L-4/T-2/ChE **Date : 02/07/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2012-2013

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

1. (a) "For buried pipelines, there are usually more pits on the bottom side of a pipe than on the top side" – why? **(5)**

   (b) How can you detect strong current? **(5)**

   (c) What are the five generic methods for corrosion prevention? **(10)**

   (d) When and why do you need to use corrosion monitoring techniques? **(15)**

2. The roof of a swimming pool is supported by stainless steel rods in tension. The maintenance staffs of the swimming pool use chloride containing compounds for pool cleaning. Under the specific temperature conditions near the ceiling, chloride containing chemical species in vapors from the pool water can condense onto the stainless steel components.

   (a) What kind of corrosion is most likely to occur in this situation? **(5)**

   (b) Describe the mechanism of this type of corrosion. **(10)**

   (c) What preventive measures should be taken to avoid such a situation, both at the design and operation stage? **(20)**

3. (a) "For sacrificial coatings degree of porosity is not as important as it is in the case of noble coatings" – Explain. **(10)**

   (b) Discuss the importance of critical concentration in the use of passivators. **(10)**

   (c) What do you understand by dezincification? **(5)**

   (d) Why lead and its alloys should not be used in food, dairy and pharmaceutical industries? **(5)**

   (e) "Though tin is cathodic to iron, in food containers tin is almost always anodic to steel" – How? **(5)**

4. (a) What are the five classes of stainless steels? **(10)**

   (b) What is weld decay? How does it occur? What are the preventive measures? **(10)**

   (c) If you are using deactivation and deaeration for reduction of dissolved oxygen from water, which one should you do first? Why? **(5)**

   (d) What is carbonic acid corrosion? How can you prevent carbonic acid corrosion in the condensate return line? **(10)**

Contd P/2

CHE 409

SECTION – B

There are **FOUR** questions in this Section. Answer Q. No. 5 as Compulsory and any **TWO** from the rest.

5. (COMPULSORY) (Answer all the questions. Choose the correct answer and give reasons for your answer) Give (√) marks to the correct answer. **(5×9=45)**

(a) Uniform corrosion is a form of chemical corrosion. TRUE/FALSE

(b) Tempering is done only for iron-carbon alloys. TRUE/FALSE

(c) The position of metal in the EMF series can change due to complex formation. TRUE/FALSE

(d) Effect of heat treatment on corrosion of carbon steel in dilute acid can be confusing. TRUE/FALSE

(e) O_2 concentration continuously increases corrosion of Iron and Steel in flowing acid solution. TRUE/FALSE

(f) Activation Polarization of the Cathode decreases corrosion. TRUE/FALSE

(g) The lower the Flade potential, easier it is for corrosion to occur. TRUE/FALSE

(h) "Critical Humidity" does not apply to air containing SO_2. TRUE/FALSE

(i) During solidification of molten metal, atoms arrange themselves in a well ordered arrangement which begins at one point in the melt. TRUE/FALSE

6. (a) Show how Activation Polarization becomes the critical factor in corrosion. Give two examples. **(10+10)**

(b) An austenitic iron-carbon alloy has been quenched. What kind of corrosion and mechanical behavior can be expected? How can corrosion resistance of this alloy be improved? **(5+5)**

7. (a) How can you prove that a certain metal will exhibit active-passive behavior? **(10)**

(b) In an industrial situation an alloy was showing passive behavior. One day it started corroding. What may have caused this change in corrosion behavior? **(10)**

(c) Analyze the role of grain Boundaries in altering the corrosion rate. **(10)**

8. Write short notes on: **(7 ½ ×4=30)**

(a) Metallurgical History

(b) Area Effect

(c) Importance of Hydrogen Over voltage

(d) Effect of fluid velocity on corrosion of iron-carbon alloys.

L-4/T-2/ChE **Date : 09/07/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2012-2013

Sub : **CHE 493** (Petroleum Reservoir 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 **FOUR** questions in this Section. Answer any **TREE**.

2 page (Formula) + 1Chart

1. (a) What is meant by "Volumetric reservoir". Simplify the general material balance equation so that it can be used for a gas reservoir. **(5+5)**

   (b) The following Production data are available from a gas reservoir produced under volumetric control: **(25)**

Pressure (Psia)	Cumulative gas Production
5000	200
4000	420

The initial reservoir temperature was 237°F and the reservoir gas gravity is 0.7.

(i) What will be the cumulative gas production at 2500 psia?

(ii) What fraction of the initial reservoir gas will be produced at 2500 psia?

(iii) Assuming the reservoir rock has a porosity of 12%, the water saturation is 30% and the reservoir thickness is 15ft. How many acres does the reservoir cover?

2. (a) Define "pseudo pressure". Explain the necessity of using pseudo pressure for flow of compressible fluid. **(5)**

   (b) Derive the radial diffusivity equation for flow of compressible fluid in terms of-

   (i) Pressure and Time **(7)**

   (ii) Pseudo Pressure and Pseudo Time **(8)**

   (c) For a gas reservoir the following data are given: **(15)**

   Permeability = 1.50 mD

   Formation thickness = 39 ft

   Reservoir temperature = 252°F

   Outer boundary Pressure = 4625 Psia

   Well bore radius = 0.333 ft

   Reservoir fluid viscosity = 0.02695 cp

   Reservoir gas gravity = 0.759

   Gas production rate at surface condition = 3900 MSCFD

   Outer boundary radius = 550 ft.

Determine the well bore pressure assuming the steady state flow conditions.

Contd P/2

CHE 493

3. (a) A well and reservoir have the following characteristics : The well is producing only oil; if is producing at a constant rate of 20 STB/D. Data describing the well and formation are- **(17)**

$\mu = 0.72cp$	$p_I = 3000$ psi
$k = 0.1$ mD	$r_e = 3000$ ft
$c_t = 1.5 \times 10^{-5}$ psi^{-1}	$r_w = 0.5$ ft
$h = 150$ ft	B_o=1.475 RB/STB
$\varphi = 0.23$	

Calculate the reservoir pressure at a radius of 1 ft, after 3 hours of production.

(b) Reservoir and well data are:

$p_e = 3350$ psi		$\varphi = 0.2$
$C_L = 10^{-5}$ psi^{-1}	$r_w = 0.5$ ft	$h = 105$ ft
$\mu_o = 0.65$ cp	$q_o = 900$ stb/day	
$p_w = 3050$ psi	B_o= 1.150 rb/stb	

The P_{wf} is declining at a constant rate of 0.092 psi/hr. **(6×3=18)**

(i) Determine the area being drained.

(ii) What is the improved permeability if a pressure drawdown analysis indicates that pressure drop due to skin is 150 psi;

(iii) Repeat part (ii) assuming there is water drive and bottomhole pressure remains constant.

4. (a) List the assumptions that are made to derive Darcy's law. What is meant by k = 1 Darcy? **(8)**

(b) A homogenous formation has an effective permeability k_e. The effective permeability out to a radius r_a from the well has been altered (damage/stimulation) so that its average value in this region is k_a. Show that for this situation, the skin factor may be expressed as- **(10)**

$$S = \left(\frac{k_e}{k_a} - 1\right)\left[\ln\frac{r_e}{r_w} - \frac{3}{4}\right]$$

[Symbols represent their usual meaning]

Assuming that the flow can be described under semi steady state condition.

(c) A well procucer 100 STB/D oil at a measured flowing bottomhole pressure of 1500 psi. A recent pressure survey showed that average reservoir pressure is 2000 psi. Logs indicate a net sand thickness of 10 ft. The well drains an area with drainage of 1000 ft. The borehole radius is 0.25 ft. Fluid samples indicate that at current reservoir pressure oil viscosity is 0.5 cp and formation volume factor is 1.5 RB/STB. **(17)**

(i) Estimate formation permeability.

(ii) Core data from the well indicate an effective permeability to oil of 50 mD. What does it imply? What is the apparent skin factor?

(iii) Estimate the productivity Index for the well.

Contd P/3

CHE 493

SECTION – B

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

5. (a) A black oil reservoir has just been discovered. Reservoir pressure appears to be above bubble point pressure of the oil. Measured at reservoir conditions, 86.3 barrels per day enter the well bore. The oil is processed through a separation into a stock tank accumulates 57.9 barrels of 44.2° API oil each day. The separator produces 43150 SCF/D of 0.724 gravity gas and the stock time vents 7240 SCF/day of 1.333 gravity gass. What is the formation volume factor of the oil and what is the solution gas oil ratio? **(10)**

(b) What is two phase FVF? Show the variations of B_o, B_t and R_s with pressure on the same plot and explain their behavior above and below saturation pressure. [Symbols have their usual meaning] **(15)**

(c) The laboratory analysis of a reservoir sample from an oil well producing 41.5° API stock tank oil are given in the table? The sample was obtained from the reservoir at 184°F and 3463 psia. **(10)**

Pressure(psia)	B_o(bbl/STB)	R_s(SCF/STB)	B_g(bbl/SCF)
5000	1.498	941	-
4500	1.507	941	-
3500	1.527	941	-
3054	1.538	941	0.000866
2400	1.441	732	0.001090
1200	1.287	400	0-002285

Determine Bt at 3500 and 2400 psia

6. (a) Define the following terms **(3×3=9)**
   -Drainage
   -Imbibition
   -Relative permeability

(b) Draw a relative permeability-saturation graph for a gas water system. State the factors upon which capillary pressure-saturation relationship depends. **(7+8)**

(c) A capillary tube is immersed in a beaker and the beaker is placed in air. Interfacial tension between capillary tube and air and between capillary tube and water are 72 and 24 dyne/cm respectively. Pressure of air just above and below the air water surface are 60 and 10 dyne/cm^2, respectively. Determine the radius of the capillary tube and water height inside the capillary tube. **(5)**

(d) The volume of the core chamber of a stevens porosimeter is 15 cm^3. The air in the core chamber is expanded repeatedly into an evacuated system and measured at atmospheric pressure in a graduated tube. The following volume readings are taken-

Volume of air (first reading) = 6.970 cm^3
Volume of air (second reading) = 0.03 cm^3
Volume of air (third reading) = 0 cm^3

Determine the porosity of the cylindrical core sample with radius and height 10 and 30 mm respectively. **(6)**

Contd P/4

CHE 493

7. (a) The Virginia Hills Beaver hill Lake field is a volumetric undersaturated reservoir. Volumetric calculations indicate that the reservoir contains 270.6 MMSTB of oil initially in place. The initial reservoir pressure was 3685 psi. The following additional data are available. **(20)**

$S_{wi} = 24\%$, $C_w = 3.62 \times 10^{-6}$ psi, $C_f = 4.95 \times 10^{-6}$ psi^{-1} $B_w = 1.0$ bbl/STB, $P_b = 1500$ psi

The field production and PVT data are summarized in the table.

Volumetric Average Pressure (Psi)	B_o(bbl/STB)	N_p (MSTB)	W_p (MSTB)
3685	1.3102	0	0
3680	1.3104	20.481	0
3676	1.3104	34.750	0
3667	1.3105	78.557	0
3664	1.3105	101.846	0
3640	1.3109	215.681	0
3605	1.3116	364.613	0
3567	1.3122	542.985	0.159
3515	1.3128	841.591	0.805
3448	1.3130	1273.530	2.579
3360	1.3150	1691.887	5.008
3275	1.3160	2127.077	6.500
3188	1.3170	2575.330	8.00

Calculate the initial oil in place. Note: $\Delta p = p - p_i$, where p_i is initial reservoir pressure and p = volumetric average pressure.

(b) Simplify oil MBE for following conditions [Give: reason] **(3×5=15)**

(i) Gas cap volumetric oil reservoir with negligible water production.

(ii) Water drive oil reservoir with no initial gas cap.

(iii) Water drive oil reservoir with initial gas cap.

8. (a) What are drive indices? Explain. **(10)**

(b) Name different types of recovery technologies. **(5)**

(c) A wildcat well is drilled into an anticline and it encountered oil. [No oil/water contact was detected] An oil sample has a density of 46 lbm/ft^3. Oil pressure at 5623 feet was 2830.5 psia. Pressures were also measured at neighboring aquifers and water pressure at depth 5517 feet and 6313 feet were 2773 psia and 3079 psia respectively. What is the depth of the oil/water contact? **(20)**

USEFUL FORMULAE

[Symbols represent their usual meaning]

1. General material balance equation

$$N(B_t - B_{ti}) + \frac{mNB_{ti}}{B_{gi}}[B_g - B_{gi}] + (1+m)NB_{ti}\left[\frac{C_w S_{wi} + C_f}{(1-S_{wi})}\right]$$

$$\Delta p + W_e = N_p[B_t + (R_p - R_{soi})B_g] + B_w W_p.$$

2. Gas initially in place

$$V_i = GB_{gi} = Ah\phi(1-S_{wi})$$

$$B_{gi} = 0.02829\frac{Z_i P_i}{T_i}$$

3. Critical Pressure; $P_c = 756.8 - 131.0\gamma_g - 3.6\gamma_g^2$

Critical Temperature; $T_c = 169.2 + 349.5\gamma_g - 74.0\gamma_g^2$

4. In field unit gas flow rate for steady state flow

$$q_{sc} = \frac{0.007027\, kh(\bar{p}^2 - p_w^2)}{\mu_g \bar{Z} T \log\left(\frac{r_e}{r_w}\right)}$$

5. Solution of transient flow condition for infinite cylindrical reservoir with line source well

$$p = p_i + 70.6\frac{qB\mu}{kh} Ei\left(\frac{-948\phi\mu c_t r^2}{kt}\right)$$

6. Ei-function solution is an accurate approximation to the more exact solution for time

$$3.79 \times 10^5 \frac{\phi\mu c_t r_w^2}{k} < t < \frac{948\phi\mu c_t r_e^2}{k}$$

7. Radial inflow equations for stabilized flow condition —

i) Steady state : $P_e - P_{wf} = \frac{141.2 q \mu B}{kh} \ln \frac{r_e}{r_w}$

ii) Steady state : $\bar{P} - P_{wf} = \frac{141.2 q \mu B}{kh} \left[\ln \frac{r_e}{r_w} - \frac{1}{2} \right]$

iii) Pseudo steady state :

$$P_e - P_{wf} = \frac{141.2 q B \mu}{kh} \left[\ln \frac{r_e}{r_w} - \frac{1}{2} \right]$$

iv) Pseudo steady state :

$$\bar{P} - P_{wf} = \frac{141.2 q B \mu}{kh} \left[\ln \frac{r_e}{r_w} - \frac{3}{4} \right]$$

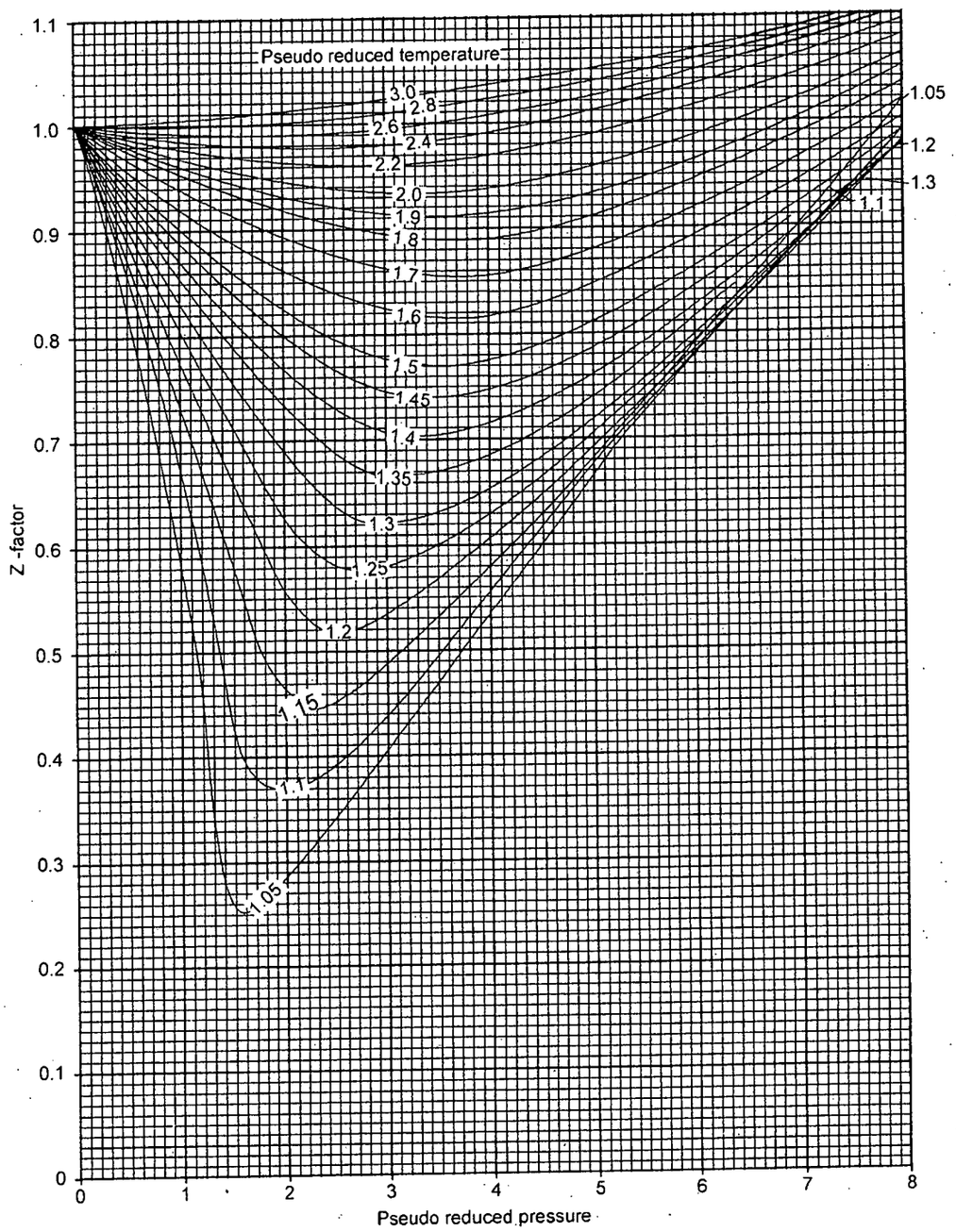


Fig. [illegible] **The Z–factor correlation chart of Standing and Katz**[11] *(Reproduced by courtesy of the SPE of the AIME)*

Useful Formula

General oil MBE

$$N_p[B_o + (R_p - R_s)B_g] = NB_{oi}\left[\frac{(B_o - B_{oi}) + (R_{si} - R_s)B_g}{B_{oi}} + m\left(\frac{B_g}{B_{gi}} - 1\right) + (1+m)\left(\frac{c_w S_{wc} + c_f}{1 - S_{wc}}\right)\Delta p\right] + (W_e - W_p)B_w$$

General gas MBE:

$$G(B_g - B_{gi}) + GB_{gi}\left[\frac{c_w S_{wc} + c_f}{1 - S_{wc}}\right]\Delta p + W_e = G_p B_g + B_w W_p$$

$$B_g = 0.02829\frac{ZT}{p} \text{ ft}^3/\text{SCF}$$

$$= 0.00504\frac{ZT}{p} \text{ bbl/SCF}$$

where,
p in psia. and T in °R

L-4/T-2/ChE **Date : 09/07/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2012-2013

Sub : **CHE 485** (Industrial Pollution Control)

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 different levels of Wastewater Treatment. **(10)**

   (b) Industrial effluent treatment plants use variety of reactors for physicochemical and biological treatment. Briefly describe the mechanisms and principal applications of reactors used for wastewater treatment. **(15)**

   (c) Briefly describe the functions, mechanisms and applications of Tube Settling and inclined Plate as wastewater treatment options. **(10)**

2. (a) Describe the commonly used techniques and devices for wastewater aeration. **(15)**

   (b) The average flowrate at a medium capacity paper mill is 720 m^3/day. The highest observed peak daily flowrate is 1200 m^3/day. Design cylindrical primary clarifiers with a water depth of 3 m. Use a minimum of two clarifiers. Calculate the scour velocity, to determine if settled material will become resuspended. Estimate the BOD and TSS removal at average and peak flow. What would be the maximum flow rate that the primary clarifier can function satisfactorily without resuspending settled material? Use an overflow rate of 30m^3/m^2-day at average flow. **(20)**

   Equation for BOD and TSS Removal:

$$R = \frac{1}{a + bt}$$

   Where,

   R = expected removal efficiency, %

   t = nominal detention time (retention time), hr

   a, b = empirical constants

   for BOD, a = 0.018 and b = 0.020

   for TSS, a = 0.0075 and b = 0.014

   Equation and Parameters of Scour Velocity:

$$V_H = \left(\frac{8k(s-1)gd}{f} \right)^{1/2}$$

   Where,

   V_H = horizontal velocity that will just produce scour, m/s

   k = constant that depends on type of material being scoured = 0.05

Contd P/2

CHE 485

Contd ... Q. No. 2(b)

s = specific gravity of particles = 1.25

g = acceleration due to gravity = 9.81 m/s^2

d = diameter of particles = 100 μm

f = Darcy-Weisbach friction factor = 0.025

3. (a) A factory desires to reduce the existing running cost of its effluent treatment plant (ETP). As an Environmental Engineer, what options would you suggest to the factory management regarding the cost reduction? Give reasoning of your suggestions. **(10)**

(b) A textile dyeing plant of daily dyeing capacity 5 ton, dyes medium and light shade fabrics. The pre-dyeing, dyeing and post-dyeing stages include the following steps (see the table below). The liquor ratio for any steps (except rinsing) of pre-dyeing, dyeing and post-dyeing stages is 1 : 7 (i.e., 7 litre liquor/water for 1 kg fabric). For rinsing, the dyeing machine uses three times more water than a regular dyeing step. Key pollution indicating parameters of different dyeing steps for a 500 kg fabric batch are given in the table below. The industry discharges the wastewater to the nearby wetland without treatment. What are the composite characteristics of the effluent produced by the above mentioned industry? What would be the yearly TDS, TSS and BOD_5 load discharged in the environment by the effluent produced from the industry? **(25)**

Fabric: 500 Kg

Stages	TDS (mg/L)	TSS (mg/L)	BOD_5 (mg/L)
Scouring	9906	110	2250
Hot Wash	5407	174	1700
Neutralization	2977	103	750
Dyeing	55285	455	700
Rinsing	16396	362	390
Neutralization	4227	125	350
Rinsing	1167	15	210
Hot Wash with Soap Agent	1123	12	440
Rinsing (Hot)	471	40	390
Softening	439	32	290

4. (a) A leather processing industry operations an effluent treatment plant which contains a digester to digest primary sludge. The solid contents, volatile matter, specific gravity of fixed solids and specific gravity of volatile solids of the primary sludge are 5%, 60%, 2.5 and 1.0, respectively. After digestion, the solid contents, volatile matter, specific gravity of fixed solids and specific gravity of volatile solids of the digested sludge are 10%, 37.5%, 2.5 and 1.0, respectively. Determine the liquid volume before and after digestion for 500 kg (dry basis) of primary sludge. **(15)**

Contd P/3

CHE 485

Contd ... Q. No. 4

(b) How the trends of Environment Impact Assessment (EIA) have changed over time? **(5)**

(c) Considering the increasing power demand of the country, a group of non-resident Bangladeshi entrepreneurs has initiated to establish hydro power projects at the hill tract areas. As a part of the feasibility study the Government has recruited a local consulting company to asses the environmental impact of the proposed projects. As the project leader of the consulting company, how would you proceed to assess the relevant environmental impacts? What are the key factors one would consider for the environmental impact assessment during the operation phase and construction phase of the projects? **(15)**

SECTION – B

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

5. (a) How will you describe the air pollution system? What are the challenges involved in controlling the air pollution? **(10)**

(b) Describe the air quality standard philosophy. If the national ambient air quality standard (ECR'97) for sulfer dioxide is 80 $\mu g/m^3$, You are required to check the concentration resulting from striking of a simple wooden match (a 2 inch wooden match contains 2.5 mg sulfer) in modest size room (15 ft × 15 ft × 10 ft) whether it exceeds the standard or not. **(10)**

(c) Classify the air pollutants according to their origin and describe briefly with examples their sources and possible impacts. **(15)**

6. (a) What are the factors that influence the reliability of particulate measurements? How will you estimate fugitive emission of pollutant for a source? **(10)**

(b) Show that the environmental adiabatic lapse rate is 10°C per km of vertical distance. **(10)**

(c) Describe the relationship between actual lapse rate, adiabatic lapse rate and atmospheric stability. On a cloudless day with low or average winds, when might we encounter stable, neutral and unstable atmosphere? **(15)**

7. (a) Derive the expression for ground level cQ/u directly under the plume centerline as a function of downwind distance from the source and effective stack height considering the ground level modification of Gaussian plume model. **(15)**

(b) A power plant emits 100 g/s of NOx from a stack with physical stack height 150 m and plume rise is given by **(20)**

$$\Delta h = \frac{200 \frac{m^2}{s}}{u}$$

Contd P/4

CHE 485

Contd ... Q. No. 7

The atmospheric stability category is C and wind speed is 2 m/s.

(i) What is the maximum ground level concentration of NOx due to this source?

(ii) How far downwind of the source does the maximum occur?

8. (a) You are required to design a gravity settler having dimension of length L, height H and width W for separating particulate matters from pollutant gas. If the average gas velocity through the cross section of gravity settler is V_{avg}, derive the efficiency-diameter relationship both for block flow model and mixed flow model. **(15)**

(b) You have a cyclone separator that is operating with D_{cut} = 5 μm. You are required to increase the flow rate to the cyclone by 25%. All the others parameter will be unchanged. Considering the block flow model is valid, estimate the new cut diameter. **(10)**

(c) What is the driving force for Electrostatic precipitator? How does it work? **(10)**

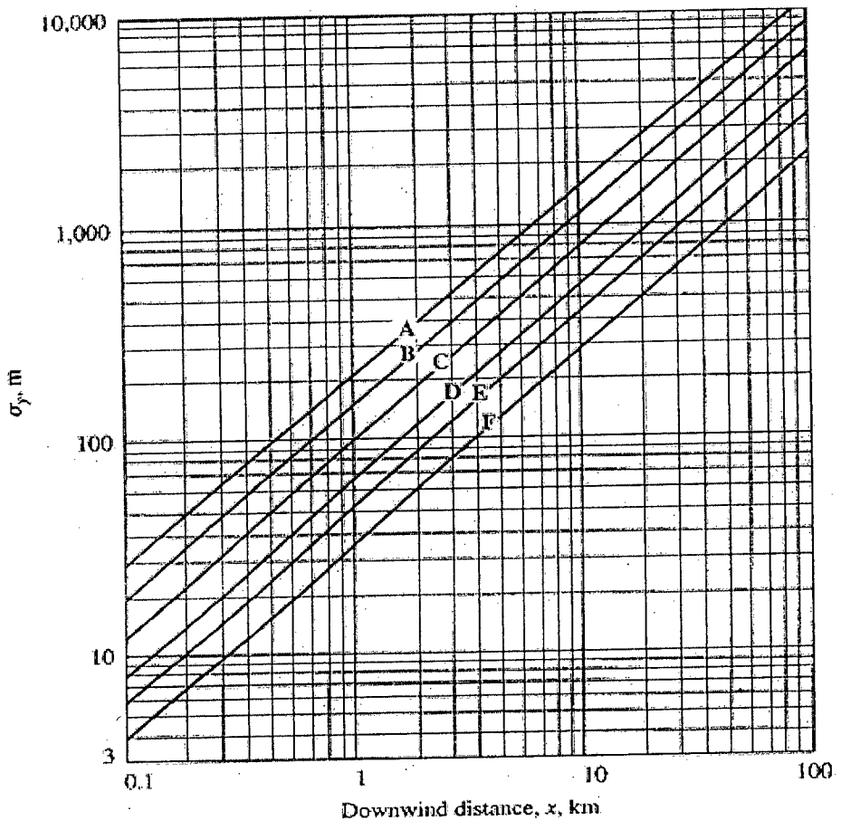


FIGURE 6.7 for Q.7
Horizontal dispersion coefficient σ_y as a function of downwind distance from the source for various stability

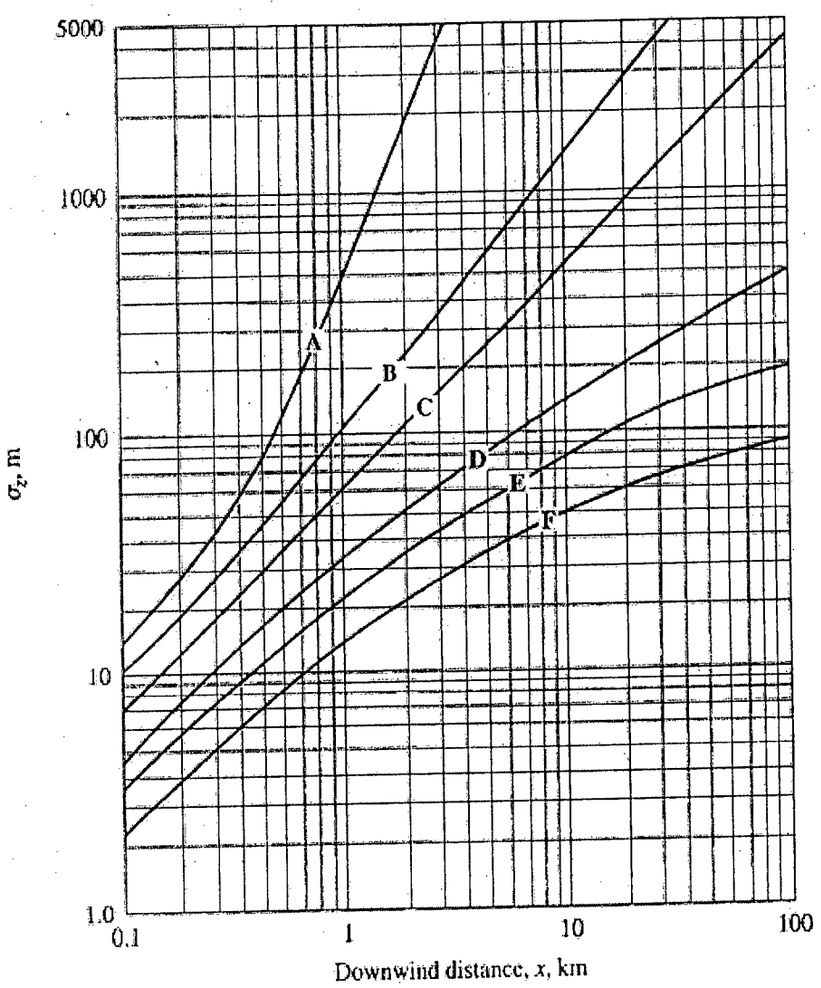


FIGURE 6.8 for Q.7.
Vertical dispersion coefficient σ_z as a function of downwind distance from the source for various stability

L-4/T-2/ChE **Date : 09/07/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2012-2013

Sub : **CHE 457** (Reactor Design)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

Symbols have their usual meanings. Assume reasonable value if any additional data is required.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this Section. Q. 1 is COMPULSORY. And Answer any **TWO** from the rest.

1. Synthesis gas from the reforming section of an ammonia plant is available at the following conditions: Feed (Dry gas basis): 12400 lbmoles/hr

Component	Mole%
CO	13.0
CO_2	7.9
H_2	56.8
N_2	21.8
CH_4	0.5

Total wet feed from the reformer : 20460 lb moles/her

Reformer discharge conditions: 400 psia, 1750°F

You are required to design a shift-conversion system for converting the carbon monoxide present in the gas from the reformer to carbon dioxide. CO concentration after shift conversion should be within 0.2% to 0.5%. Two catalysts are available for the shift conversion. Data for both these catalysts are provided. Kinetic expressions of these catalysts and adiabatic for shift conversion at various steam-to-CO ratios are also given. Assume adiabatic reactor and a 50°F approach to equilibrium answer the followings:

(a) Would you go for a high or low steam-to-CO ratio? Why? **(5)**

(b) How many alternatives can you think of to achieve the desired reduction in CO? Out of these alternatives which one would you select? Give appropriate reasons for eliminating/selecting each of these alternatives. **(20)**

(c) What should be the operating pressure of the shift reactor(s)? Why? **(5)**

(d) Select appropriate inlet temperature for the shift reactor(s). What will be the corresponding reactor outlet temperature? **(10)**

(e) Results for the calculations of catalyst requirements are provided. Considering a cost of $16,500/yr for each increase of 0.1% CO, select the appropriate outlet CO concentrations form both the reactors. **(15)**

2. (a) Define molar flux. What is the molar flux of A in a system where the flux of A results primarily from forced convection? **(5)**

Contd P/2

CHE 457

Contd ... Q. No. 2

(b) Calculate the molar flux of reactant A to a single catalyst pellet 1 cm in diameter suspended in a large body of liquid. The reactant is present is present in dilute concentrations, and the reaction is considered to take place instantaneously at the external surface. The bulk concentration of the reactant is 1.0 M, and the free-system liquid velocity is 0.1 m/s. The kinematic viscosity is 0.5×10^{-6} m^2/s and the liquid diffusivity of a is 10^{-10} m^2/s. Also calculate the reaction rate per unit surface area of catalyst. For dilute concentrations of the solute, $W_{Ar} = k_c(C_{Ab} - C_{As})$ **(20)**

3. (a) Perform a shell balance on a catalyst pellet to obtain a differential equation that would describe both diffusion and reaction rate. Also mention the boundary conditions required to solve the differential equation. **(20)**

   (b) Define internal and overall effectiveness factors. **(5)**

4. (a) How would you modify the "4-step algorithm for isothermal reactor design" for designing steady state isothermal reactor? Write down all the steps of the modified algorithm. **(10)**

   (b) The elementary irreversible organic liquid-phase reaction A + B → C is carried out adiabatically in a flow reactor. An equal molar feed in A and B enters at 27°C, and the volumetric flow rate is 2 dm^3/s and C_{Ao} = 0.1 $kmol/m^3$. Calculate the CSTR volume necessary to achieve 85% conversion. Comment on the reactor volume, if a PFR is used for the reaction. Would you need a larger or a smaller reactor? Explain. **(15)**

SECTION – B

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

5. (a) Hydrogen and toluene are reacted over a solid mineral catalyst containing clinoptilolite (a crystalline silica-alumina) to yield methane and benzene. **(20)**

$$C_6H_5CH_3 + H_2 \rightarrow C_6H_6 + CH_4$$

   Determine the rate law from the differential reactor data presented in Table-1.

   (b) What is homogeneous catalysis? Describe the steps of a heterogeneous catalytic reaction. **(3+12=15)**

6. (a) The decomposition of cumene to form benzene and propylene is a heterogeneous catalytic reaction. The overall reaction is

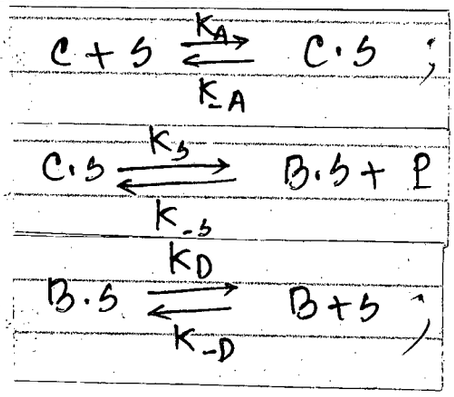
$$C_6H_5CH(CH_3)_2 \rightarrow C_6H_6 + C_3H_6$$

Contd P/3

CHE 457

Contd ... Q. No. 6(a)

The reaction mechanism is



Adsorption of cumec on the surface

Surface reaction to form adsorbed benzene and propylene in the gas phase

Desorption of benzene and propylene in the gas phase

Derive the rate law assuming: **(10×2=20)**

(i) The surface reaction is rate-limiting.

(ii) The adsorption of cumec is rate-limiting.

(b) What is adsorption isotherm? Show that the amount of CO molecule adsorbed per unit mass of a heterogeneous catalyst increases linearly with pressure of CO at low pressure. **(3+1215)**

7. (a) The exothermic reaction $A \rightarrow B + C$ was carried out adiabatically and the following data was recorded. **(18)**

X	0	0.2	0.4	0.45	0.5	0.6	0.8	0.9
$-r_A$ (mol/dm^{3}min)	1.0	1.67	5.0	5.0	5.0	5.0	1.25	0.91

The entering molar flow rate of A was 300 mole/min

(i) What are the PFR and CSTR volumes necessary to achieve 40% convention?

(ii) Over what range of conversions would the CSTR and PFR reactor volumes be identical?

(iii) What is the maximum conversion that can be achieved in a 10.5 dm^3 CSTR?

(iv) What conversion can be achieved if a 72 dm^3 PFR is followed in series by a 24 dm^3 CSTR?

(b) For the parallel reactions

$$A + B \rightarrow D; \qquad r_D = k_1 C_A^{\alpha_1} C_B^{\beta_1}$$

$$A + B \rightarrow U; \qquad R_U = k_2 C_A^{\alpha_2} C_B^{\beta_2}$$

Consider all possible combinations of reaction orders and select the reaction scheme that will maximum $S_{D/U}$. **(17)**

8. (a) The gas phase reaction $\frac{1}{2}N_2 + \frac{3}{2}H_2 \rightarrow NH_3$ is to be carried out isothermally. The molar feed is 50% H_2 and 50% N_2 at a pressure of 16.4 atm and 277°C **(17)**

CHE 457

Contd ... Q. No. 8(a)

(i) Construct a complete stoichiometric table.

(ii) What are C_{AD}, δ and ε? Calculate the concentrations of ammonia and hydrogen when the conversion of H_2 is 60%

(iii) Suppose by chance the reaction is elementary with $k_{N2} = 40$ $dm^3/mol/s$. Write the note of reaction solely as a function of conversion for a flow system and a constant volume batch system.

(b) It is designed to produce 200 million pounds per year EG. The reactor is to be operated isothermally. A 1 $lbmol/ft^3$ solution of ethylene oxide (EO) in water is fed to the reactor together with an equal volumetric solution of water containing 0.9 wt% of the catalyst H_2SO_4. The specific reaction rate constant is 0.311 men^{-1}. **(18)**

(i) If 80% conversion to be achieved, determine the necessary CSTR volume.

(ii) If two 800-gal reactors were arranged in parallel, what is the corresponding conversion?

For Question - 1

Type	Chromia-promoted iron oxide	copper-zinc oxide
Maximum operating temp., °F	890	500–550
Tablet size (in.)	$\frac{1}{4} \times \frac{1}{4}$	$\frac{1}{4} \times \frac{1}{8}$
Bulk density (lb/cu ft)	70	90
Particle density (lb/cu ft)	126	155
Cost ($/cu ft)	20.00	75.00
Catalyst poisons	Inorganic salts, boron, oils, or phosphorous compounds, liquid H_2O is a temporary poison. Sulfur compounds in an amount greater than 50 ppm	Sulfur and halogen compounds, and unsaturated hydrocarbons
Catalyst life	3 yr and over depending on care in startup and operation (Use times up to 15 yr have been reported)	2–3 yr

$$(-r_{CO}) = \psi k(y_{CO}\, y_{H_2O} - y_{CO_2}\, y_{H_2}/K)/(379\rho_b) \qquad \text{(CS-5.1)}$$

where k = rate constant
$= \exp(15.95 - 8820/T)$ for iron catalyst
$= \exp(12.88 - 3340/T)$ for copper-zinc catalyst
K = equilibrium constant
$= \exp(-4.72 + 8640/T)$ for $760 \leq T \leq 1060$
$= \exp(-4.33 + 8240/T)$ for $1060 \leq T \leq 1360$
P = pressure, atm
$(-r_{CO})$ = rate, lb moles CO converted/(lb catalyst)(hr)
T = temperature, °R
y_j = mole fraction of component indicated
ρ_b = catalyst bulk density, lb/cu ft
ψ = activity factor

Iron catalyst $\psi = 0.816 + 0.184P$ for $P \leq 11.8$
$= 1.53 + 0.123P$ for $11.8 < P \leq 20.0$
$= 4.0$ for $P > 20.0$

Copper-zinc catalyst $\psi = 0.86 + 0.14P$ for $P \leq 24.8$
$= 4.33$ for $P > 24.8$

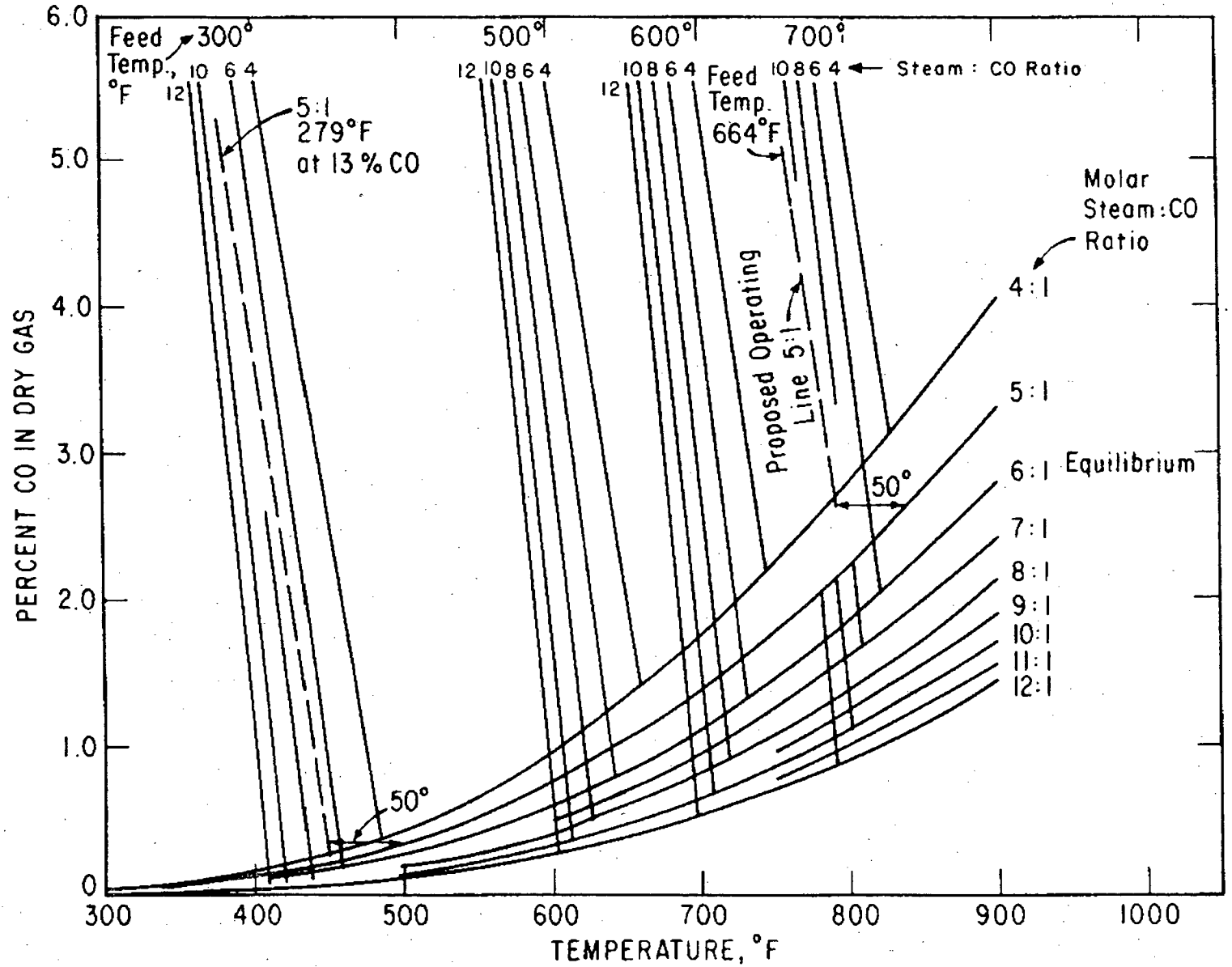


Fig. CS-5.2 Adiabatic plot for shift conversion at various steam-to-CO ratios.

= 6 =
For Question-1

 for Question - 1

Table CS-5.1 Results of Calculations

Reactor No.	Outlet CO, %	Temperature, °F In	Temperature, °F Out	Pounds of Catalyst	Cost of Catalyst, $[a]	4-Yr Cost, $
Case 1:						
#1	2.25	640	771	215,800	61,657	
#2	0.3	400	429	150,040	125,033	
Total					186,690	311,725
#1	2.25	640	771	215,800	61,657	
#2	0.35	421	448.3	131,750	109,792	
Total					171,449	281,241
#1	2.25	640	771	251,800	61,657	
#2	0.40	421	447.5	116,900	97,417	
Total					159,074	256,491
Case 2:						
#1	2.65	670	794	157,700	45,057	
#2	0.2	370	400	205,400	171,500	
Total					216,557	388,057
#1	2.65	670	794	157,700	45,057	
#2	0.3	395	429	160,100	133,417	
Total					178,474	311,891
#1	2.65	670	794	157,700	45,057	
#2	0.35	415	448	141,230	117,692	
Total					162,749	280,441
#1	2.65	670	794	157,700	45,057	
#2	0.4	425	457.5	126,140	105,117	
Total					150,174	255,291
Case 3:						
#1	3.0	670	790	132,229	37,780	
#2	0.3	400	439	167,600	139,467	
Total					177,447	317,114
#1	3.0	670	790	132,229	37,780	
#2	0.35	410	448	148,330	123,608	
Total					161,388	284,996
#1	3.0	670	790	132,229	37,780	
#2	0.4	420	457.5	133,000	110,833	
Total					148,613	259,446

[a] Basis: Catalyst Life Reactor No. 1, 4 yr.
Catalyst Life Reactor No. 2, 2 yr.

Formula sheet for CHE457

$$N_{A0}\frac{dX}{dt} = -r_A V$$

$$V = \frac{F_{A0}X}{-r_A}$$

$$F_{A0}\frac{dX}{dV} = -r_A$$

$$F_{A0}\frac{dX}{dW} = -r'_A$$

$$C_A = \frac{F_A}{\upsilon} = \frac{F_{A0}(1-X)}{\upsilon_0(1+\varepsilon X)}\frac{T_0}{T}\frac{P}{P_0} = C_{A0}\frac{(1-X)}{(1+\varepsilon X)}\frac{T_0}{T}\frac{P}{P_0}$$

$$C_B = \frac{F_B}{\upsilon} = \frac{F_{A0}\left(\Theta_B - \frac{b}{a}X\right)}{\upsilon_0(1+\varepsilon X)}\frac{T_0}{T}\frac{P}{P_0} = C_{A0}\frac{\left(\Theta_B - \frac{b}{a}X\right)}{(1+\varepsilon X)}\frac{T_0}{T}\frac{P}{P_0}$$

$$\Theta_i = \frac{F_{i0}}{F_{A0}} = \frac{C_{i0}\upsilon_0}{C_{A0}\upsilon_0} = \frac{C_{i0}}{C_{A0}} = \frac{y_{i0}}{y_{A0}}$$

$$\delta = \frac{d}{a} + \frac{c}{a} - \frac{b}{a} - 1$$

$$\frac{dP}{dz} = \frac{-G}{\rho_0 g_c D_P}\left(\frac{1-\phi}{\phi^3}\right)\left[\frac{150(1-\phi)\mu}{D_P} + 1.75G\right]\frac{P_0}{P}\frac{T}{T_0}\frac{F_T}{F_{T0}}$$

$$\beta_0 = \frac{G}{\rho_0 g_c D_P}\left(\frac{1-\phi}{\phi^3}\right)\left[\frac{150(1-\phi)\mu}{D_P} + 1.75G\right]$$

$$W = zA_c\rho_b = zA_c(1-\phi)\rho_c$$

$$\frac{d(P/P_0)}{dW} = -\frac{\alpha}{2}\frac{1}{(P/P_0)}\frac{T}{T_0}(1+\varepsilon X)$$

$$\boxed{\frac{dy}{dW} = -\frac{\alpha}{2y}(1+\varepsilon X)}$$

$$S_{DU} = \frac{r_D}{r_U}$$

$$\tilde{S}_{DU} = \frac{F_D}{F_U}$$

Formula sheet for CHE457

$$k = k_1 \exp\left[\frac{E}{R}\left(\frac{1}{T_1} - \frac{1}{T}\right)\right]$$

$$K_C = K_{C2}\exp\left[\frac{\Delta H_{RX}}{R}\left(\frac{1}{T_2} - \frac{1}{T}\right)\right]$$

$$T = T_0 - \frac{X\left[\Delta H_R^\circ(T_R) + \Delta \hat{C}_P(T_0 - T_R)\right]}{\sum \Theta_i \tilde{C}_{Pi} + X\Delta\hat{C}_P} = T_0 - \frac{X[\Delta H_R(T)]}{\sum \Theta_i \tilde{C}_{Pi} + X\Delta\hat{C}_P}$$

$$\Delta C_P = \frac{d}{a}C_{PD} + \frac{c}{a}C_{PC} - \frac{b}{a}C_{PB} - C_{PA}$$

$$\boxed{\Delta H_{RX} = \frac{d}{a}H_D + \frac{c}{a}H_C - \frac{b}{a}H_B - H_A}$$

$$\boxed{X_{EB} = \frac{\left(\frac{UA}{F_{A0}}(T - T_0)\right) + \Sigma\theta_i \tilde{C}_{P_i}(T - T_0)}{-\Delta H_{RX}}}$$

$$D_{AB}(T_2) = D_{AB}(T_1)\left(\frac{T_2}{T_1}\right)^{1.75}\left(\frac{P_1}{P_2}\right)$$

$$Sh = \frac{k_c d_p}{D_{AB}} = 2 + 0.6Re^{1/2}Sc^{1/3}$$

$$W_A = \frac{D_{AB}}{\delta}[C_{AO} - C_{AS}] = k_C[C_{AO} - C_{AS}]$$

Table for Ques. No. 5(a)

Table 1: Data from a differential reactor.

Run	$-r'_T \times 10^{10}$ $\left(\frac{\text{g mol toluene}}{\text{g cat.} \cdot \text{s}}\right)$	Partial Pressure (atm)			
		Toluene, P_T	*Hydrogen* (H_2),[a] P_{H_2}	*Methane*, P_M	*Benzene*, P_B
Set A					
1	71.0	1	1	1	0
2	71.3	1	1	4	0
Set B					
3	41.6	1	1	0	1
4	19.7	1	1	0	4
5	42.0	1	1	1	1
6	17.1	1	1	0	5
Set C					
7	71.8	1	1	0	0
8	142.0	1	2	0	0
9	284.0	1	4	0	0
Set D					
10	47.0	0.5	1	0	0
11	71.3	1	1	0	0
12	117.0	5	1	0	0
13	127.0	10	1	0	0
14	131.0	15	1	0	0
15	133.0	20	1	0	0
16	41.8	1	1	1	1

[a] $P_H \equiv P_{H_2}$.

L-4/T-2/CHE **Date : 02/08/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2012-2013

Sub : **CHE 411** (Economics and Management of Chemical Process Industry)

Full Marks: 280 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**.

Symbol have their usual meanings

1. (a) How can you rank the order of MEAs (for investment alternative) for their comparison with rate of return method? - Explain. (10)

   (b) What investment criteria should the firm follow when it faces capital rationing? Why? (10)

   (c) A piece of production equipment is to be replaced immediately because it no longer meets quality requirements for the end product. The two best MEAs are a used piece of equipment (M) and a new automated model (N). The economic estimates for each are shown in table below. (26 2/3)

	Alternatives	
	'M'	'N'
Capital Investment	-$14,000	-$65,000
Annual Expenses	-14,000	-9,000
Market Value	8,000	13,000
Useful life (years)	5	20

   The MARR is 15% per year. Based on principle of MEA, specify which of the MEAs you will recommend for the proposed service. Find your answer with ERR method using a study period of 12 years.

2. (a) Show some basic differences between privately owned and publicly owned projects. (13)

   (b) What is self-liquidating project? Give an example is the context of Bangladesh and explain its purposes. What are the difficulties in evaluating public sector projects? (13 2/3)

   (c) Two mutually exclusive alternative public projects are under consideration. Their respective cash flow is included in the table below. Project-I has an anticipated life of 30 years and useful life of project-II has been estimated to be 20 years. If the nominal interest rate is 7% per period and compounded semi-annually, which are of the projects should be selected? Assume cotermination and a study period of 20 years. Use modified B/C ratio method. (20)

Contd P/2

CHE 411

Contd ... Q. No. 2 (c)

	project – I	project – II
Capital investment	$ 800 × 10^3	$ 650 × 10^3
Annual 'O' and 'M'	$ 125 × 10^3	$ 115 × 10^3
Annual benefit	$ 250 × 10^3	$ 235 × 10^3
Salvage value	$ 75 × 10^3	$ 60 × 10^3
Useful life (years)	30	20

3. (a) What is the importance of input output analysis is engineering economy? Explain with an example. $(16\frac{2}{3})$

(b) Each year, sector 'A' purchases $ 5 million of goods from sector 'B' and $ 10 million from sector 'C'. Sector 'B' makes annual purchases of $ 2 million from sector 'A' and $ 8 million from sector 'C'. Annual purchases of sector 'C' are $ 3 million from sector 'A' and $ 6 million from sector 'B'. Within-sector purchases are $ 1 million for sector 'A', $ 4 million for sector 'B', and $5 million for sector 'C'. Total sales in the sectors are $ 20 million, $ 20 million, and % 30 million, respectively. (30)

(i) Develop 3-sector input/output table

(ii) Write the transaction matrix for the three sectors

(iii) How much is value added for sector 'A'?

(iv) How much is final demand in sector 'A'?

(v) Write the direct-indirect requirements matrix for the model.

4. Write short notes on the following. $(11\frac{2}{3} \times 4)$

(a) Risk adjusted MARR

(b) Perpetuities and capitalized costs

(c) Capital asset pricing model (CAPM)

(d) General guidelines in estimating net cash flow from the project.

Contd P/3

CHE 411

SECTION-B

There are **FOUR** questions in this section. Question No. 5 is Compulsory
Answer any two from the rest.

5. **Compulsory** Select the correct answer and give concise reason for your choice. (10×5=50)

i. Communication begins with

a. encoding
b. idea origination
c. decoding
d. channel selection

ii. Functional managers are responsible

a. for a single area of activity
b. to the upper level of management and staff
c. for complex organizational sub-units
d. for obtaining copyrights and patents for newly developed processes and equipment

iii. The problem-solving process begins with

a. clarification of the situation
b. establishment of alternatives
c. identification of the difficulty
d. isolation of the cause

iv. In what **order** do managers typically perform the managerial functions?

(a) organizing, planning, controlling, leading
(b) organizing, leading, planning, controlling
(c) planning, organizing, leading, controlling
(d) planning, organizing, controlling, leading

v. Of the following leadership styles which one can be characterized as being "boss-centered"?

(a) The manager presents the problem
(b) The manager takes care of safety needs of the subordinate (employee)
(c) The manager makes the decision and announces it through an e-mail
(d) The manager invites questions

vi. The most general form of standing plans that specifies the broad parameters within which organization members are expected to operate in pursuit of organizational goals are called

(a) Procedures
(b) Programmes
(c) Single-use plan
(d) Policies
(e) Rules

Contd P/4

CHE 411

Contd ... Q. No. 5

vii. Douglas McGregor identified two opposing perspectives (Theory X and Theory Y) that he believed typified managerial views of employees and suggested that management must start with the basic question of how managers see themselves in relation to others. Which of the following is not correct about his theory?

(a) Theory X managers view people as having an inherent dislike of work
(b) Theory X managers assume that people are self motivated and do not want to be directed
(c) Theory Y managers assume that the average person will accept, even seek, responsibility
(d) Theory Y managers view people as responsible and conscientious
(e) Theory Y managers assume that people are internally motivated to accomplish the goals and objectives

viii. The communication process is made up of various components. Which of the following is the actual physical product from the source?

(a) Feedback
(b) Filter
(c) Message
(d) Channel
(e) Understanding

ix. Planning by a supervisor of a goods processing department to rearrange the location of several pieces of equipment so that the new order can begin on time, three months hence, would be an example of a/an

(a) Tactical plan
(b) Operational plan
(c) Tactical goal
(d) Operational goal
(e) Strategic goal.

x. Which of the following is **not true** with regard to functional authority?

(a) Functional authority is the authority staff members have over line members within the limits of their functions
(b) Functional authority has the same effect as line authority but it doesn't have the right that line authority has, to punish violations or deviations in order to ensure compliance
(c) Functional authority is limited to those areas where a staff member has some technical competence
(d) The use of functional authority should be restricted to the procedural aspects of a function
(e) Functional authority is in sync with the principle of unity of command

Contd P/5

CHE 411

6. (a) Draw an organization chart showing at least 5 levels for a Bangladeshi chemical and consumer products manufacturing company having the following features: (21)

   - Operates in two regions of the country
   - Produces three (3) different types of products
   - Develops new products through research ad development
   - There are staff supports at the higher level
   - Company regularly looks to reinvest profits in new ventures

   (b) This question refers of Technology Management (TM). (8×3=24)

   (i) Why is TM more important nowadays compared to 30 years back?

   (ii) Explain the Technology lifecycle?

   (iii) Using a good example explain Sequential Technology S-curves.

7. (a) What is the MATRIX organization? Give an appropriate international example and elaborate your answer. (20)

   (b) List five (5) advantages that help in deciding whether to use a committee or some other group method of decision making. (10)

   (c) In planning we need "Objectives and Goals"? What are these? Use multiple (at least 3) examples to elaborate your answer. (15)

8. (a) The following table shows the activities that need to be undertaken to complete an engineering project. Calculate the early time, late time and total float for each event. Identify the Critical Path of the given project with the help of arrow network. (35)

Activity Symbol	Estimated Time (weeks)	Post Requisite
A	7	E
B	2	E
C	15	I
D	8	F
E	10	G, D
F	2	I
G	5	H, F
H	8	
I	2	J
J	3	

   (b) Why is it important for Chemical Engineers to study MANAGEMENT? Which management function is most important for Chemical Engineers and why? (10)

L-4/T-2/ChE **Date : 10/08/2015**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-4/T-2 B. Sc. Engineering Examinations 2012-2013

Sub : **CHE 407** (Process Design II)

Full Marks : 140 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) Write down the distinguishing features of codes and standards. **(9)**

   (b) What are the points to be covered in preparing an individual specification in general? **(9)**

   (c) List the codes and standards applicable for cooling tower and Shell and Tube Heat Exchanger. **(5 ⅓)**

2. (a) Explain the stages of procurement for an engineering project. State the experience in Bangladesh regarding this matter. **(13)**

   (b) Discuss the process of evaluation of pre-qualification applications and bids. **(10 ⅓)**

3. (a) Discuss the steps that are involved in review and approval of engineering documents. **(13 ⅓)**

   (b) Explain the points to be considered in carrying out performance tests of the plant. **(10)**

4. (a) Discuss the impact of documentation for a project. **(8)**

   (b) Point out the scope of inspection and test. **(6)**

   (c) Discuss the stages of negotiating a contract for procurement. **(9 ⅓)**

SECTION – B

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

5. (a) Distinguish between basic and detailed engineering. **(5 ⅓)**

   (b) What are the role of process engineering in Detailed Engineering? **(9)**

   (c) What are the document included in Process Licensor's Basic Package. **(9)**

6. (a) How will you evaluate Process Licensors? **(10)**

   (b) Name two process Licensors for each of the following process: **(5)**

   (i) Urea (ii) Nitric Acid (iii) Styrene (iv) PVC (v) CO_2

   (c) Discuss the experience of process licensing in Bangladesh. **(8 ⅓)**

Contd P/2

CHE 407

7. (a) Write a short notes on **(9×2=18)**

   (i) Start-up and Performance Test

   (ii) Auxiliaries, offsites and Package Units

   (b) What are factors in the design Philosophy? **(5 ⅓)**

8. (a) Define a Process Plant. **(5 ⅓)**

   (b) Write the factors to be included in Feasibility Study. **(10)**

   (c) In context of Bangladesh, describe how the process plant design is carried out. **(8)**
