

الموضوع : انتقال الحرارة
الوقت : ثلاث ساعات
الامتحان : درجات مانع

الامتحانات النهائية / الدور الأول
2008 \ 6 \ 8

الجامعة التكنولوجية
قسم الهندسة الكيميائية
الصف الثالث

ملاحظة : الاجابه على اربعة اسئلة فقط وضمنها الأول والرابع

Q1 : Answer briefly the following questions:

- 1) Discuss the factors that influence the value of heat transfer coefficient for fluids flowing under condition of forced convection inside tube?
- 2) What is the physical meaning of Biot number ?
- 3) Discuss the cases for temperatures change with Heat Exchanger area ?
- 4) Define the thermal diffusivity ?
- 5) What is meant by the term "Fin Efficiency" ?

Q2 : Explain an experimental procedure and the way of analyzing the data in order to determine the values of c, m, and n in the general equation:

$$Nu = c Re^m Pr^n$$

Q3 : Air at 2 atm and 200 °C is heated as it flows through a tube of a diameter 2.54 cm. at a velocity of 10 m/s . Calculate the heat transfer per unit length of the tube if a constant -heat- flux condition is maintained at wall and the wall temperature is 20 °C above the air temperature along the length of the tube . How much would the bulk temperature increase over 3 m length of the tube ?

Q4 : A) It is desired to heat 230 kg/h of water from 35 to 93 °C with oil having an initial temperature of 175 °C. The mass flow of oil is also 230 kg/h , Cp of water = 4180 J/kg.°C, Cp of oil = 2100 J/kg.°C

Two double -pipe heat exchanger are available:

- 1) $U = 570 \text{ W/m}^2 \cdot \text{C}$ $A = 0.47 \text{ m}^2$
- 2) $U = 370 \text{ W/m}^2 \cdot \text{C}$ $A = 0.94 \text{ m}^2$

Which exchanger should be used ?

B) For a solid body suddenly placed in a large volume of liquid with heat flow either to or from the body show that :

$$\theta/\theta_0 = \text{EXP} (- Bi \cdot Fo) , \text{ where } \theta = T - T_f, T_f = \text{fluid temp.}, \theta = \theta_0 \text{ at time } \tau = 0 .$$

Q5 : Derive an expression for the condensation of a vapor on a vertical surface stating your assumptions :

$$\bar{h} = 0.943 \{ \lambda \rho^2 g k^3 / \mu \Delta T x \}^{0.25}$$

Q6 : The bottom of copper pan, 0.3 m in diameter is maintained at 391 K by an electric heater .

Estimate the power required to boil water in this pan. What is the evaporation rate ? Estimate the maximum heat flux.

Given the following at 100 °C :

$C_p = 4217 \text{ J/kg K}$, $\lambda = 2.257 \times 10^6 \text{ J/kg}$, $\mu = 2.79 \times 10^{-4} \text{ kg/m s}$, $k = 0.68 \text{ W/m K}$, $\sigma = 58.9 \text{ mN/m}$, $\rho_f = 957.9 \text{ kg/m}^3$, $C_{sf} = 0.01$, $\rho_v = 0.5955 \text{ kg/m}^3$, $Pr_f = 1.76$.

Good Luck

بسم الله الرحمن الرحيم

المادة: الديمقراطية

امثلة الامتحان النهائي

الجامعة التكنولوجية

المرحلة: الثالثة

للعام الدراسي 2008/2007

قسم الهندسة الكيميلوية

الزمن : 3 ساعات

ملاحظة: الاجابة على اربعة اسئلة فقط

س¹ : عرف ما يأتي (10 فقط): (20 درجة)

- | | |
|-------------------------|----------------------------|
| 1- جان جاك روسو | 7 - الديمقراطية المباشرة |
| 2 - الصكوك الغفرانية | 8 - ديانا رافيتش |
| 3 - الحقوق السياسية | 9 - رينيه ديكارت |
| 4 - النظام التوتاليتاري | 10 - نظام الهواة |
| 5 - ابراهام لنكولن | 11 - عمليات التلقين الفكري |
| 6 - الحزب المسيطر | 12 - كارل ماركس |

س² : تكلم عن الخلفية التاريخية للديمقراطية. (15 درجة)

س³ : عدد خصائص النظام الديمقراطي. (15 درجة)

س⁴ : ما هي علاقة الديمقراطية بالتربية والتعظيم؟. (15 درجة)

س⁵ : ما هو مفهوم جماعات الضغط؟ تكلم عنها بالتفصيل (15 درجة)

مع تمنياتي لكم بالموفقية والنجاح

مدرسة المادة.

Note : Answer only four questions.

Q1) A tubular chemical reactor of length (L) m and cross section area (A) m² is employed to carry out 1st order chemical reaction $A \xrightarrow{K} B$. Find the concentration (C_A) equation as a function of distance (X) into reactor under steady state condition.

Where : U: Velocity , D: Diffusivity , K: reaction rate constant , C_A: concentration of A .
(20 Marks)

Q2) Find the solution of the following equation:

$$t(1-t)y'' - (5t-2)y' - 4y = 0$$

$$\text{where: } y' = \frac{dy}{dt} , y'' = \frac{d^2y}{dt^2}$$

(20 Marks)

Q3) Obtain the solution of the heat conduction equation:

$$\frac{\partial^2 T}{\partial Z^2} - \alpha \frac{\partial T}{\partial t} = 0$$

Which satisfies the boundary conditions :

$$\begin{aligned} T(0, t) &= 0 & t \geq 0 \\ T(Z, 0) &= f(Z) & 0 \leq Z \leq 1 \end{aligned}$$

(20 Marks)

Q4) Isolated metal heating tank (continuous process) with cylindrical shape and have thickness of (Z) m and surface area of (A) m² is used to heat (M) kg of water with initial temperature of (T₀) C°. Electrical heater (Q) watts is used . If the power of heater is increased gradually (Q(t) = 4t). What is the response equation of the water temperature (T) into tank.

(20 Marks)

Q5) Solve (numerically) by using two methods the following equation:

$$y^2 - y \frac{dw}{dy} = W$$

If y₀ = w₀ = 1 . What is the value of W , when y = 3 . Discuss your results .

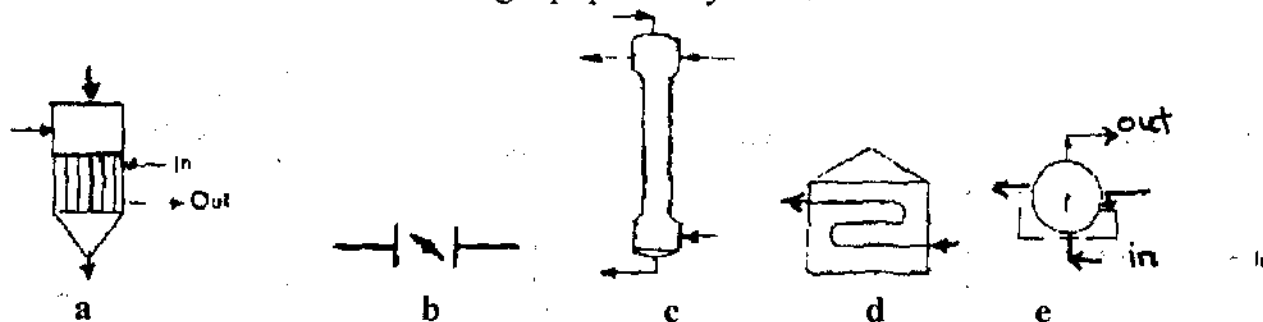
(20 Marks)

Answer Four Questions

Q1

A- What are the main considerations that must be applied by the chemical engineer in order to select the position (site) of any chemical plant?

B- Write the name of the following equipment symbols:



Q2 In petroleum refining process it is required to design a bubble cap tray that used as an internal in the distillation column. The following information are given in this case:

The material is Benzene, molecular weight = 78

Pressure is atmospheric, Liquid density = 50 lb/ft^3 , vapour density = 0.17 lb/ft^3

Liquid load = 600 gal/min , Vapour load = $400 \text{ ft}^3/\text{sec}$, Take $C_s = 0.74$

Q3 Write the steps of complete design procedure for shell and tube heat exchanger. Assuming that the hot fluid is liquid benzene and the cold fluid is water. And write all necessary design equations.

Q4 Design liquid surge drum holding reduced crude (RC). It is located between two distillation column (atmospheric & vacuum distillation). The drum diameter is (2 m) and the operating pressure is (53 bar) and operating temperature 200°C . Calculate the following:-

- The design and test pressures of the drum.
- The cost of the surge drum of new volume (Twice (two-folds) of the original one in m^3) knowing that, the cost of original drum capacity was 0.1 million \$.
- Thickness of the material of construction, $f = 1400 \text{ kg/m}^2$.

Q5 A feed mixture containing two liquids (Light liquid "A" of 63 wt%) and (heavy liquid "B" of 37 wt%). Therefore, it is required to design horizontal liquid-liquid separator using the following information.

- The two liquids mixture having a flow rate of 2000 kg/hr
- The operating temperature is 30°C , The operating pressure is 25 bar
- Liquid A : density = 800 kg/m^3 and Viscosity $\mu_L = 0.55 \text{ centipoise}$
- Liquid B : density = 1000 kg/m^3 and Viscosity $\mu_h = 0.72 \text{ centipoise}$
- $k_s = 0.05$, and $(A_h/A) = 0.2$

Good Luck
10-6-2008

Bubble Cap Tray Design

a) standard bubble cap design for trapezoidal slots with $C_s = 0.74$

material	carbon steel		
nominal size	<u>3"</u>	<u>4"</u>	<u>6"</u> inch
no. of slots	10	26	39
slot height	1	1.25	1.5
slot area	5	8.12	14.64 inch ²
cap area	7.5	13.15	29 inch ²
slot to cap ratio	0.67	0.62	0.5

b) bubble cap size and slot area

	ratio of slot/allocated cap area			
nominal cap size inch	<u>=0.25</u>	<u>=0.3125</u>	<u>=0.375</u>	<u>=0.5</u>
3"	0.39	0.35	0.32	0.27
4"	0.36	0.33	0.30	0.25
6"	0.29	0.26	0.24	0.20

c) tray type selection

estimated tower dia	ft	range of liquid	capacity gpm		
		<u>reverse flow</u>	<u>cross flow</u>	<u>double pass</u>	<u>cascade double pass</u>
3		0.30	30-200		
4		0.40	40-300		
6		0.50	50-400	400-700	
8		0.50	50-500	500-800	
10		0.50	50-500	500	900-1400
12		0.50	50-500	500-1000	1000-1600
15		0.50	50-500	500-1100	1100-1800
20		0.50	50-500	500-1100	1100-2000

d) distribution of area as % of tower area

tower dia	ft	<u>down flow area</u>		<u>liquid distribution area</u>			<u>end and wastage</u>
		cross flow	double pass	cross flow	double pass	cascade double pass	
3		10-20		10-25			10-30
4		10-20		8-20			7-22
6		10-20	20-30	5-12	15-20		5-18
8		10-20	18-27	4-10	12-16		4-15
10		10-20	16-24	3-8	9-13	20-30	3-12
12		10-20	14-21	3-6	8-11	15-25	3-10
15		10-20	12-18	2-5	6-9	12-20	2-8
20			10-15		5-7	9-15	2-6

e) tray design standard

nominal size for		
2.5-5	ft tower	3 inch
4-15	ft tower	4 inch
10-20	ft tower	6 inch

Answer four questions only

Q.1) The strength of bars is normally distributed with mean 28.4 and standard deviation of 2.95. To ensure safety, a customer requires at least 95% of the bars to be greater than 24.0.

- A) Do the bars meet the specification?
- B) The manufacturer can make the bars more uniform (decrease the standard deviation). What value of standard deviation will just meet the specification?

Q.2) The proportion of males is 0.52. Find the probability that a sample of 50 people will contain at least 29 males but no more than 34 males. Using:

- A) Binomial distribution.
- B) Normal distribution approximation to binomial.

Q.3) It is required to fit the following equation $y = \frac{x}{a+bx}$ to the data:

y:	3.5	7.2	12.6	16.4	20.2
x:	100	200	300	400	500

- A) Use the least square method to derive an expression for the constants.
- B) Transform the equation to a straight line form and thus determine the constants.

Q.4) The following data shows the number of days (F) in a 50 days period during which (X) automobile accidents occurred in a city. Determine the goodness of fit of poisson distribution at a significance level of 0.05.

F:	21	18	7	3	1
X:	0	1	2	3	4
$\chi^2_{0.95}$:	3.84	5.99	7.81	9.49	11.1
v:	1	2	3	4	5

Given that:

Q.5)

A. Calculate the maximum error in q for the following formula $q = C(L - 0.2H)^{1.5}$

$C = 3.33 \pm 3\%$ $L = 8.0 \pm 0.1$ $H = 4$

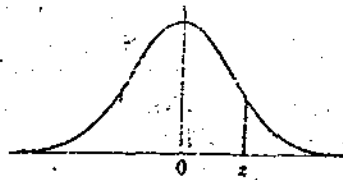
B. Explain the following:

- 1) The instruments of temperature measurement which depend on solid expansion.
- 2) The instruments of pressure measurement by balancing the force produced on a known area against the stress in an elastic medium.

With My Best Wishes For Success

343

AREAS
under the
STANDARD
NORMAL CURVE
from 0 to z



Z	0	1	2	3	4	5	6	7	8	9
0-0	0-0000	0-0040	0-0080	0-0120	0-0160	0-0199	0-0239	0-0279	0-0319	0-0359
0-1	0-0398	0-0438	0-0478	0-0517	0-0557	0-0596	0-0636	0-0675	0-0714	0-0754
0-2	0-0793	0-0832	0-0871	0-0910	0-0948	0-0987	0-1026	0-1064	0-1103	0-1141
0-3	0-1179	0-1217	0-1255	0-1293	0-1331	0-1368	0-1406	0-1443	0-1480	0-1517
0-4	0-1554	0-1591	0-1628	0-1664	0-1700	0-1736	0-1772	0-1808	0-1844	0-1879
0-5	0-1915	0-1950	0-1985	0-2019	0-2054	0-2088	0-2123	0-2157	0-2190	0-2224
0-6	0-2258	0-2291	0-2324	0-2357	0-2389	0-2422	0-2454	0-2486	0-2518	0-2549
0-7	0-2580	0-2612	0-2642	0-2673	0-2704	0-2734	0-2764	0-2794	0-2823	0-2852
0-8	0-2881	0-2910	0-2939	0-2967	0-2995	0-3023	0-3051	0-3078	0-3106	0-3133
0-9	0-3159	0-3186	0-3212	0-3238	0-3264	0-3289	0-3315	0-3340	0-3365	0-3389
1-0	0-3413	0-3438	0-3461	0-3485	0-3508	0-3531	0-3554	0-3577	0-3599	0-3621
1-1	0-3643	0-3665	0-3686	0-3708	0-3729	0-3749	0-3770	0-3790	0-3810	0-3830
1-2	0-3849	0-3869	0-3888	0-3907	0-3925	0-3944	0-3962	0-3980	0-3997	0-4015
1-3	0-4032	0-4049	0-4066	0-4082	0-4099	0-4115	0-4131	0-4147	0-4162	0-4177
1-4	0-4192	0-4207	0-4222	0-4236	0-4251	0-4265	0-4279	0-4292	0-4306	0-4319
1-5	0-4332	0-4345	0-4357	0-4370	0-4382	0-4394	0-4406	0-4418	0-4429	0-4441
1-6	0-4452	0-4463	0-4474	0-4484	0-4495	0-4505	0-4515	0-4525	0-4535	0-4545
1-7	0-4554	0-4564	0-4573	0-4582	0-4591	0-4599	0-4608	0-4616	0-4625	0-4633
1-8	0-4641	0-4649	0-4656	0-4664	0-4671	0-4678	0-4686	0-4693	0-4699	0-4706
1-9	0-4713	0-4719	0-4726	0-4732	0-4738	0-4744	0-4750	0-4756	0-4761	0-4767
2-0	0-4772	0-4778	0-4783	0-4788	0-4793	0-4798	0-4803	0-4808	0-4812	0-4817
2-1	0-4821	0-4826	0-4830	0-4834	0-4838	0-4842	0-4846	0-4850	0-4854	0-4857
2-2	0-4861	0-4864	0-4868	0-4871	0-4875	0-4878	0-4881	0-4884	0-4887	0-4890
2-3	0-4893	0-4896	0-4898	0-4901	0-4904	0-4906	0-4909	0-4911	0-4913	0-4916
2-4	0-4918	0-4920	0-4922	0-4925	0-4927	0-4929	0-4931	0-4932	0-4934	0-4936
2-5	0-4938	0-4940	0-4941	0-4943	0-4945	0-4946	0-4948	0-4949	0-4951	0-4952
2-6	0-4953	0-4955	0-4956	0-4957	0-4959	0-4960	0-4961	0-4962	0-4963	0-4964
2-7	0-4965	0-4966	0-4967	0-4968	0-4969	0-4970	0-4971	0-4972	0-4973	0-4974
2-8	0-4974	0-4975	0-4976	0-4977	0-4977	0-4978	0-4979	0-4979	0-4980	0-4981
2-9	0-4981	0-4982	0-4982	0-4983	0-4984	0-4984	0-4985	0-4985	0-4986	0-4986
3-0	0-4987	0-4987	0-4987	0-4988	0-4988	0-4989	0-4989	0-4989	0-4990	0-4990
3-1	0-4990	0-4991	0-4991	0-4991	0-4992	0-4992	0-4992	0-4992	0-4993	0-4993
3-2	0-4993	0-4993	0-4994	0-4994	0-4994	0-4994	0-4994	0-4995	0-4995	0-4995
3-3	0-4995	0-4995	0-4995	0-4996	0-4996	0-4996	0-4996	0-4996	0-4996	0-4997
3-4	0-4997	0-4997	0-4997	0-4997	0-4997	0-4997	0-4997	0-4997	0-4997	0-4998
3-5	0-4998	0-4998	0-4998	0-4998	0-4998	0-4998	0-4998	0-4998	0-4998	0-4998
3-6	0-4998	0-4998	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999
3-7	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999
3-8	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999	0-4999
3-9	0-5000	0-5000	0-5000	0-5000	0-5000	0-5000	0-5000	0-5000	0-5000	0-5000

In absorption Column operating at (4.5) bar, the bulk concⁿ. Of gas and liquid are ($x = 0.0014$ $y = 0.02$), $k_x = 80 \text{ kmol/m}^2 \cdot \text{hr} \cdot \Delta x$ $k_y = 15 \text{ kmol/m}^2 \cdot \text{hr} \cdot \Delta y$ Calculate :-

- 1- The interfacial Concⁿ. at a certain point .
- 2- Overall M.T. Coeff. and the rate of absorption in terms of Δy .
- 3- k_x' and k_y' (Where M.wt of $\text{SO}_2 = 64 \text{ gm/mol.}$)

Q3

(A) A feed mixture containing 38.5% benzene , 34.5% Toluene and 27% Cumene (in mol %) to be fractionated to recover about 96% of Benzene in the distillate and 95.8% of Toluene as the bottom product .

The feed is at dew point and the reflux at bubble point . Calculate using the (F.U.G) method:-

- 1- N_{\min} .
- 2- R_{\min} .
- 3- No. of ideal stages and feed position .
- 4- Amount of Vapoure returned from the reboiler .

Given that :-

$$Y = 1 - \text{Exp} \left[\left(\frac{1 + 54.4 X}{11 + 117.2 X} \right) \left(\frac{X - 1}{X^{0.5}} \right) \right]$$

$$R_{\text{op}} = 1.5 R_{\min} \quad P_T = 1 \text{ atm}$$

$$\alpha_{\text{ABT}} = 2.55$$

$$\alpha_{\text{ABB}} = 2.25$$

$$\alpha_{\text{CBT}} = 0.254$$

$$\alpha_{\text{CBB}} = 0.31$$

(B) A binary solution of 60 mol% of (A) 40 mol% of (B) is to be separated .

The feed is a tow-phase mixture containing 72% liquid. Determine graphically R_{\min} and N_T , Show the Pinch Point position in the plot .

The (V.L. E) given as:-

x	0	0.05	0.1	0.15	0.2	0.25	0.3	0.4	0.5	0.6	0.7	0.8	0.9
y	0	0.07	0.14	0.21	0.3	0.39	0.55	0.75	0.86	0.93	0.96	0.98	0.99

GOOD LUCK

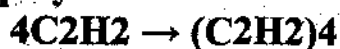
UOT
Chem.Eng.Dept .
1st attempt

Final-Year Exam.
June- 2008
Third Year Class

Subject: Reactor Design
Time: 3 hours
Date: 16 / 6 / 2008

Note : Answer Four questions only

Q1- Two hundred m³/h of gaseous mixture containing 80% acetylene and 20% inerts measured at 550 C and 20 atm , are to be fed to a tube furnace having anywhere up to 100 tubes in series , each tube is 3.5 m long and 5 cm inside diameter , all kept at 550 C . At this temperature acetylene polymerizes as follows :



The rate constant (at 400 C) = 0.6 m³/kmol.s

Neglecting pressure drop through the tubes , find how many tubes are needed for 60% conversion of acetylene to tetramer complex . The activation energy(E)=500 cal/gmol.K

Q2- The liquid phase reversible reaction $\text{A} \rightleftharpoons \text{B}$ is carried out in a 120 liter CSTR . Two feed streams , one containing 2.5 mol A/liter and the other containing 1.5 mol A/liter , are to be introduced in equal volumetric flow rate into the reactor , and 50% of the equilibrium conversion is obtained . Assume a constant density throughout and given $k_1=7$ liter/mol.min ; $k_2=3$ liter/mol.min

a- What should be the flow rate of each stream .

b- If the effluent from the 1st reactor is charged to another CSTR where the irreversible reaction $\text{A} \rightarrow \text{B}$ takes place with $k=3 \text{ min}^{-1}$. Calculate the volume of CSTR needed to obtain 90% conversion of A .

Q3- A gas-phase reaction $\text{A} \rightarrow \text{R}$ is carried out in a batch reactor with initial conditions of $T_0 = 127 \text{ C}$, total pressure = 4 atm and constant volume of 0.5 m³ .The initial composition of reaction mixture is 80 mol%A and the balance inert material. The reaction rate constant is :

$k = 10^{12} \exp(-10000/T) \text{ h}^{-1}$. The heat of reaction is -1500 kcal/kmol and the heat capacity of A and R are 30 and 25 kcal/kmol.K respectively.

Compute the time required for 90% conversion of A, if an adiabatic condition is applied.

Q4- The gas-phase reaction $A \rightarrow B$ is conducted at 500 C and 3 atm in a tubular flow reactor. The feed contains 30 mole% A and the balance inert material. Total feed rate is 50 gmole/h. The rate constant is 0.2 min^{-1} . What volume of reactor is needed for 95% conversion?.

Q5 – The production of methylbromide (C) is an irreversible liquid phase reaction which is first order with respect to methylamine (A) : $A + B \rightarrow C + D$, this reaction is carried out in a semibatch reactor. Methylamine(A) at a concentration of 0.025 gmol/dm^3 is to be fed at a rate of $0.5 \text{ dm}^3/\text{s}$ to an aqueous solution of bromine cyanide (B) contained in a glass lined reactor. The specific rate constant is $k = 0.01 \text{ s}^{-1}$. The initial volume of fluid in the reactor to be 5 dm^3 . The initial moles of A in feed $N_{A0} = 0.1 \text{ moles}$. Determine the conversion of A as a function of time.

$$R_g = 0.082 \text{ atm.lit/gmol.K} = 1.987 \text{ cal/gmol.K}$$