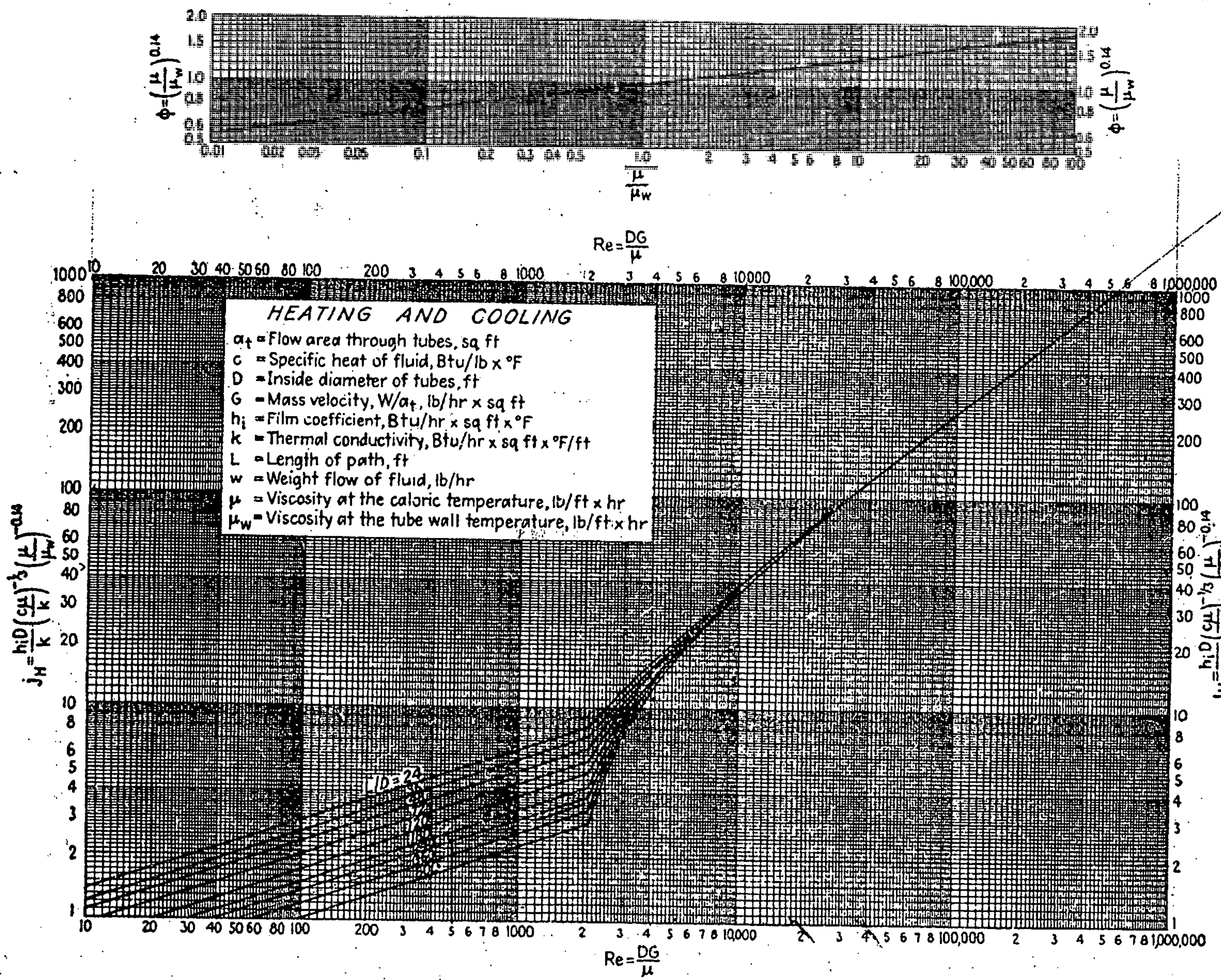

FIG. 24. Tube-side heat-transfer curve. *(Adapted from Sieder and Tate.)*

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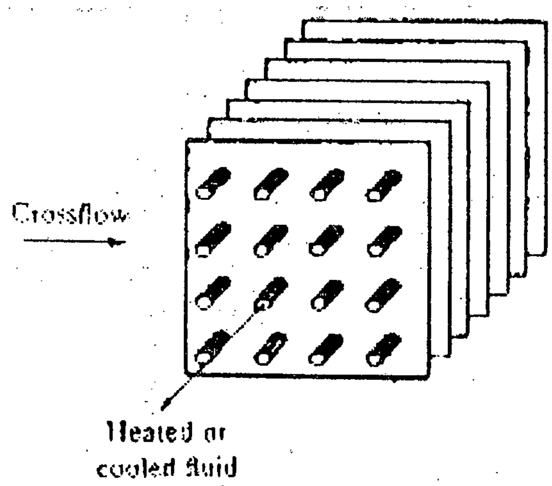
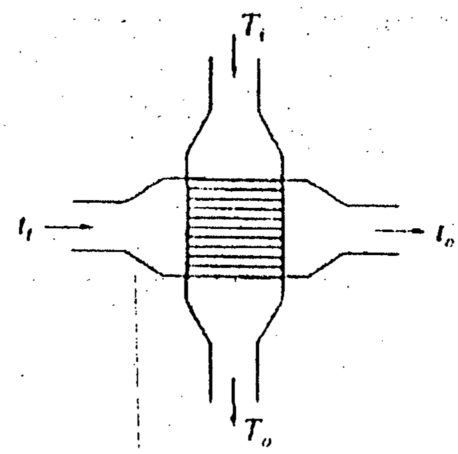
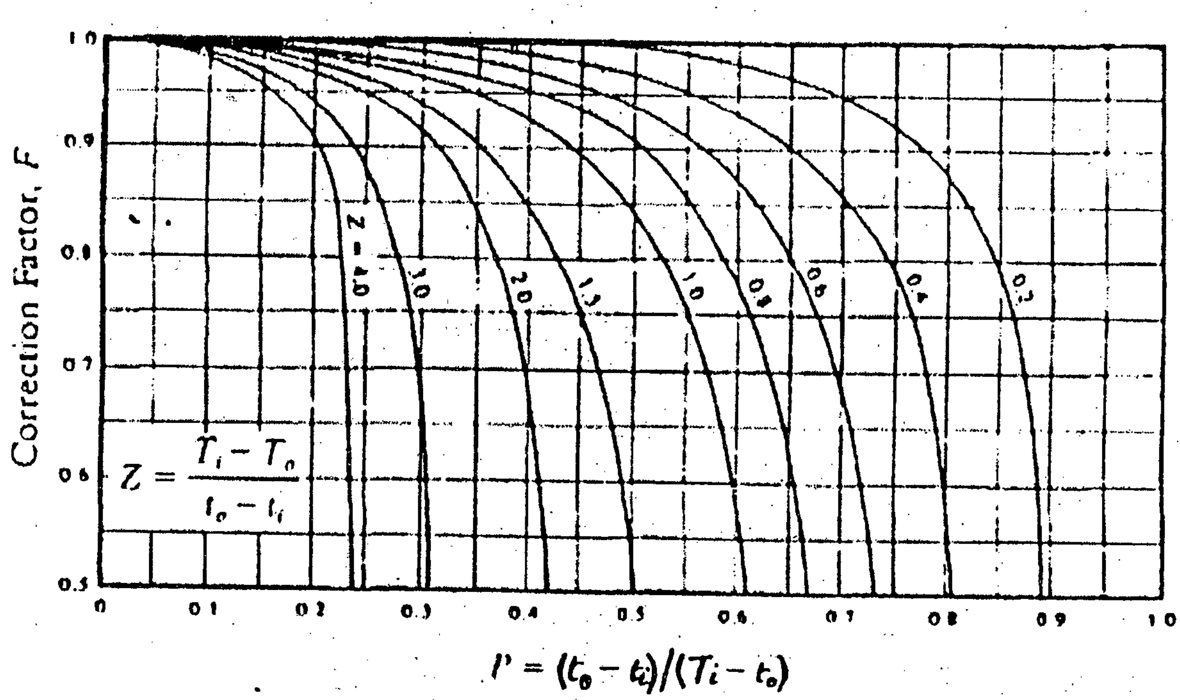
Fig for G-5





Heat Exchanger with Both Fluids Unmixed



Heat exchanger correction factor plot for single pass, crossflow with both fluids unmixed.

Figure for Q ~~8(a)~~ 7(a)

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Figure G-51

HEAT EXCHANGER SPECIFICATION SHEET

1.			JOB NO.
2.	CUSTOMER		REFERENCE NO
3.	ADDRESS		PROPOSAL NO.
4.	PLANT LOCATION		DATE
5.	SERVICE OF UNIT		ITEM NO.
6.	SIZE	TYPE (HORIZ.) (VERT.)	CONNECTED IN
7.	SQ. FT. SURF/UNIT (GROSS)	SHELLS/UNIT	SQ. FT. SURF/SHELL (GROSS)
8.	**PERFORMANCE OF ONE UNIT**		
9.		SHELL SIDE	TUBE SIDE
10.	FLUID CIRCULATED		
11.	TOTAL FLUID ENTERING		
12.	VAPOR		
13.	LIQUID		
14.	STEAM		
15.	NON-CONDENSABLES		
16.	FLUID VAPORIZED OR CONDENSED		
17.	STEAM CONDENSED		
18.	GRAVITY		
19.	VISCOSITY		
20.	MOLECULAR WEIGHT		
21.	SPECIFIC HEAT	BTU/LB.°F	BTU/LB.°F
22.	THERMAL CONDUCTIVITY	BTU/HR.FT.°F	BTU/HR.FT.°F
23.	LATENT HEAT	BTU/LB	BTU/LB
24.	TEMPERATURE IN	°F	°F
25.	TEMPERATURE OUT	°F	°F
26.	OPERATING PRESSURE	PSIG	PSIG
27.	NO. PASSES PER SHELL		
28.	VELOCITY	FT/SEC	FT/SEC
29.	PRESSURE DROP	PSI	PS
30.	FOULING RESISTANCE (MIN.)		
31.	HEAT EXCHANGED (BTU/HR)	MTD CORRECTED. °F	
32.	TRANSFER RATE SERVICE	CLEAN	
33.	**CONSTRUCTION OF ONE SHELL**		
34.	DESIGN PRESSURE	PSI	PSI
35.	TEST PRESSURE	PSI	PSI
36.	DESIGN TEMPERATURE	°F	°F
37.	TUBES NO. O.D.	BWG	LENGTH PITCH
38.	SHELL I.D. O.D.	SHELL COVER	(INTEG) (REMOV)
39.	CHANNEL OR BONNET	CHANNEL COVER	
40.	TUBE SHEET-STATIONARY	TUBESHEET.FLOATING	
41.	BAFFLES – CROSS TYPE	FLOATING HEAD COVER	
42.	BAFFLES – LONG TYPE	IMPINGEMENT PROTECTION	
43.	TUBE SUPPORTS		
44.	TUBE TO TUBE SHEET JOINT		
45.	GASKETS		
46.	CONNECTIONS- SHELL SIDE IN	OUT	RATING
47.	CHANNEL SIDE IN	OUT	RATING
48.	CORROSION ALLOWANCE – SHELL SIDE		TUBE SIDE
49.	CODE REQUIREMENTS		TEAM CLASS
50.	REMARKS		
51.			
52.			
53.			
54.			

STANDARDS OF TUBULAR EXCHANGER MANUFACTURES ASSOCIATION

TEMA sheet for Question No. 5 (F)

N.B.: This sheet must be filled up and attached with the answer script.

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26/12/2011

ChE 301

Table A-5 Properties of Air at Atmospheric Pressure†

The values of μ, k, c_p, and Pr are not strongly pressure-dependent and may be used over a fairly wide range of pressures.

T, K	ρ kg/m³	c_p, kJ/kg°C	μ, kg/m s × 10^5	ν, m²/s × 10^6	k, W/m°C	α, m²/s × 10^4	Pr
100	3.6010	1.0266	0.6924	1.923	0.009246	0.02501	0.770
150	2.3675	1.0099	1.0283	4.343	0.013735	0.05745	0.753
200	1.7684	1.0061	1.3289	7.490	0.01809	0.10165	0.739
250	1.4128	1.0053	1.5990	11.31	0.02227	0.15675	0.722
300	1.1774	1.0057	1.8462	15.69	0.02624	0.22160	0.708
350	0.9980	1.0090	2.075	20.76	0.03003	0.2983	0.697
400	0.8826	1.0140	2.286	25.90	0.03365	0.3760	0.689
450	0.7833	1.0207	2.484	31.71	0.03707	0.4222	0.683
500	0.7048	1.0295	2.671	37.90	0.04038	0.5564	0.680
550	0.6423	1.0392	2.848	44.34	0.04360	0.6532	0.680
600	0.5879	1.0551	3.018	51.34	0.04659	0.7512	0.680
650	0.5430	1.0635	3.177	58.51	0.04953	0.8578	0.682
700	0.5030	1.0752	3.332	66.25	0.05230	0.9672	0.684
750	0.4709	1.0856	3.481	73.91	0.05509	1.0774	0.686
800	0.4405	1.0978	3.625	82.29	0.05779	1.1951	0.689
850	0.4149	1.1095	3.765	90.75	0.06028	1.3097	0.692
900	0.3925	1.1212	3.899	99.3	0.06279	1.4271	0.696
950	0.3716	1.1321	4.023	108.2	0.06525	1.5510	0.699
1000	0.3524	1.1417	4.152	117.8	0.06752	1.6779	0.702
1100	0.3204	1.160	4.44	138.6	0.0732	1.969	0.704
1200	0.2947	1.179	4.69	159.1	0.0782	2.251	0.707
1300	0.2707	1.197	4.93	182.1	0.0837	2.583	0.705
1400	0.2515	1.214	5.17	205.5	0.0891	2.920	0.705
1500	0.2355	1.230	5.40	229.1	0.0946	3.262	0.705
1600	0.2211	1.248	5.63	254.5	0.100	3.609	0.705
1700	0.2082	1.267	5.85	280.5	0.105	3.977	0.705
1800	0.1970	1.287	6.07	308.1	0.111	4.379	0.704
1900	0.1858	1.309	6.29	338.5	0.117	4.811	0.704
2000	0.1762	1.338	6.50	369.0	0.124	5.260	0.702
2100	0.1682	1.372	6.72	399.6	0.131	5.715	0.700
2200	0.1602	1.419	6.93	432.6	0.139	6.120	0.707
2300	0.1538	1.482	7.14	464.0	0.149	6.540	0.710
2400	0.1458	1.574	7.35	504.0	0.161	7.020	0.718
2500	0.1394	1.688	7.57	543.5	0.175	7.441	0.730

†From *Natl. Bur. Stand. (U.S.) Circ.* 564, 1955.

Table for Q. 3(c)

26/12/2011 Fig for Q. 5

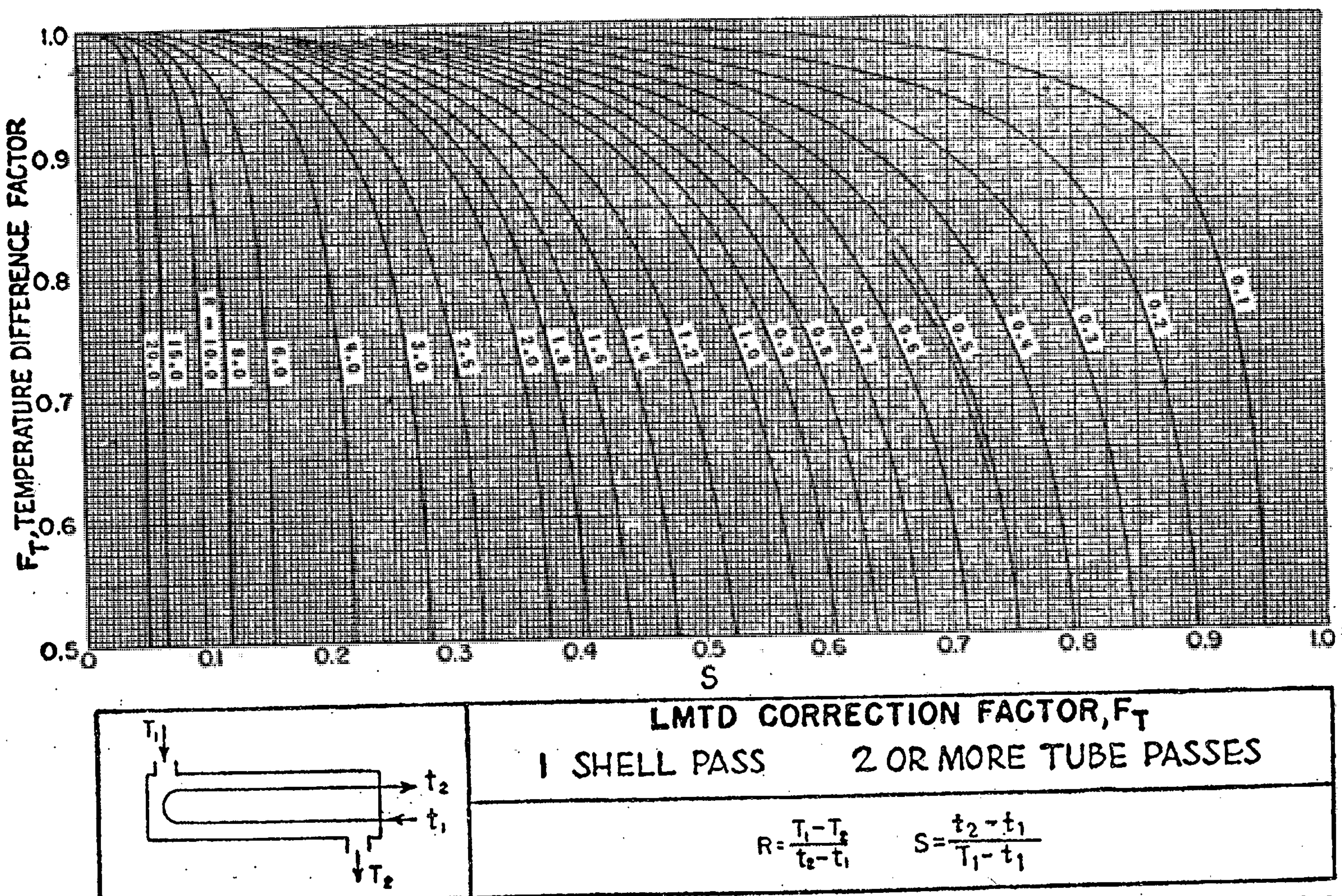


FIG. 18. LMTD correction factors for 1-2 exchangers. (*Standards of Tubular Exchanger Manufacturers Association*, 2d ed., *New York*, 1949.)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2010-2011

Sub : **CHE 307** (Chemical Engineering Thermodynamics II)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols and notations have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A concentrated binary solution containing mostly species 2 (but $x_2 \neq 1$) is in equilibrium with a vapor phase containing both species 1 and 2? The pressure of this two-phase system is 1 bar; the temperature is 25°C. Estimate x_1 and y_1 from the following data. **(15)**

$$H_1 = 200 \text{ bar} \qquad P_2^{Sat} = 0.1 \text{ bar}$$

State and justify all assumptions.

(b) A binary system of species 1 and 2 consists of vapor and liquid phases in equilibrium at temperature T. The overall mole fraction of species 1 in the system is $z_1 = 0.65$. **(20)**

At temperature T,

$$\ln\gamma_1 = 0.67\, x_2^2 \qquad \ln\gamma_2 = 0.67\, x_1^2$$

$$P_1^{Sat} = 32.27 \text{ KPa} \qquad P_2^{Sat} = 73.14 \text{ KPa}$$

Assuming the validity of modified Raoult's law.

(i) Over what range of pressures can this system exist as two phases at given T and z_1?

(ii) Show whether or not the system exhibits an azeotrope.

2. (a) For the ammonia synthesis reaction **(17)**

$$\frac{1}{2}N_2(g) + \frac{3}{2}H_2(g) \rightarrow NH_3(g)$$

with 0.5 mol N_2 and 1.5 mol H_2 as the initial amounts of reactants with the assumption that the equilibrium mixture is an ideal gas, show that:

$$\varepsilon_e = 1 - \left(1 + 1.299\, K \frac{P}{P^o}\right)^{-1/2}$$

(b) Carbon black is produced by the decomposition of methane **(18)**

$$CH_4(g) \rightarrow C(s) + 2H_2(g)$$

For equilibrium at 650°C and 1 bar find the gas phase composition if pure methane enters the reactor. Use the booklet for standard enthalpy and Gibbs energy of formation. Ignore the effect of temperature on enthalpy in your calculation.

Contd P/2

CHE 307

3. (a) Write down the algorithm for the calculation of BUBL P by gamma/phi formulation. List the equations needed to execute the algorithm. **(15)**

(b)Derive the general relation between n, the moles adsorbed and $\bar{P}$, the gas pressure in terms of compressibility factor, z for pure gas adsorption. Find the adsorption isothermal for $z = 1 + \beta n$, where β is a function of T only. Write down the condition when it reduces to Longmuir isotherm. **(20)**

4. (a) Derive an expression for osmotic pressure for a dilute solution in an osmotic system using the concept of fugacity. **(13)**

(b) Determine the number of degrees of freedom F for (i) a system prepared by partially decomposing $CaCo_3$ into an evacuated space and (ii) a system prepared by partially decomposing NH_4Cl into an evacuated space. **(14)**

(c) Draw the P, x, y diagram of a binary mixture at constant T. Show the P_x relation for Raoult's law by a dashed line on the diagram. **(8)**

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) A vapor-compression refrigeration system is conventional except that a countercurrent heat exchanger is installed to subcool the liquid from the condenser by heat exchange with the vapor stream from the evaporation. The minimum temperature difference for heat transfer is 10°F. Tetrafluoroethane is the refrigerant [Fig. for Q. 5(a)] evaporating at 20°F and condensing at 80°F. The heat load on the evaporator is 2000 Btu/s. If the compressor efficiency is 75%, what is the power requirement? How does this result compare with the power required by the compressor if the system operates without the heat exchanger? How do the refrigerant circulation rates compare for the two cases? **(24)**

(b) What is the more effective way to increase the coefficient of performance of a Carnot refrigerator: to increase T_C with T_H constant or to decrease T_H with T_C constant. For a real refrigerator, does either of these strategies make sense? **(11)**

6. (a) The excess Gibbs energy of a particular ternary liquid mixture is represented by the empirical expression with parameters A_{12}, A_{13} and A_{23} functions of T and P only **(10+10=20)**

$$G^E/RT = A_{12}\,x_1x_2 + A_{13}\,x_1x_3 + A_{23}\,x_2x_3$$

(i) Determine the implied expressions for $\ln\gamma_1$, $\ln\gamma_2$ and $\ln\gamma_3$.

(ii) For species 1 determine expressions for $\ln\gamma_1$ for the limiting cases:

$$x_1 = 0,\quad x_2 = 0 \text{ and } x_3 = 0$$

What does these limiting cases represent?

Contd P/3

CHE 307

Contd ... Q. No. 6

(b) Given below are values of G^E, H^E nd $C_P{}^E$ for some equimolar binary liquid mixtures at 298 K. Estimate values of G^E, H^E and S^E at 328 K by two procedures: (i) Use all the data, (ii) Assume $C_P{}^E = 0$. **(15)**

Compare and discuss your results for the two procedures.

Acetone/Chloroform: $G^E = -622$ J/mol

$H^E = -1920$ J/mol

$C_P{}^E = 4.2$ J/mol-k

7. The following is a set of VLE data for the system methanol/water at 333 K **(35)**

P/KPa	x_1	y_1	P/KPa	x_1	y_1
19.95	0.0	0.0	60.6	0.53	0.81
39.2	0.16	0.56	63.9	0.60	0.84
42.9	0.22	0.63	67.9	0.68	0.87
48.8	0.31	0.69	72.8	0.78	0.91
52.7	0.36	0.73	84.56	1.0	1.0
56.6	0.44	0.77			

(a) Find parameter values for the Margules equation that provide the best fit of G^E/RT to the data.

(b) Prepare a P_{xy} diagram that compares the experimental points with curves determined from the correlation.

Note that: $\ln\gamma_1^{\alpha} = A_{12}$ $(x_1 = 0)$ and $\ln\gamma_2^{\alpha} = A_{21}$ $(x_2 = 0)$ where A_{12} and A_{21} are parameters of Margules equations.

8. (a) If pure liquid H_2SO_4 at 80°F is added adiabatically to pure liquid water at 80°F to form a 40 wt% solution, what is the final temperature of the solution? **(10)**

(b) If a liquid solution of HCl in water, containing 1 mol of HCl and 4.5 mol of H_2O absorbs an additional 1 mol of HCl (g) at the constant temperature of 25°C, what is the heat effect? **(13)**

(c) What is the heat effect when 20 kg of LiCl (s) is added to 125 kg of an aqueous solution containing 10 wt% LiCl in an isothermal process at 25°C? [MW of LiCl = 42.39] **(12)**

For Q. 5(a)

Table 9.1: Thermodynamic properties of saturated tetrafluoroethane†

		Volume $(ft)^3(lb_m)^{-1}$		Enthalpy $(Btu)(lb_m)^{-1}$		Entropy $(Btu)(lb_m)^{-1}(R)^{-1}$	
t(°F)	P(psia)	V^l	V^v	H^l	H^v	S^l	S^v
−40	7.429	0.01132	5.782	0.000	97.050	0.00000	0.23125
−35	8.577	0.01139	5.053	1.489	97.804	0.00352	0.23032
−30	9.862	0.01145	4.432	2.984	98.556	0.00701	0.22945
−25	11.297	0.01152	3.901	4.484	99.306	0.01048	0.22863
−20	12.895	0.01158	3.445	5.991	100.054	0.01392	0.22786
−15	14.667	0.01165	3.052	7.505	100.799	0.01733	0.22714
−10	16.626	0.01172	2.712	9.026	101.542	0.02073	0.22647
−5	18.787	0.01180	2.416	10.554	102.280	0.02409	0.22584
0	21.162	0.01187	2.159	12.090	103.015	0.02744	0.22525
5	23.767	0.01194	1.934	13.634	103.745	0.03077	0.22470
10	26.617	0.01202	1.736	15.187	104.471	0.03408	0.22418
15	29.726	0.01210	1.563	16.748	105.192	0.03737	0.22370
20	33.110	0.01218	1.410	18.318	105.907	0.04065	0.22325
25	36.785	0.01226	1.275	19.897	106.617	0.04391	0.22283
30	40.768	0.01235	1.155	21.486	107.320	0.04715	0.22244
35	45.075	0.01243	1.048	23.085	108.016	0.05018	0.22207
40	49.724	0.01252	0.953	24.694	108.705	0.05359	0.22172
45	54.732	0.01262	0.868	26.314	109.386	0.05679	0.22140
50	60.116	0.01271	0.792	27.944	110.058	0.05998	0.22110
55	65.895	0.01281	0.724	29.586	110.722	0.06316	0.22081
60	72.087	0.01291	0.663	31.239	111.376	0.06633	0.22054
65	78.712	0.01301	0.608	32.905	112.019	0.06949	0.22028
70	85.787	0.01312	0.558	34.583	112.652	0.07264	0.22003
75	93.333	0.01323	0.512	36.274	113.272	0.07578	0.21979
80	101.37	0.01335	0.472	37.978	113.880	0.07892	0.21957
85	109.92	0.01347	0.434	39.697	114.475	0.08205	0.21934
90	119.00	0.01359	0.400	41.430	115.055	0.08518	0.21912
95	128.63	0.01372	0.369	43.179	115.619	0.08830	0.21890
100	138.83	0.01386	0.341	44.943	116.166	0.09142	0.21868
105	149.63	0.01400	0.315	46.725	116.694	0.09454	0.21845
110	161.05	0.01415	0.292	48.524	117.203	0.09766	0.21822
115	173.11	0.01430	0.270	50.343	117.690	0.10078	0.21797
120	185.84	0.01447	0.250	52.181	118.153	0.10391	0.21772
125	199.25	0.01464	0.231	54.040	118.591	0.10704	0.21744
130	213.38	0.01482	0.214	55.923	119.000	0.11018	0.21715
135	228.25	0.01502	0.198	57.830	119.377	0.11333	0.21683
140	243.88	0.01522	0.184	59.764	119.720	0.11650	0.21648
150	277.57	0.01567	0.157	63.722	120.284	0.12288	0.21566
160	314.69	0.01620	0.134	67.823	120.650	0.12938	0.21463
170	355.51	0.01683	0.114	72.106	120.753	0.13603	0.21329

†Adapted by permission from *ASHRAE Handbook: Fundamentals*, p. 17.29, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1993

For Q. 5(a)

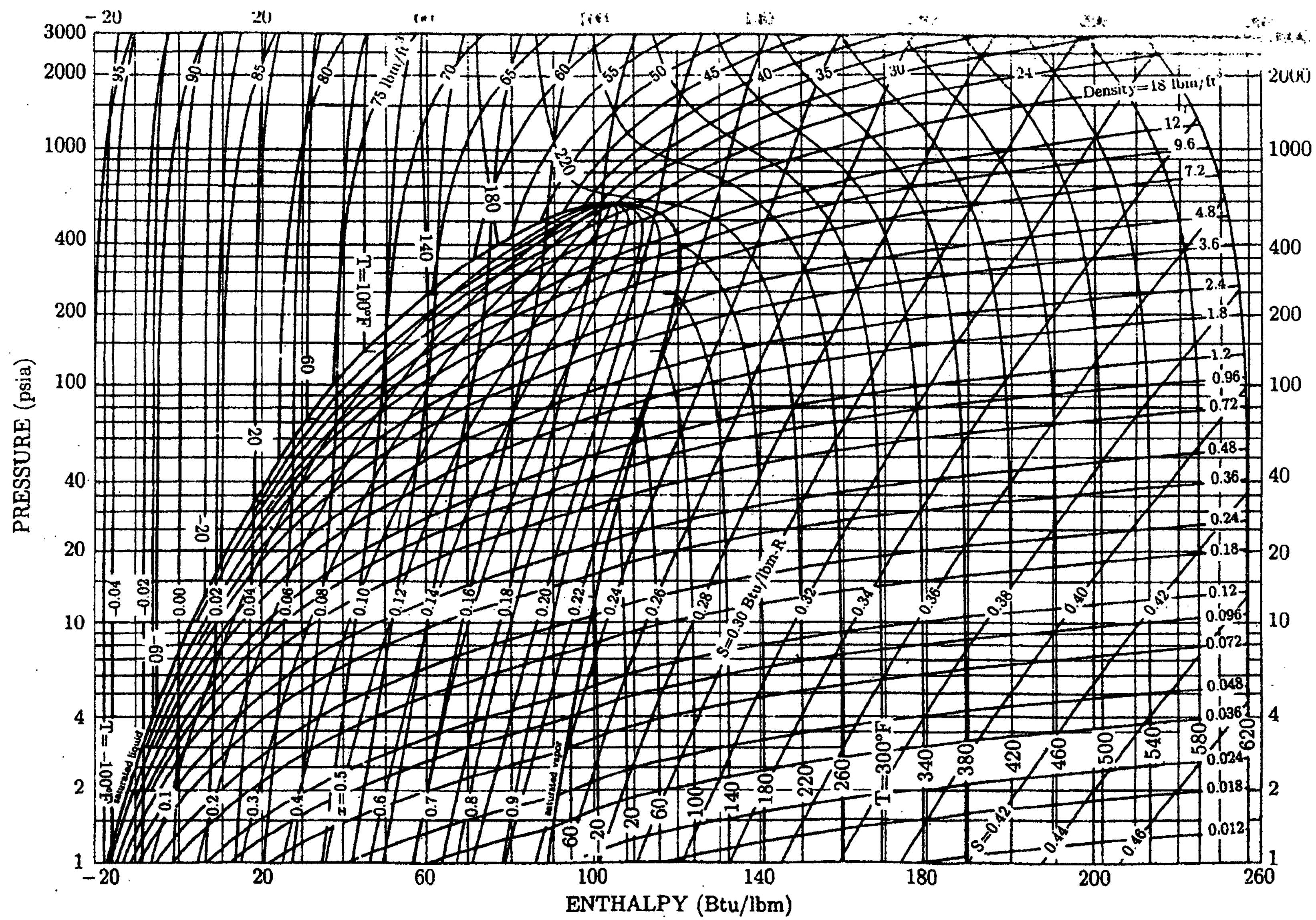


Figure 9.3: *PH* diagram for tetrafluoroethane(HFC-134a). (*Reproduced by permission. ASHRAE Handbook: Fundamentals*, p. 17.28, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, 1993.)

For · Q no. 8(a)

Enthalpy-composition diagram for water-sulfuric acid mixtures at 1 atm

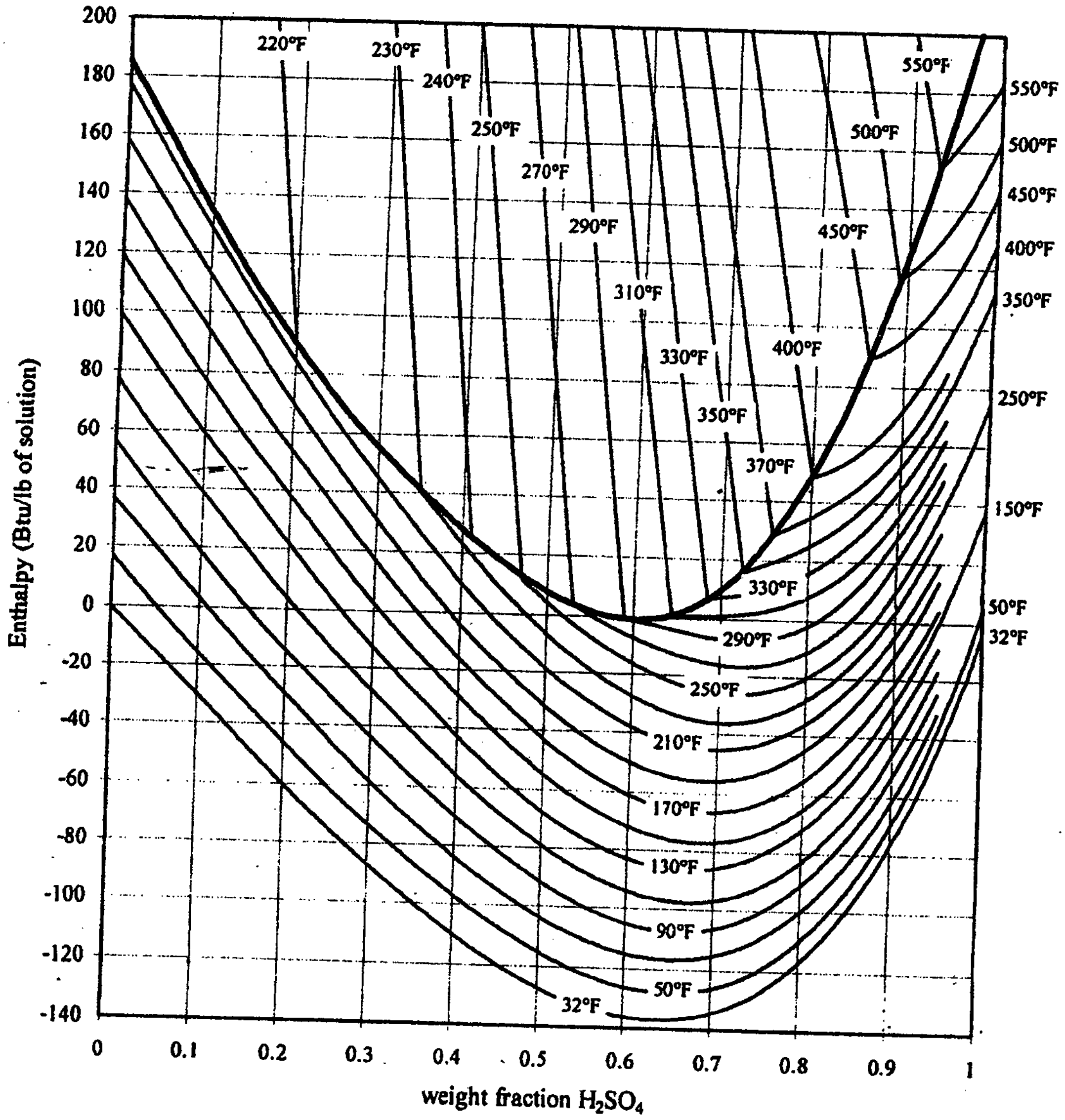
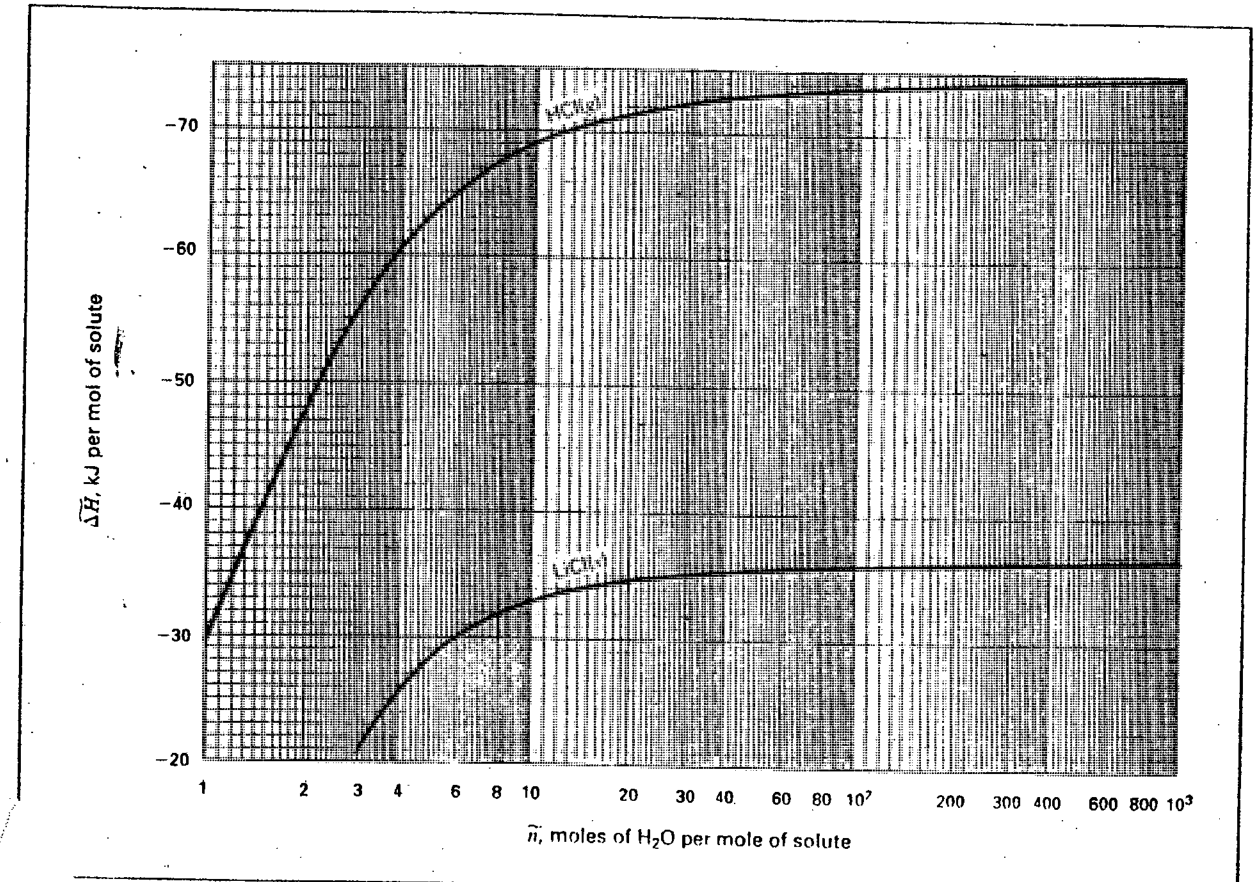


Diagram adapted from Hougen, O. A., Watson, K. M. 1946. *Chemical Process Principles Charts*, Wiley & Sons.

Fig. for Q 8.(b) & 8(c)



.14: Heats of solution at 25°C. (Based on data from "The NBS Tables of Chemical Thermodynamic Properties," *J. Phys. Chem. Ref. Data*, ol. 2, 1982.)

L-3/T-1/CHE **Date : 28/02/2012**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2010-2011

Sub : **MATH 323** (Fourier Analysis, Harmonic Functions and Partial Differential Equations)

Full Marks: 210 Time : 3 Hours

The figures in the margin indicate full marks.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Answer any **THREE**.

Symbols have their usual meaning

1. (a) Expand $f(x) = x^2$, $0 < x < 2\pi$, in a Fourier series if the period is 2π. Hence show that **(18)**

$$\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{3^2}+\ldots\ldots=\frac{\pi^2}{6}$$

(b) Draw the graph of the function f(x) defined as **(17)**

$$f(x)=\begin{cases} 0 & ; \quad 0 \le x < \pi \\ \sin x & ; \quad \pi \le x \le 2\pi \end{cases} \quad \text{period } 2\pi$$

Find the Fourier cosine series of f(x) and discuss the convergence of the series.

2. (a) Find the Fourier transform of **(18)**

$$f(x)=\begin{cases} 1 & , \quad |x| < a \\ 0 & , \quad |x| > a \end{cases}$$

Graph f(x) and its Fourier Transform for a = 3 use the above result to evaluate

$$\int_{-\infty}^{\infty} \frac{\sin \alpha a \cos \alpha x}{\alpha} d\alpha$$

Deduce the value of $\int_{0}^{\infty} \frac{\sin u}{u} du$

(b) Use Fourier transform to solve the boundary value problem **(17)**

$$\frac{\partial u}{\partial t} = k\,\frac{\partial^2 u}{\partial x^2},\ u(x, 0) = f(x).\ |u(x, t)| < M$$

where $-\infty < x < \infty$, $t > 0$.

Give a physical interpretation.

3. (a) Use Fourier integral to show that **(17)**

$$\int_{0}^{\infty} \frac{x \sin \lambda x}{x^2+1} dx = \frac{\pi}{2} e^{-\lambda},\ \lambda > 0$$

(b) A semi – infinite thin bar ($x \ge 0$) whose surface is insulated has an initial temperature equal to f(x). A temperature of zero is suddenly applied to the end x = 0 and maintained. The boundary value problem for the temperature u(x, t) at any point x at time t, is **(18)**

$$\frac{\partial u}{\partial t} = k\,\frac{\partial^2 u}{\partial x^2} \quad x > 0,\ t > 0$$

u (x, 0) = f(x), u(0, t) = 0, |u(x, t)| < M

Find the temperature u(x, t) at any later time t, by using Fourier integral.

Contd P/2

MATH 323

4. (a) Find the Fourier transform of **(18)**

$$f(x) = \begin{cases} 1-x^2 & , \ |x|<1 \\ 0 & , \ |x|>1 \end{cases}$$

and evaluate $\int_0^\infty \left(\frac{x\cos x - \sin x}{x^3}\right)\cos\frac{x}{2}\,dx$

(b) Solve and physically interpret the following boundary value problem **(17)**

$$\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}=0 \quad y>0$$

$$u(x, 0) = \begin{cases} -1 & , \ x<0 \\ 1 & , \ x>0 \end{cases} \qquad u(x, y) < M$$

SECTION – B

There are **FOUR** questions in this Section. Answer any **THREE**.

5. (a) Solve the PDE: $p\cos(x+y)+ q \sin(x+y) = z$. **(10)**

(b) Find the complete and singular (if exists) integral of the equation $pxy+pq+qy-yz=0$. **(12)**

(c) Find the integral surface of the equation $(x - y)y^2p+(y-x)x^2q = (x^2+y^2)z$ which passes through the curve $xz = a^3$, $y = 0$. **(13)**

6. Solve the following higher order PDEs

(a) $\left(D_x^2+6D_xD_y+6D_y^2\right)z=\frac{1}{y-2x}+xy$ **(11)**

(b) $\left(3D_xD_y-2D_y^2-D_y\right)z=x^2\sin(x+y)$ **(12)**

(c) $\left(x^2D_x^2-4xyD_xD_y+4y^2D_y^2+6yD_y\right)z=x^3y^4$ **(12)**

7. (a) Find a surface satisfying $r + s = 0$ and touching the elliptic paraboloid $z = 4x^2 + y^2$ along its section by the plane $y = 2x + 1$. **(20)**

(b) A long rectangular plate of width a cm insulated surface has its temperature v equal to zero on both the long sides and one of the short sides so that **(15)**

$v(0, y) = 0 \qquad v(a, y) = 0$

$v(x, 0) = kx \qquad v(x, \infty) = 0$

Find the temperature of the plate.

8. (a) Find the circular harmonics. show that when the potential function on the boundary of a circle of radius R are given by $v(R, \theta) = F(\theta)$, the potential at any interior point is given by $v(r, \theta) = \frac{1}{\pi}\int_{-\pi}^{\pi}\left[\frac{1}{2}+\sum_{n=1}^{\infty}\left(\frac{r}{R}\right)^n\cos n(\theta-u)\right]F(u)du.$ **(20)**

(b) Solve the Laplace's equation $\nabla^2 v = 0$ in spherical polar coordinates (r, θ, φ) when v is independent of φ. Hence find the potential at any point due to a ring of radius a. **(15)**
