L-3/T-2/CHE **Date: 06/05/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHE 305** (Mass Transfer II)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section.
Answer **Question No. 1** and any two form the rest.
All Notations have usual meanings

1. **This question is compulsory**

(a) Hydrogen can be purified through several techniques, such as pressure swing adsorption (PSA), cryogenic distillation, or membrane separation. Compare the three techniques mentioned above with respect to the process, operating, energy consumption, safety, and environmental aspects. **(8)**

(b) The figure for Question no 1(b) presents an adsorption isotherm for hydrogen on powdered copper at 25°C. If your use copper as an adsorbent in a PSA system to separate hydrogen what would be your operating pressures? Justify your answer. **(7)**

(c) The figure for Question no 1(c) presents a simplified flow schematic of a membrane system to recover hydrogen from an ammonia reactor purge stream. A two-step membrane (M-1 and M-2) system is used to reduce permeate compression costs. Estimated the selectivity of hydrogen over methane in membrane M-1. Consider the temperature of M-1 at 25°C. **(20)**

2. (a) What will happen to the breakthrough curve (C/Co vs time) of a fixed bed of absorbent behaving ideally: **(12)**

i. if we increase the length of the absorbent bed

ii. if we increase the concentration of the bed

iii. if we increase the particle size of the adsorbent

(b) Air at 25°C, 1 atm, containing 0.01008 lb H_2O/lb dry air, and a superficial velocity of 100 ft/minutes passes through a bed of 2.8-mm spherical particles of silica gel with voidage, $\varepsilon = 0.4$ and density of the bed, $\rho_b = 39$ lb/ft^3. The adsorption-equilibrium isotherm at 25°C is given by **(23)**

$q_{H2O} = 15.9\ p_{H2O}$

where q is in lb H_2O/lb gel and p is in atmosphere. Treated air needs to contain 0.0009 lb H_2O/lb dry air. i) Given $K_c = 8.63$ cm/s, what is the minimum bed length considering irreversible adsorption? ii) For a bed 50 cm deep, what is the predicted time to breakthrough for an ideal bed?

Contd P/2

CHE 305

3. (a) Which factors affect the performance of a packed column? If you need to operate the column at high flow rates what type of packing would you prefer? Explain your answer. **(12)**

(b) Acetone is being absorbed by water in a packed tower having a cross -sectional area of 0.186 m^2 at 293K and 101.32kPa. The inlet air contains 2.6 mol% of acetone and the outlet 0.5%. The gas flow is 13.65 kg mol/h and the water inlet flow is 45.36 kg mol water/h. Film coefficients for the given flows in the tower are $k_y a = 3.78 \times 10^{-2}$ kg mol/s-m^3-molfrac and $k_x a = 6.16 \times 10^{-2}$ kg mol/s-m^3-molfrac. The equilibrium line is given by $y = 1.186x$. Calculate the tower height considering a dilute system. **(23)**

4. (a) You want to produce 99.5 wt% ethanol from a feed of 60 wt% ethanol. Which separation process or processes would you apply? Explain you answer. **(9)**

(b) Using a shorter bed length means a lower pressure drop in the bed. How do you estimate the pressure drop in a packed bed? Discuss the ways you can reduce the required height of a packed bed for distillation or absorption process. **(9)**

(c) What is mass transfer zone in an adsorption bed? What happens when the mass transfer zone in a bed becomes longer? Illustrate with the help of breakthrough curves. **(9)**

(d) Define the overall mass transfer coefficient for adsorption and compare it with the overall mass transfer coefficient for membrane separation using an asymmetric membrane. **(8)**

SECTION – B

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

5. (a) "When mass is transferred from one distinct phase to another or through a single phase, the basic mechanisms are the same whether the phase is a gas, liquid or solid" - justify this statement. **(15)**

(b) Ammonia gas is diffusing at a steady state through N_2 by equimolar counter diffusion in a conduit 1 m long at 25°C and total pressure of 101.32 kPa abs. The partial pressure of ammonia gas at the left end is 24.5 kPa and at the other end 4.033 kPa. The cross-section of the conduit is circular, the radius being 0.05 m at the left end and tapering uniformly to 0.025m at the right end. Calculate the molar flux of ammonia. The diffusivity of NH_3 in other gases is given in Figure for Question No. 5(b) **(20)**

Contd P/3

CHE 305

6. (a) A mixture of 60 mole% ethanol and 40 mole% water is to be separated using a distillation column where ethanol is 2.1 times more volatile than water. The $N_{F,min}$, N_F, N of the column are 5, 9, 20 respectively. If the fractional recovery of water in the bottoms is 80 mole%, find the fractional recovery of ethanol in distillate. **(10)**

(b) A distillation column is separating C_2, C_3, C_4, 5 atm pressure. Operation is at total reflux. A 98.9% recovery of ethane in the distillate and a 99.8% recovery of n-butane in the bottoms are required. F = 100 kmol/h and is 30 mol% ethane, 33 mol% propane and 37 mol% n-butane. Feed is a saturated liquid. The vapor pressure at 25°C of the 3 components are given below: **(25)**

Components Name	Vapor Pressure (psia)
C_2	465.2
C_3	135.7
C_4	35.4

Show the variation of optimum feed stage with reflux ratio in a graph.

Given, Gilliland Correlation:

$$\frac{n-n_m}{n+1}=1-exp\left[\left(\frac{1+54.4\Psi}{11+117.2\Psi}\right)\left(\frac{\Psi-1}{\Psi^{0.5}}\right)\right] \qquad \textit{where} \qquad \Psi=\frac{R-R_m}{R+1}$$

n = Actual number of stages

n_m = minimum number of stages

R = Actual reflux ratio

R_m = minimum reflux ratio

7. The liquid diffusion coefficient measuring apparatus shown in the Figure for Q. No. 7 is used to determine the diffusivity of NaCl solution in describe-ionized water. A known concentration of NaCl solution is placed in a diffusion cell immersed in water. A magnetic stirrer and a conductivity meter are provided to monitor the progress of diffusion over time. Supplier of the equipment provided the following data:

Volume of water in diffusion vessel, V=1.1 L

Length of capillaries, x = 0.5 cm

8Diameter of the capillaries, d = 0.1 cm

Number of capillaries, N = 97

Change of electrical conductivity with the change of concentration of NaCl solution, $C_M = 4.1\times10^{-5}\frac{\mu S}{mol.L^{-1}}$.

Contd P/4

CHE 305

Contd... Q. No. 7

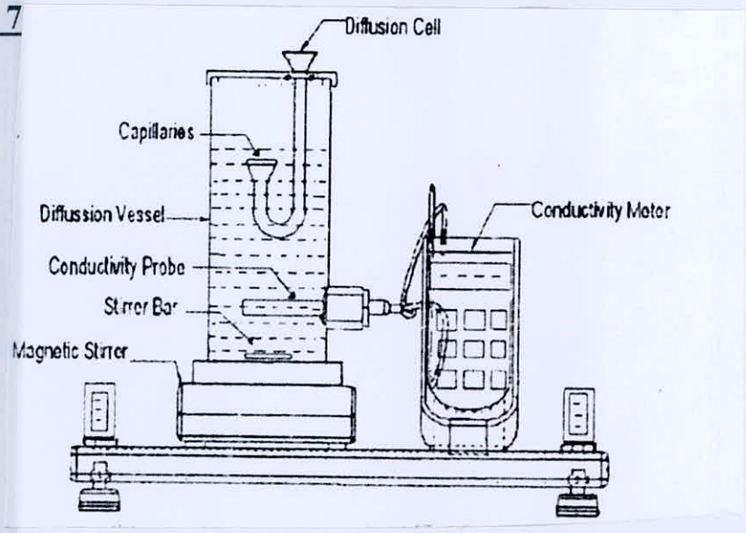


Figure for Question No. 7

Experimental conductivity data with time for 1M and 4M solutions are given below:

No. of observation	Tim, t (s)	1M NaCl solution	4M NaCl solution
		Conductivity (μS)	Conductivity (μS)
01	900	224.30	659.30
02	1200	234.60	707.30
03	1500	242.60	742.70
04	1800	247.70	772.20
05	2100	253.40	796.20

(a) Derive an expression diffusivity of NaCl in water based on this experimental setup. Start with Fick's law of diffusion and make necessary assumptions. **(10)**

(b) Evaluate the diffusivity outside two different concentrated solutions of NaCl. **(15)**

(c) The diffusivity of 1M and 4M concentrated NaCl solution should be same. What do you think about the statement? Briefly explain. **(10)**

8. (a) Write the difference between natural draft and force draft cooling tower **(6)**

(b) The performance of cooling tower depends on the environment conditions. Explain briefly. **(5)**

(c) Water is to be cooled from 328 to 293 K by means of a countercurrent air stream entering at 293 K with a relative humidity of 20 percent. The flow of air is 0.68 m^3/m^2 s and the water throughput is 0.26 kg/ m^2s.The whole of the resistance to heat and mass transfer may be assumed to be in the gas phase and the product, (h_Da), may be taken as 0.2, (m/s) (m^2/m^3/) that is 0.2 s^{-1} . **(24)**

What is the required height of packing and the condition of the exit air stream?

Assuming the latent heat of water at 273K= 2495 kJ/kg

specific heat of air =1.003 kJ/kg K

and specific heat of water vapor = 2.006 kJ/kg K

Figure for Q no 1(b)

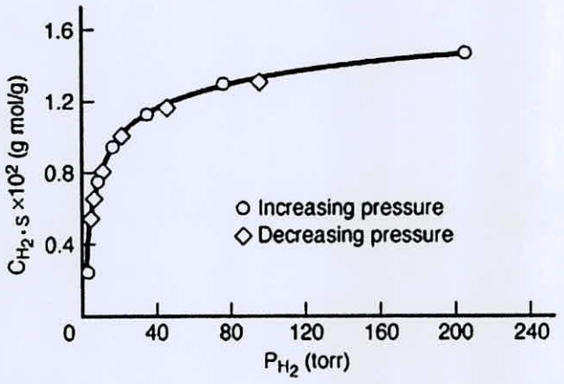
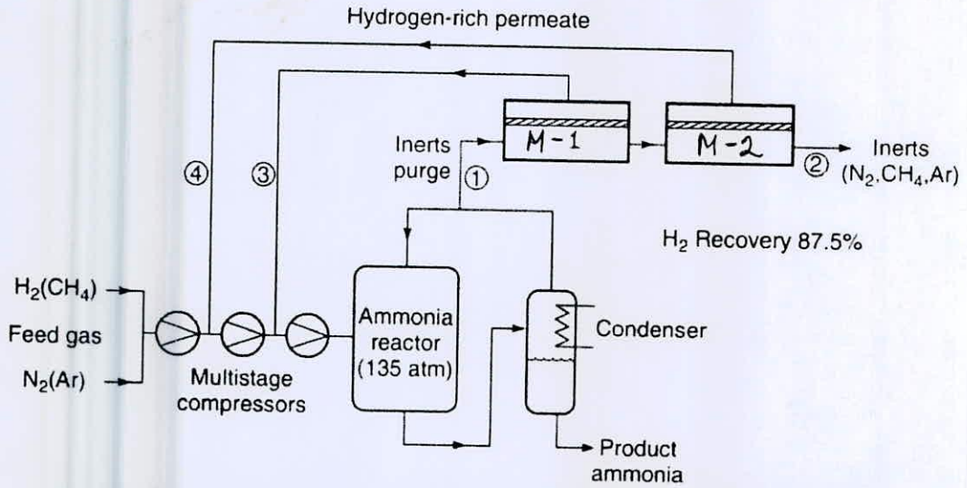


Figure for Q no 1(c)



	Stream Composition (%)			
	Membrane Feed ①	Membrane Vent ②	High-Pressure Permeate ③	Low-Pressure Permeate ④
Hydrogen	62	21	87.3	84.8
Nitrogen	21	44	7.1	8.4
Methane	11	23	36	4.3
Argon	6	13	2.0	2.5
Pressure (atm)	135	132	70	28
Flow (scfm)	2000	740	830	430

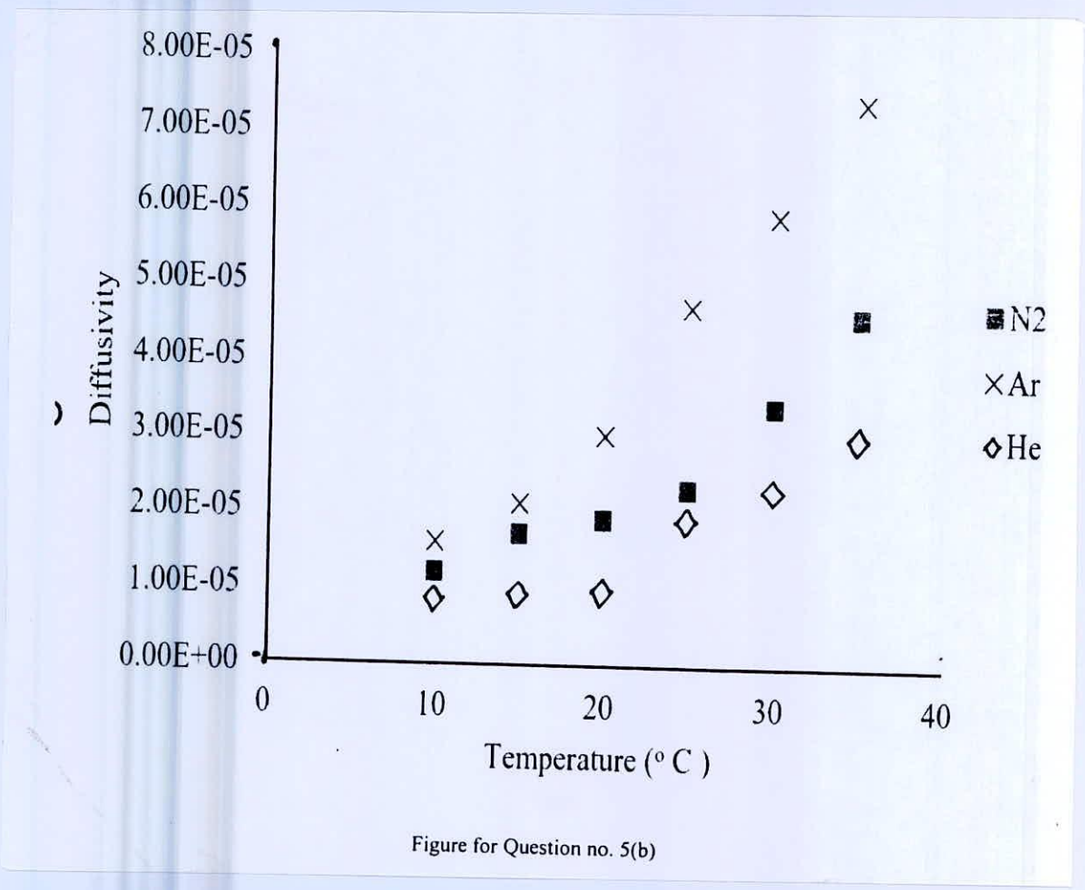


Figure for Question no. 5(b)

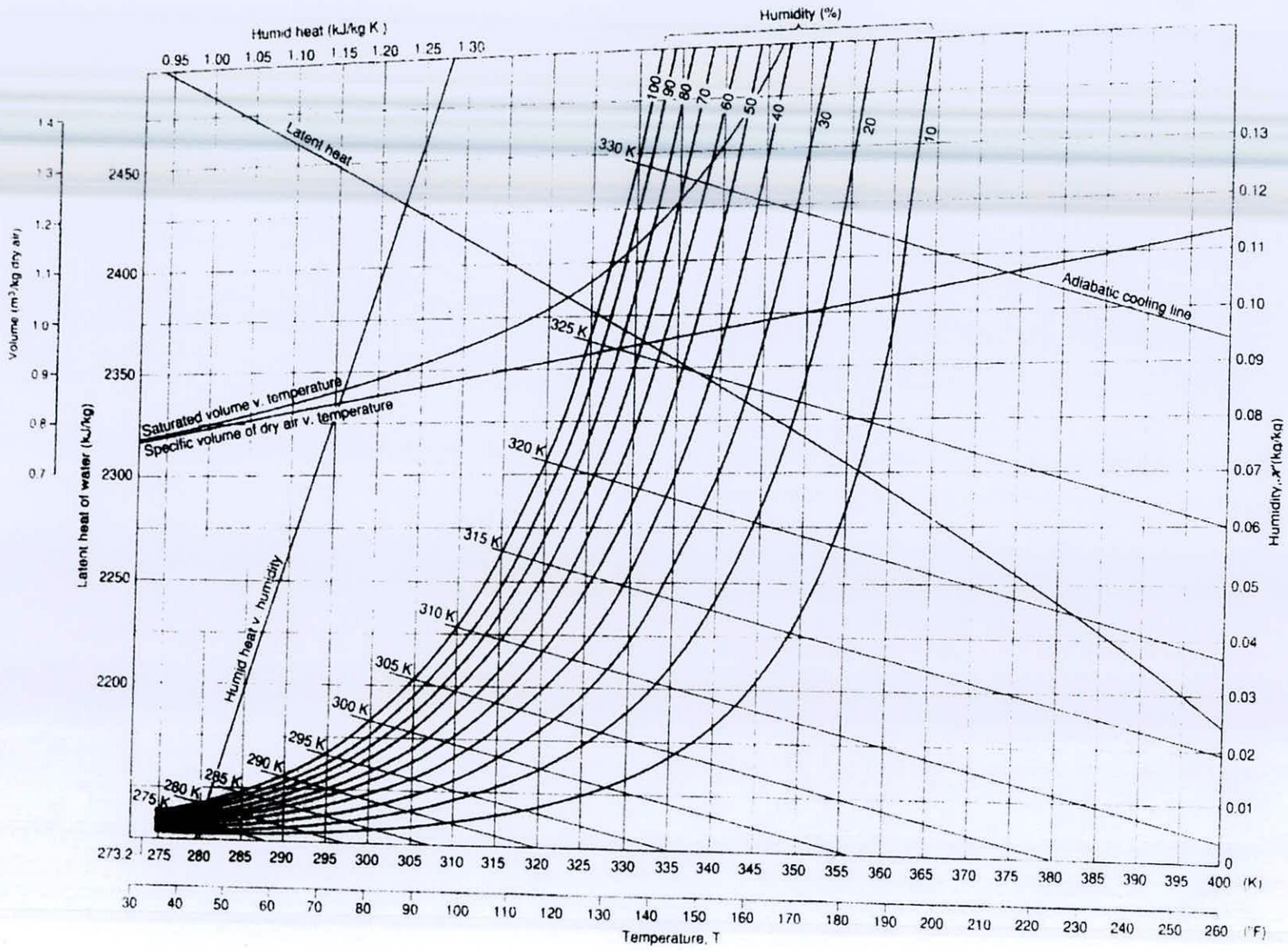


Figure for Question 8(b)

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHE 309** (Particle Technology)

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** questions.

1. (a) Answer the following questions briefly: **(4+3+3+6+4=20)**

   (i) Does sphericity of particles affect the porosity of a bed of these particles? If yes, how?

   (ii) Why are normalized moments used to describe crystal population?

   (iii) Comment on how filter aids can sometimes cause additional problems in filtration operations.

   (iv) Derive the expression for total mass of crystals in terms of seed size, crystal size and seed mass fractions.

   (v) For a compressible cake in filtration operations, predict the behaviour of the graph of $d\theta/dV$ vs V, stating your reasoning.

   (b) The following equations can be derived from the Carman Kozeny Equation: **(15)**

$$\frac{1}{A}\frac{dV}{d\theta} = \frac{(-DP_t)g_c}{\mu\frac{\alpha w V}{A}} \quad \text{(A)}$$

   (i) Derive the expression for the time (θ) taken for volume (V) of filtrate to flow through a constant pressure filtration system where α is the specific cake resistance. V_e (fictitious volume related to medium resistance) can be ignored.

   (ii) Carry out a mass balance on the filtration cake, and derive an expression relating the volume of filtrate and cake length.

   (iii) Simplify the expressions for θ, eliminating A (area of filtration) from the expression.

2. (a) A slurry, containing 0.2 kg of solid per kilogram of water, is fed to a rotary drum filter 0.8 m long and 0.5 m diameter. The drum rotates at one revolution in 360 s and 20 per cent of the filtering surface is in contact with the slurry at any instant. If filtrate is produced at the rate of 0.125 kg/s and the cake has a voidage of 0.4, what thickness of cake is produced when filtering with a pressure difference of 65 kN/m^2? The density of the solids is 2500 kg/m^3. **(27)**

Contd P/2

CHE 309

Contd.... for Q. No. 2(a)

The rotary filter breaks down and the operation has to be carried out temporarily in a plate and frame press with square frames with 0.3 m sides, and each frame is 47 mm in thickness. If filtration is to be carried out at the same overall rate as before, with an operating pressure difference of 175 kN/m^2, what is the number of frames that needs to be used? It may be assumed that the cake are incompressible and that the resistance of the filter medium may be neglected.

(b) Identify the suitable filtration equipment for the following situations, and state very briefly the reason for picking the equipment: **(8)**

(i) Area of filtration equipment must be minimal for high filtration throughputs

(ii) Equipment will be used primarily for pilot tests

(iii) Equipment will be used for final clarifying of slurries

(iv) Large quantities of dilute slurries will be clarified.

3. (a) The suspension density was 335 g/L and the retention time was fixed at 2.0 hr. Determine the predominant crystal length, crystal nucleation rate and growth rate. Also determine the total number of crystals per litre. **(10+15=25)**

Mesh Size	Cumulative percent retained (%)	Population density at crystal size, n (10^9/ft-ft^3)
14	3	0.16
20	16	1.82
28	40	10.5
35	63	31.6
48	83	81.8
65	93	152.3

(b) A packed bed, consisting of uniform spherical particles of diameter 3 mm density 4200 kg/m^3, is fluidized by means of a liquid of viscosity 1×10^{-3} Ns/m^2 and density 1100 kg/m^3. Using Ergun's equation for the pressure drop and assuming the voidage to be 0.48, calculate the minimum fluidizing velocity. **(10)**

4. (a) A 2 m diameter absorption tower contains plastic Raschig rings randomly packed to a height of 5 m. Air passes upwards through the absorption tower at a flow rate of 6 m^3/s and the temperature is maintained at 20°C. Details of the packing are given below: **(8+10+7=25)**

Contd P/3

CHE 309

Contd.... for Q. No. 4(a)

Surface area per unit volume of packed bed, 190 m^2/m^3.

Voidage of randomly packed bed = 0.71

Density of plastic = 960 kg/m^3

(i) Calculate the diameter of a sphere having the same surface area to volume ratio as the Raschig rings.

(ii) Using the diameter you found in part (i) and other information provided, calculate the pressure drop across the packed bed.

(iii) Comment on whether laminar or turbulent flow is predominant in this case. Also mention how the pressure drop found in part (ii) will vary with temperature of air.

(b) What are the criteria of MSMPR crystallizers? Comment on the likelihood of the criteria working or failing in practical crystallizers? **(10)**

SECTION – B

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

5. A continuous thickener is to be designed for 100 tons/h activated sludge (SG is 4.30) where the underflow concentration is 10,000 mg/l and the feed concentration is 2,500 mg/l. Settling tests were obtained for that sample which is presented in Table Q5. **(3+6+3+25+5+3=45)**

(i) Show the process block diagram for this system with the necessary information.

(ii) Discuss about the solid flux for a continuous thickener.

(iii) Perform the material balance for this process.

(iv) Identify the solids handling capacity (SHC) for that thickener after performing the necessary calculations.

(v) Design a thickener for clarifying the sludge based on the result in part (iv).

(vi) What is your interpretation if the thickener is operated beyond the SHC. Propose the solution(s) to overcome the difficulties.

Table Q5: Batch-Settling test of pulp

Time, hr	Interface height, mm
0	1000
3	690
5	480
10	300

Time, hr	Interface height, mm
15	220
20	180
30	130
48	128

Contd P/4

CHE 309

6. (a) The equations giving the number distribution curve for a powdered material are $dn/dd_p = d_p$ for the size range of 0 to 10 microns and $dn/dd_p = 100{,}000/d_p^4$ for the size range of 10 to 100 microns. Sketch the number distribution curve. **(20)**

(b) Give some examples of normal distribution. State four characteristics of the Normal Distribution, and write on its usefulness by including a discussion on the z-test. **(2+4+4=10)**

7. (a) Quartz and pyrites are separated by continuous hydraulic classifications. The feed to the classifier ranges in size between 10 microns and 300 microns. Three fractions are obtained, a pure quartz product, a pure pyrites product, and a mixture of quartz and pyrites. The specific gravity of quartz is 2.65, and that of pyrites is 5.1. What is the size range of the bottom product containing the maximum amount of pure pyrite? **(20)**

(b) Explain the importance of separation ratio in classification based on the terminal settling velocity. Your answer should contain the definition, derivation, and modification of hydraulic separation. **(2+5+3=10)**

8. (a) A packed absorption tower 7 ft in diameter and 55 ft high is to be filled with crushed-sized coke. Compute the vertical and lateral pressures at the base caused by the coke. Compare the pressure that would be exerted by a liquid of the same density. The bulk density and angle of repose are 33 lb/ft^3 and 28°, respectively. **(12+4+4=20)**

Given data: α_m (estimated) = 34°.

(b) Give a neat sketch of the Colloidal Model (Double Layer). Demonstrate the concept of 'flocculation by polyelectrolyte' in context of your sketch. **(5+5=10)**

Additional data

Empirical relations to calculate C_D

$$C_D = \frac{24}{N_{Re_p}} \qquad N_{Re_p} \le 1$$

$$C_D = \frac{24}{N_{Re_p}}\left[1 + 0.14 N_{Re_p}^{0.7}\right] \qquad 1 < N_{Re_p} < 1000$$

$$C_D = 0.44 \qquad N_{Re_p} \ge 1000$$

Ergun Equation:

$$\frac{(-\Delta p)}{L} = 150\,\frac{(1-\varepsilon)^2}{\varepsilon^3}\,\frac{\mu u_o}{D_p^2} + 1.75\,\frac{\rho u_o^2}{D_p}\,\frac{(1-\varepsilon)}{\varepsilon^3}$$

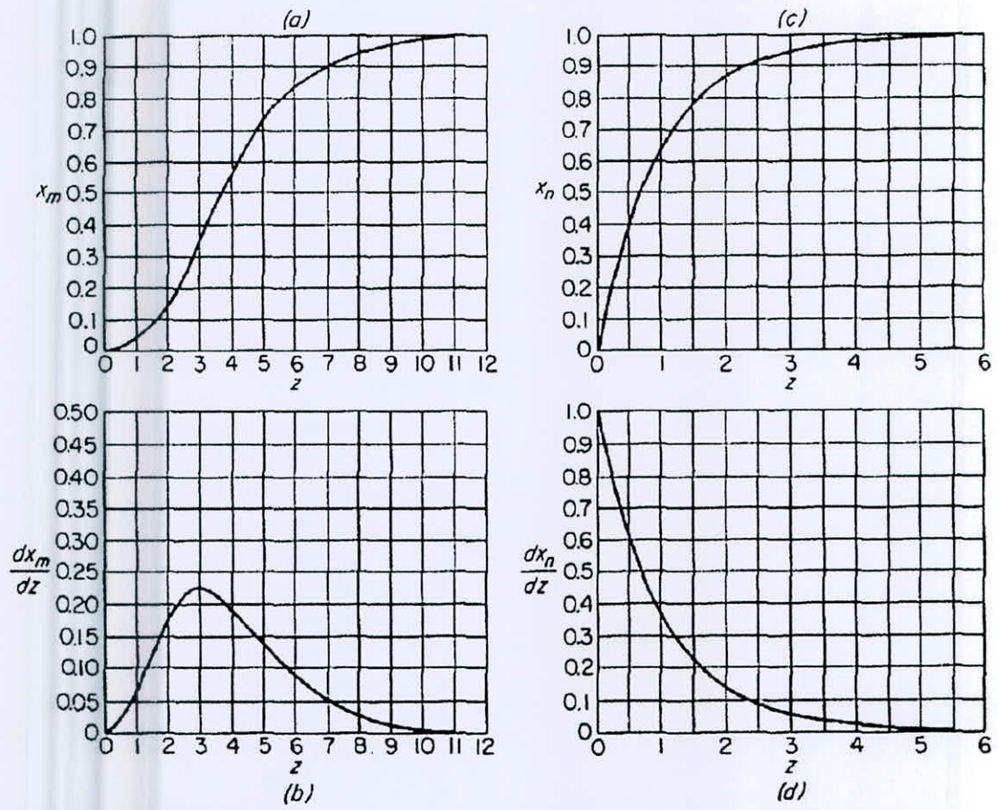


Figure: Size-distribution relations in mixed suspension: (a) cumulative mass distribution; (b) differential mass distribution; (c) cumulative population distribution; (d) differential population distribution.

Table: Properties of air at various temperatures.

Temperature	Density	Dynamic Viscosity	Kinematic Viscosity
°C	kg/m³	x10⁻⁵ kg/m.s	x10⁻⁵ m²/s
-20	1.3958	1.6222	1.1622
-15	1.3687	1.6478	1.2039
-10	1.3426	1.6731	1.2462
-5	1.3175	1.6982	1.289
0	1.2933	1.7231	1.3324
5	1.2699	1.7478	1.3763
10	1.2474	1.7722	1.4207
15	1.2257	1.7965	1.4657
20	1.2047	1.8205	1.5111
25	1.1845	1.8444	1.5571
30	1.1649	1.868	1.6036
35	1.1459	1.8915	1.6507
40	1.1275	1.9148	1.6982
45	1.1098	1.9379	1.7462
50	1.0925	1.9608	1.7947
55	1.0759	1.9835	1.8437
60	1.0597	2.0061	1.8931

TYLER STANDARD SCREEN SIZES

Standard Interval = $\sqrt{2}$, Aperture, in.	Interval = $\sqrt[4]{2}$			
	Aperture, in.	Aperture, mm	Mesh Number	Wire Diameter,,
1.050	1.050	26.67	...	0.148
	0.883	22.43	...	0.135
0.742	0.742	18.85	...	0.135
	0.624	15.85	...	0.120
0.525	0.525	13.33	...	0.105
	0.441	11.20		0.105
0.371	0.371	9.423	...	0.092
	0.312	7.925	$2\frac{1}{2}$	0.088
0.263	0.263	6.680	3	0.070
	0.221	5.613	$3\frac{1}{2}$	0.065
0.185	0.185	4.699	4	0.065
	0.156	3.962	5	0.044
0.131	0.131	3.327	6	0.036
	0.110	2.794	7	0.0326
0.093	0.093	2.362	8	0.032
	0.078	1.981	9	0.033
0.065	0.065	1.651	10	0.035
	0.055	1.397	12	0.028
0.046	0.046	1.168	14	0.025
	0.0390	0.991	16	0.0235
0.0328	0.0328	0.833	20	0.0172
	0.0276	0.701	24	0.0141
0.0232	0.0232	0.589	28	0.0125
	0.0195	0.495	32	0.0118
0.0164	0.0164	0.417	35	0.0122
	0.0138	0.351	42	0.0100
0.0116	0.0116	0.295	48	0.0092
	0.0097	0.248	60	0.0070
0.0082	0.0082	0.208	65	0.0072
	0.0069	0.175	80	0.0056
0.0058	0.0058	0.147	100	0.0042
	0.0049	0.124	115	0.0038
0.0041	0.0041	0.104	150	0.0026
	0.0035	0.088	170	0.0024
0.0029	0.0029	0.074	200	0.0021
	0.0024	0.061	230	0.0016
0.0021	0.0021	0.053	270	0.0016
	0.0017	0.043	325	0.0014
0.0015	0.0015	0.038	400	0.0010

L-3/T-2/CHE **Date: 29/03/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHE 311** (Special Topics in Unit Operations)

Full Marks: 280 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

Assume reasonably if additional data / information is required.

Notations indicates their usual meaning.

The figures in the margin indicate full marks

SECTION – A

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

1. (a) Validate

"Heat Flux in each effect of evaporator of a multiple effect evaporator $\propto \frac{1}{n}$ Heat flux of a single effect evaporator" **(10 2/3)**

(b) Illustrate the working principle of Entrainment separator with the help of a neat sketch. **(16)**

(c) A basket type double effect evaporator connected for backward feed will concentrate a NaOH solution. Each evaporator body has a 2000 ft^2 heating area. The caustic solution enters at 80°F and is 5 weight percent NaOH. It is to be concentrated to 50 weight percent. Previous operation indicates that overall coefficients of 400 Btu/hr ft^2°F may be obtained in the first and second effects, respectively. Saturated steam at 150 psia is available, and a vacuum of 2 in. Hg absolute may obtained with existing ejectors. Estimate the maximum production obtainable. **(20)**

2. (a) Based on the General Guidelines of Dryer Selection, recommend the dryer type for the cement industry. **(26 2/3)**

(b) Write short notes on following: **(10×2=20)**

(i) Fluidized bed dryer (ii) The merits of freeze dried product

3. (a) A centrifugal pump with the characteristics shown in Figure for Question No. 3(a) delivers 350 gal/min at a head of 300 ft. Find the size of the impeller and required power and justify your answer. **(10)**

(b) "In a fixed capacity ejector, an increase in steam pressure does not increase vapor handling capacity" - Evaluate the statement. Why is Ejector attractive for industrial application? Write eight reasons. **(10+8=18)**

Contd P/2

CHE 311

Contd... Q. No. 3

(c) Write the key components in the Specification Sheet of the Reciprocating Compressor. **(18 2/3)**

4. (a) Evaluate the statement - Balanced safety valve is advantageous to offset backpressure effect." **(14 2/3)**

(b) Leung reported on the data of Huff involving a 3500-gal reactor with styrene monomer undergoing adiabatic polymerization after being heated inadvertently to 70°C. The vessel's maximum allowable working pressure (MAWP) is 5 bar. Given the following data, determine the relief vent diameter required for the rupture disc. Suppose that all vapor relief was assumed. Assume a set pressure of 4.5 bar and a maximum pressure of 5.4 bar absolute: **(20)**

Data

Volume (V): 3500 gal = 13.16 m^3

Reaction mass (m,): 9500 kg

Set temperature (T,): 209.4 °C = 482.5 °K

Data from VSP

Maximum temperature (T_s): 219.5°C = 492.7 °K

(dT/dt), = 29.6°C/min = 0.493 K/s

(dT/dt), = 39.7°C/min = 0.662 K/s

γ = 1.32 and C_0 =1.0

Physical Property Data

	4.5-bar set	5.4-bar peak
v_f(m^3/kg)	0.001388	0.001414
v_g(m^3/kg)	0.08553	0.07278
C_p(kJ/kg K)	2.470	2.514
ΔH_v(kJ/kg)	310.6	302.3

Necessary equations

$$A = \frac{Q_m}{C_o P}\sqrt{\frac{R_g T}{\gamma g_c M}\left(\frac{2}{\gamma+1}\right)^{(\gamma+1)(1-\gamma)}} \qquad q = C_v\left(\frac{dT}{dt}\right)_s \qquad Q_m = \left(\frac{qm_0}{\Delta H_v}\right)$$

(c) The following configurations provide us with the information on what not to do while placing relief valves or rupture disk on process vessels. What are the wrongs with the given configurations and justify with appropriate reasons? **(6×2=12)**

Contd P/3

CHE 311

Contd... Q. No. 4(c)

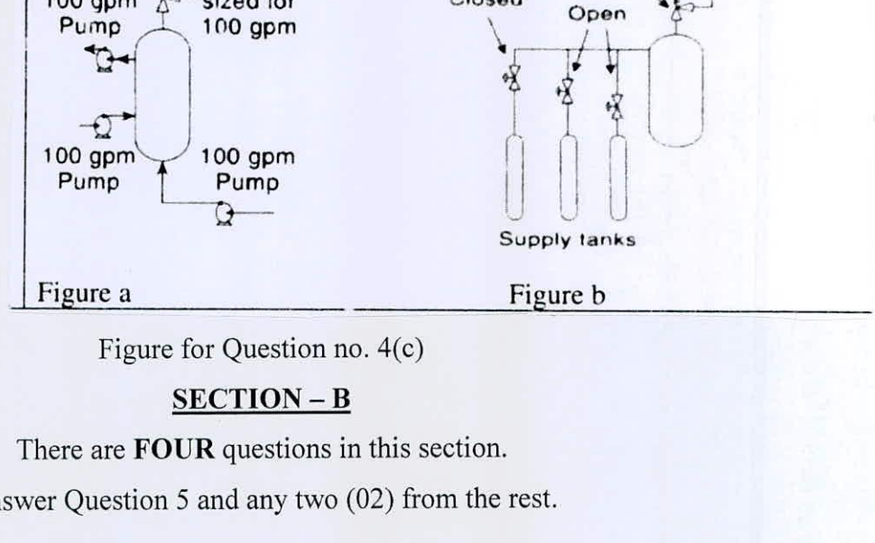


Figure for Question no. 4(c)

SECTION – B

There are **FOUR** questions in this section.

Answer Question 5 and any two (02) from the rest.

5. **(Compulsory)** (a) Which form of powder needs more energy for separation? Describe it on the basis of powder properties. **(5 $\frac{2}{3}$)**

(b) Fines are produced from raw materials' handling unit in ceramics operation at the rate of 10 grains/cu.ft. with the mean diameter of 4 micron. Propose at least two suitable equipment to achieve the highest collection efficiency and calculate the final flowrate and concentration of the fines. **Use Sylvan chart, locate the points and attach the figure with your answer script**. **(10 $\frac{2}{3}$)**

(c) Why cyclone separator is called primary collector? Define the concept of critical diameter in operating cyclone separation. **(6 $\frac{2}{3}$)**

(d) What are the deciding criteria of choosing dry and wet scrubbing technique? Illustrate with an example. **(6 $\frac{2}{3}$)**

(e) Explain velocity compounding in steam turbine and give proper reasoning of its absence in reaction turbine. **(6 $\frac{2}{3}$)**

(f) Write the successful design criteria of fabric filter and describe the effect of humidity and temperature during operating fabric filter. **(10 $\frac{2}{3}$)**

6. (a) Describe different types of steam turbine with major selecting criteria. Sketch proper diagram where necessary. **(20)**

Contd P/4

CHE 311

Contd... Q. No. 6

(b) Steam is to be supplied from a boiler to a high-pressure turbine whose isentropic efficiency is 85 percent at conditions to be determined. The steam is to leave the high-pressure turbine as a saturated vapor at 1.4 MPa pressure, and the turbine is to produce 5.5 MW of power. Steam at the turbine exit is extracted at a rate of 1000 kg/min and routed to a process heater while the rest of the steam is supplied to a low-pressure turbine whose isentropic efficiency is 80 percent. The low-pressure turbine allows the steam to expand to 10 kPa pressure and produces 1.5 MW of power. Evaluate the temperature, pressure, and the flow rate of steam at the inlet of the high-pressure turbine using Mollier diagram. (**Attach the diagram with your answer script**) **(26 2/3)**

7. (a) Draw the schematic of a three phase separator with proper labelling. **(6 2/3)**

(b) Describe the purpose of following parts and terms in a separator. **(16)**

i. Slug catcher

ii. Mist eliminator

iii. Hold up and Surge

iv. You have high and low viscous fluids. Which one will be difficult to settle?

(c) You want to design a vertical three phase separator. During performing this task, you need to check whether separation of light liquid and heavy liquids are possible with the proposed dimensions. A three phase mixture having following specifications is available. **(24)**

Phase	Mass Flow, lb/h	Density, p lb/ft^3	Viscosity, μ(cP)
Hydrocarbon Gas	415,000	0.6973	-
Hydrocarbon Liquid	16,500	53.95	0.630
Water	1,300	62.11	0.764

i. You need to calculate the internal diameter of the vertical separator.

ii. Calculate the residence time of the light and heavy liquids and state whether separation is possible with this value. Use k values = 0.35.

Contd P/5

CHE 311

8. (a) Calculate the power requirement to mix an aqueous solution of 50% NaOH in a baffled tank, 2 m in diameter. The mixing will be performed in the vertical tank filled to a height of 2 m by a disk turbine with six flat blades. The turbine is 0.67 m in diameter and positioned 0.67 m above the bottom of the tank. The turbine blades are 0.134 m wide, 0.167 m long and turn at 90 r/min. The solution has a viscosity of 0.012 Pa-s and density of 1500 kg/m^3. **(16$\frac{2}{3}$)**

(b) In case excessive of nucleation, which type of crystallizer equipment is used? Briefly describe about the crystallizer, its principle of operation, advantages and disadvantages of using it. **(16)**

(c) Write short notes on **(14)**

1. Screw conveyor
2. Laws of size reduction and applicability of these laws.

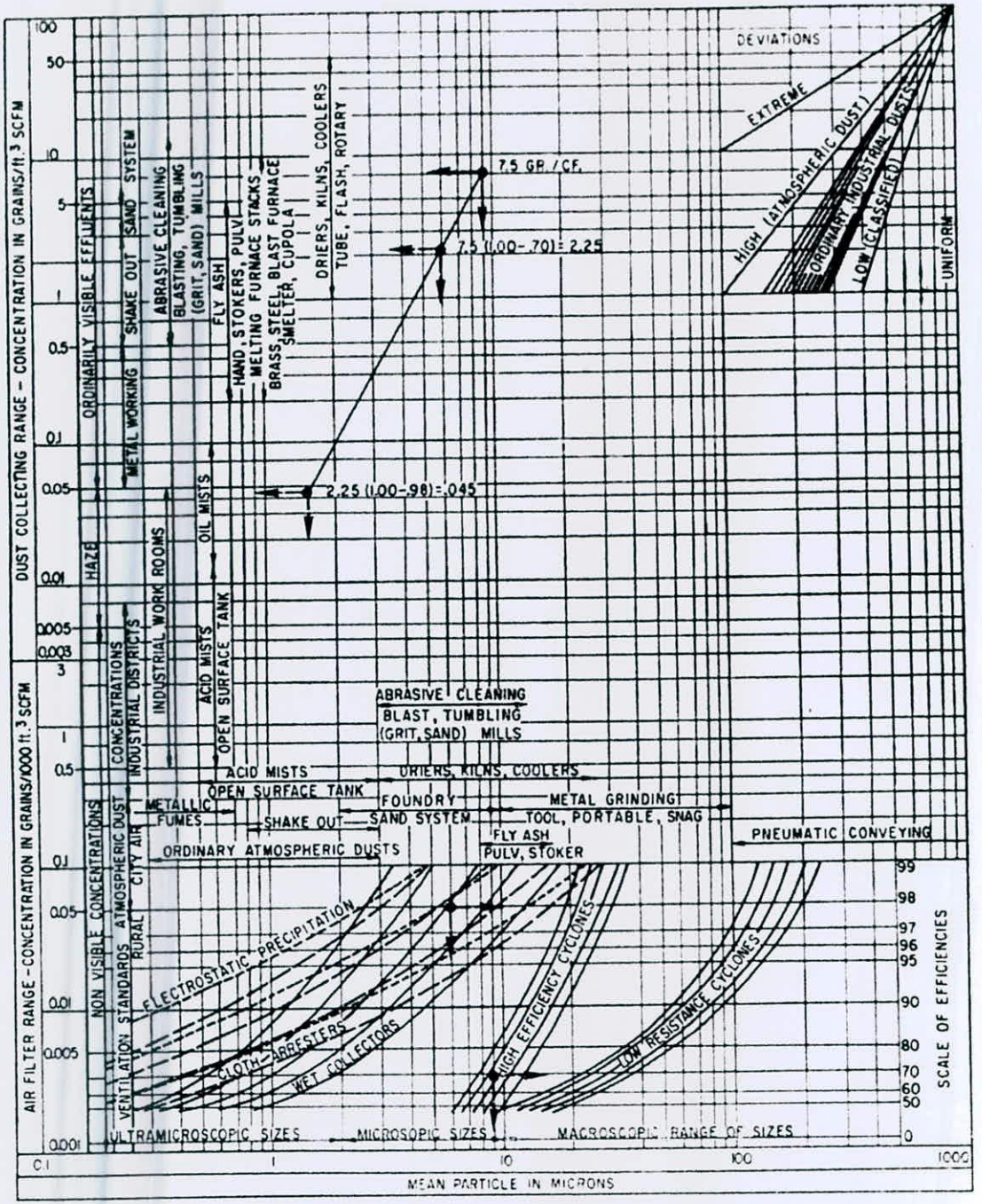


Figure for question no 5b

Steam and Water

Temperature T, °F	Vapor pressure p_A, lb/in.^{2}	Specific volume, ft^3/lb: Liquid v_f	Specific volume, ft^3/lb: Saturated vapor v_g	Enthalpy, Btu/lb: Liquid H_f	Enthalpy, Btu/lb: Vaporization λ	Enthalpy, Btu/lb: Saturated vapor H_g
32	0.08859	0.016022	3.305	0	1,075.4	1,075.4
35	0.09992	0.016021	2.948	3.00	1,073.7	1,076.7
40	0.12166	0.016020	2.445	8.02	1,070.9	1,078.9
45	0.14748	0.016021	2.037	13.04	1,068.1	1,081.1
50	0.17803	0.016024	1,704.2	18.06	1,065.2	1,083.3
55	0.2140	0.016029	1,431.4	23.07	1,062.4	1,085.5
60	0.2563	0.016035	1,206.9	28.08	1,059.6	1,087.7
65	0.3057	0.016042	1,021.5	33.09	1,056.8	1,089.9
70	0.3632	0.016051	867.7	38.09	1,054.0	1,092.0
75	0.4300	0.016061	739.7	43.09	1,051.1	1,094.2
80	0.5073	0.016073	632.8	48.09	1,048.3	1,096.4
85	0.5964	0.016085	543.1	53.08	1,045.5	1,098.6
90	0.6988	0.016099	467.7	58.07	1,042.7	1,100.7
95	0.8162	0.016114	404.0	63.06	1,039.8	1,102.9
100	0.9503	0.016130	350.0	68.05	1,037.0	1,105.0
110	1.2763	0.016166	265.1	78.02	1,031.4	1,109.3
120	1.6945	0.016205	203.0	88.00	1,025.5	1,113.5
130	2.225	0.016247	157.17	97.98	1,019.8	1,117.8
140	2.892	0.016293	122.88	107.96	1,014.0	1,121.9
150	3.722	0.016343	96.99	117.96	1,008.1	1,126.1
160	4.745	0.016395	77.23	127.96	1,002.2	1,130.1
170	5.996	0.016450	62.02	137.97	996.2	1,134.2
180	7.515	0.016509	50.20	147.99	990.2	1,138.2
190	9.343	0.016570	40.95	158.03	984.1	1,142.1
200	11.529	0.016634	33.63	168.07	977.9	1,145.9
210	14.125	0.016702	27.82	178.14	971.6	1,149.7
212	14.698	0.016716	26.80	180.16	970.3	1,150.5

Table For Question 1(c)

Temperature T, °F	Vapor pressure p_A, lb$_f$/in.^{2}	Specific volume, ft^3/lb: Liquid v_ℓ	Specific volume, ft^3/lb: Saturated vapor v_g	Enthalpy, Btu/lb: Liquid H_ℓ	Enthalpy, Btu/lb: Vaporization λ	Enthalpy, Btu/lb: Saturated vapor H_g
220	17.188	0.016772	23.15	188.22	965.3	1,153.5
230	20.78	0.016845	19.386	198.32	958.8	1,157.1
240	24.97	0.016922	16.327	208.44	952.3	1,160.7
250	29.82	0.017001	13.826	218.59	945.6	1,164.2
260	35.42	0.017084	11.768	228.76	938.8	1,167.6
270	41.85	0.017170	10.066	238.95	932.0	1,170.9
280	49.18	0.017259	8.650	249.18	924.9	1,174.1
290	57.53	0.017352	7.467	259.44	917.8	1,177.2
300	66.98	0.017448	6.472	269.73	910.4	1,180.2
310	77.64	0.017548	5.632	280.06	903.0	1,183.0
320	89.60	0.017652	4.919	290.43	895.3	1,185.8
340	117.93	0.017872	3.792	311.30	879.5	1,190.8
350	134.53	0.017988	3.346	321.80	871.3	1,193.1
360	152.92	0.018108	2.961	332.35	862.9	1,195.2
370	173.23	0.018233	2.628	342.96	854.2	1,197.2
380	195.60	0.018363	2.339	353.62	845.4	1,199.0
390	220.2	0.018498	2.087	364.34	836.2	1,200.6
400	247.1	0.018638	1.8661	375.12	826.8	1,202.0
410	276.5	0.018784	1.6726	385.97	817.2	1,203.1
420	308.5	0.018936	1.5024	396.89	807.2	1,204.1
430	343.3	0.019094	1.3521	407.89	796.9	1,204.8
440	381.2	0.019260	1.2192	418.98	786.3	1,205.3
450	422.1	0.019433	1.1011	430.2	775.4	1,205.6

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

Table For Question 1(c)

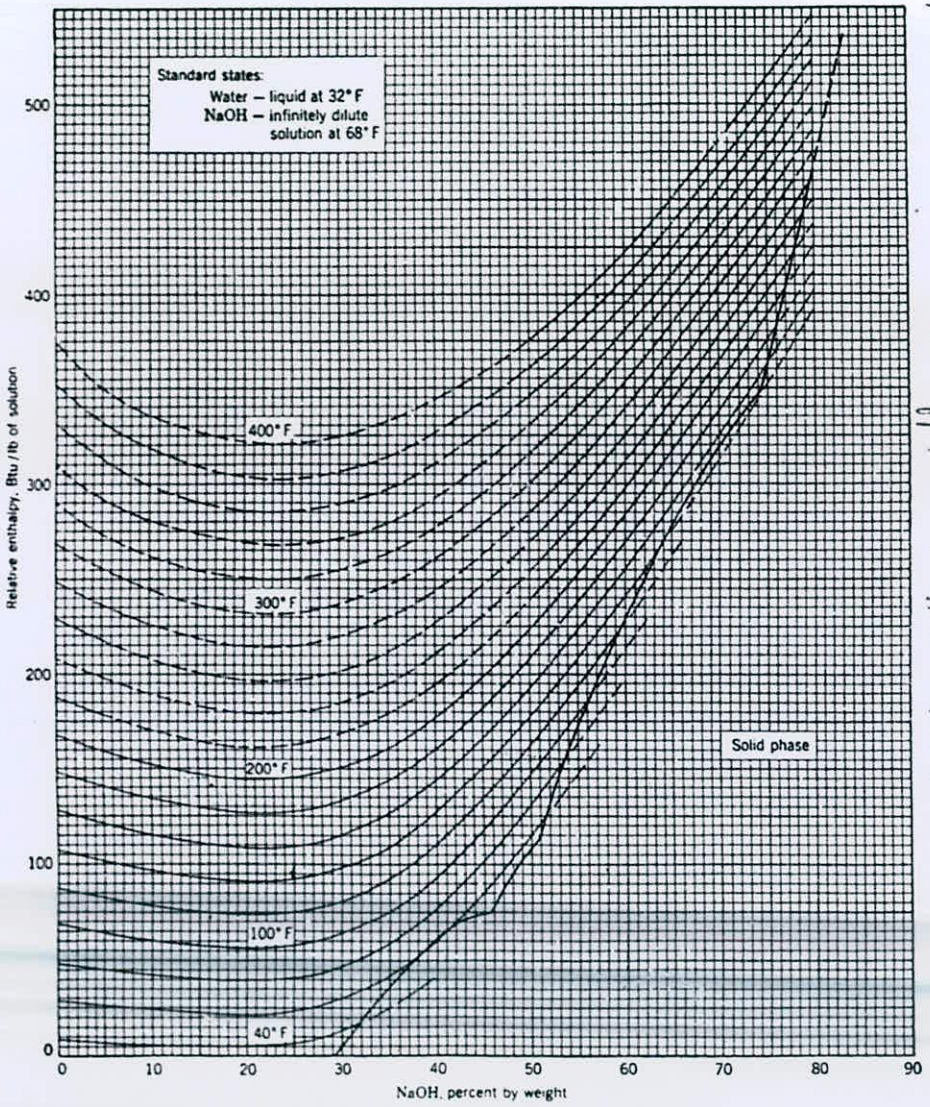


Figure 19.13. Enthalpy-concentration diagram for aqueous solutions of NaOH under a total pressure of one atmosphere. The reference state for water is taken as liquid water at 32°F under its own vapor pressure. This reference state is identical with the one used in most steam tables (8). For sodium hydroxide, the reference state is that of an infinitely dilute solution at 68°F. [From McCabe, W. L., *Trans. A.I.Ch.E.*, *31*, p. 129 (1935), by permission of A.I.Ch.E., copyright © 1935.]

Figure For Question 1(c) Attach with Answer scripts
Mbugua 06/3/2023

=9=

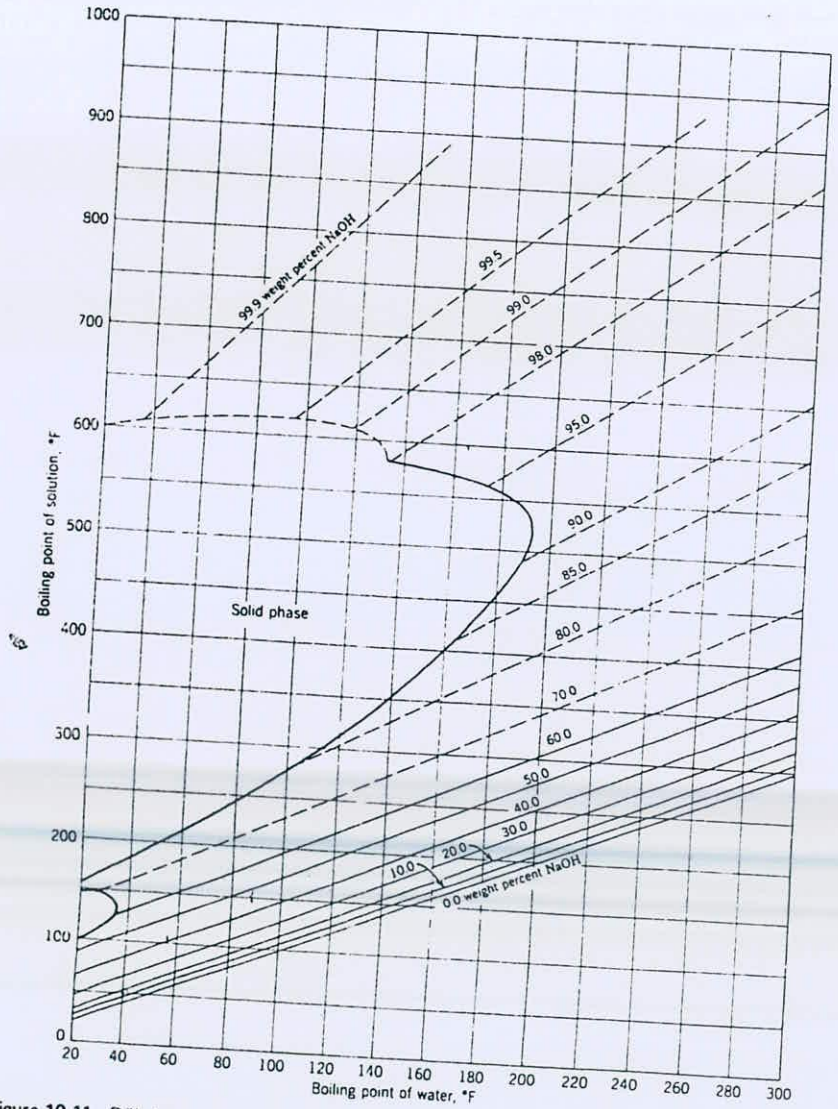


Figure 19.11. Dühring lines for the NaOH–H_2O system.

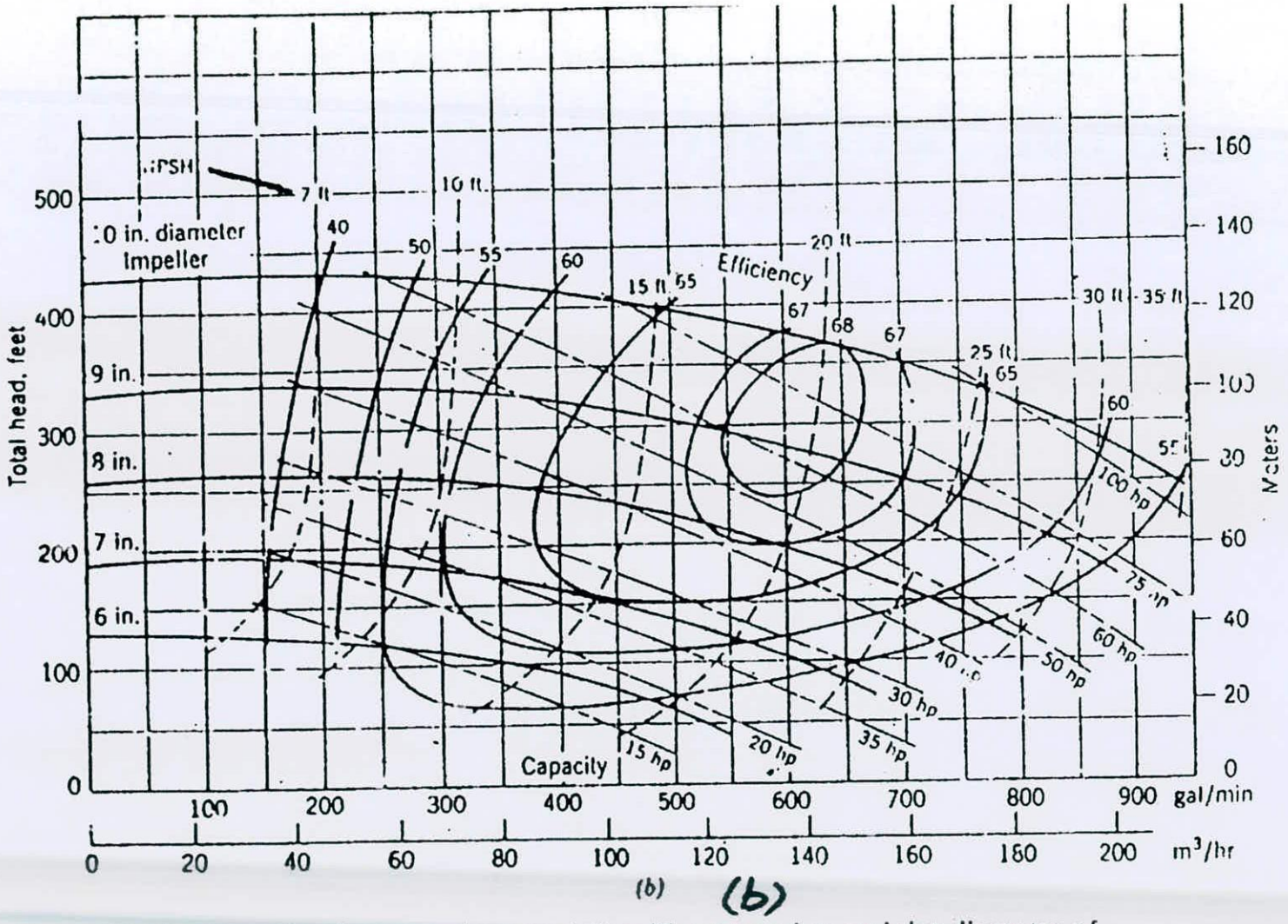


Figure 21.17. Centrifugal pump characteristics. The pump has an inlet diameter of 4 in. and an outlet diameter of 3 in. Its 10-in. casing can contain impellers of 6, 7, 8, 9, or 10 in. as shown. The pump is normally operated at one of two speeds, thereby producing two different characteristic curves: (*a*) 1750 rpm or (*b*) 3550 rpm. (Courtesy Goulds Pumps, Inc.)

Figure for Question no. 3(a)

Figure For Question 3(a) Attach With Answer scripts

= 11 =

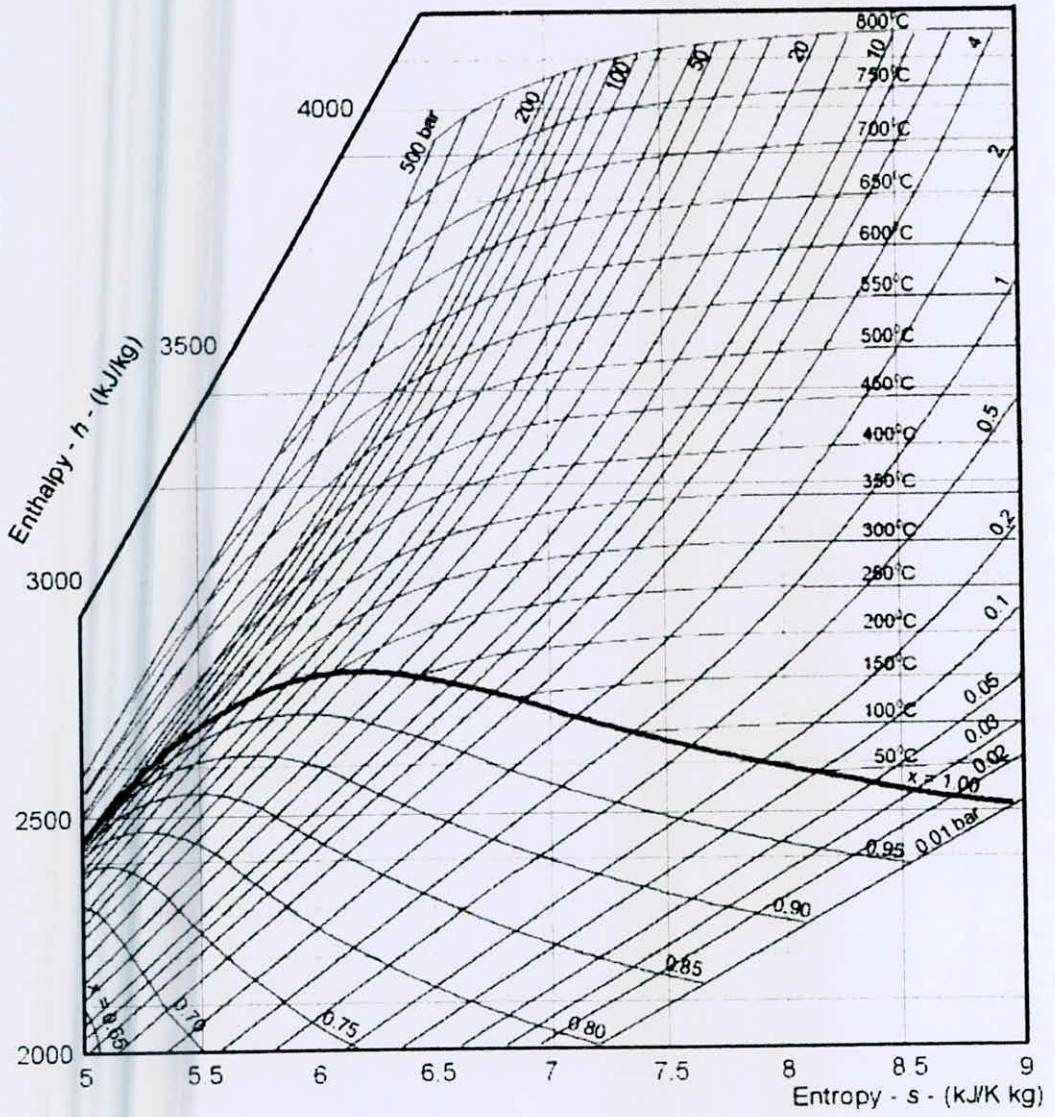
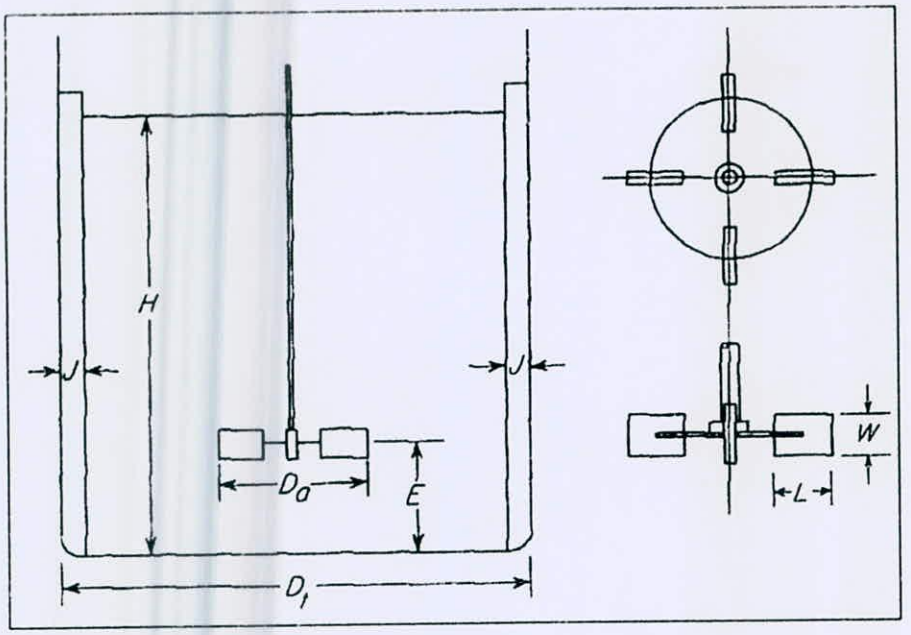


Figure for question no 6(b)



the corresponding shape factors for this mixer are $S_1 = D_a/D_t$, $S_2 = E/D_t$, $S_3 = L/D_a$, $S_4 = W/D_a$, $S_5 = J/D_t$, and $S_6 = H/D_t$. In addition, the number of baffles

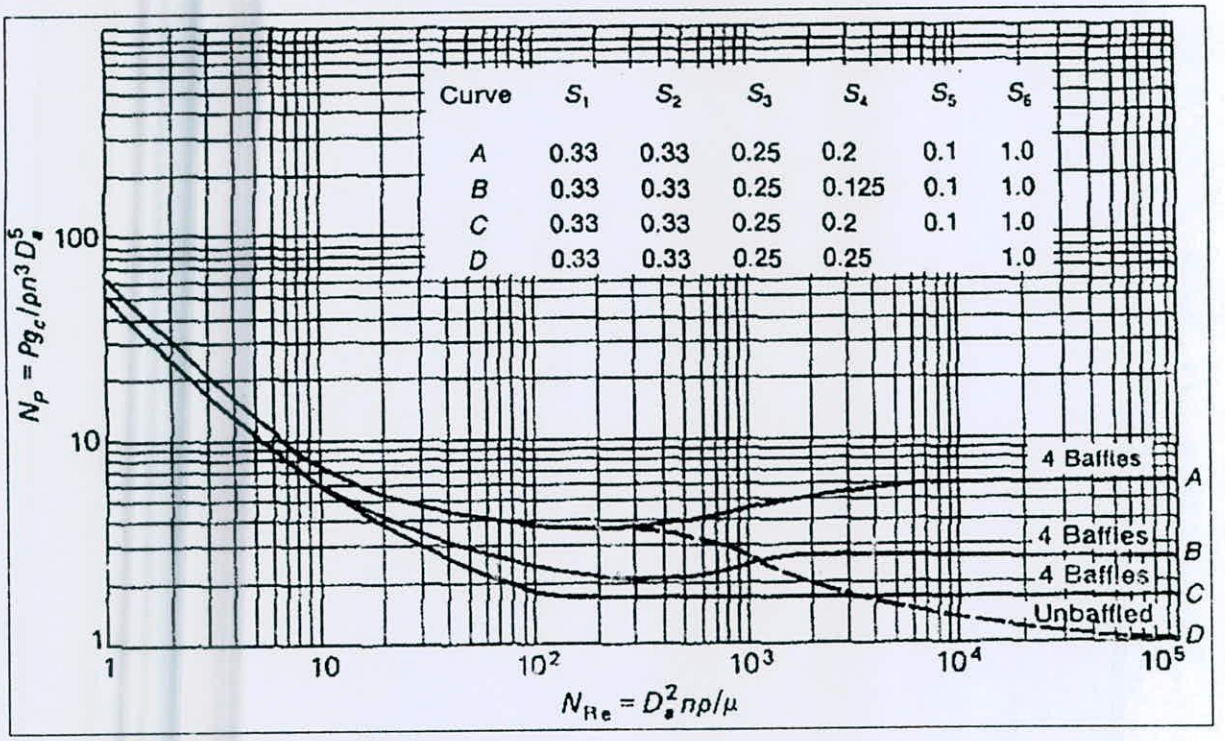


Figure for question no 8(a)

L-3/T-2/CHE **Date: 12/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHE 441** (Fertilizer, Pulp and Paper Technology)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section.

Answer **Q. No. 1** and any **TWO** from the rest. **Q. No. 1 is Compulsory.**

Symbols use have their usual meaning an interpretation.

1. (a) Write short notes on pulp and paper market in Bangladesh and worldwide. **(8)**

   (b) What do you understand by the term "pulp bleaching" in the cases of mechanical and chemical pulping? Why does pulp bleaching process differ for these two pulping technologies? **(12)**

   (c) With the help of a block diagram, show the various waste stream which are produced from the main unit operations of kraft pulping process. **(15)**

2. (a) Discuss the important pulping variables of wood and wood chips. **(8)**

   (b) What is Thermo-mechanical pulp (TMP)? What are the differences between mechanical and chemical pulping process? **(15)**

   (c) What are the advance processes for utilizing black liquor produced in pulp mills (other than combustion)? Briefly describe the lignoboost process with a neat sketch. **(12)**

3. (a) What is H-factor? Write the equation for H-factor. Determine the H-factor for up to 200 min in a digester from Figure for Q. 3(a). **(15)**

   (b) What is a recovery boiler? What are the most critical issues with operating a recovery boiler? How can those be mitigated? **(12)**

   (c) Discuss how you can contribute to the pulp and paper industries as a chemical engineer. **(8)**

4. (a) What are the major steps of paper making process from pulp? Describe using block diagram. **(17)**

   (b) Discuss the type of aqueous effluents generated from the paper industry and explain the effluent treatment system with a neat sketch. **(18)**

Contd P/2

CHE 441

SECTION – B

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

Answer **Q. No. 5** and **TWO** more from the rest.

5. (a) With required flowchart(s)/diagram(s), illustrate adequately the common production routes for the fertilizers used in developing countries. **(8)**

(b) Explain briefly how we should rationalize the use of organic and mineral fertilizers for sustainable agriculture. **(6)**

(c) NPK fertilizer is often considered as superior to DAP fertilizer – state all the reasons. **(6)**

(d) Urea as a fertilizer is in high demand and use in Bangladesh – Justify based on all technical and financial reasons. **(7)**

(e)Identify the adverse impacts of mineral fertilizers on environment considering from manufacturing process to application. **(8)**

6. (a) What would be the consequences if the raw syngas is not purified for the subsequent uses? Name the different methods available for syngas purification and propose the best method with all reasons in the context of Bangladesh. **(5+10=15)**

(b) Identify and state the basic features of ammonia synthesis loop. **(8)**

(c) Make a comprehensive comparison among the different types of ammonia converter available for the synthesis of ammonia. **(12)**

7. (a) Describe briefly the effects of process operating variables on the urea formation reaction. Also explain how the formation of biuret can be minimized. **(8+5=13)**

(b) Most of the new urea plants are based on total recycle process – elaborate the superiority of this process. Also describe the distinguishing features between the total recycle process of Stamicarbon and Snamprogetti. **(5+10=15)**

(c) Identify the major utilities which are required for the manufacture of urea. **(7)**

8. (a) List the major factors which affect and determine the quality of phosphate rock. **(10)**

(b) How does TSP differ from SSP? Demonstrate the production process of SSP with the help of a block diagram. **(4+8=12)**

(c) Write a short note on the abatement of particulate and gaseous emission in the SSP-TSP production complex. **(8)**

(d) State the salient advantages of non-granular MAP fertilizer. **(5)**

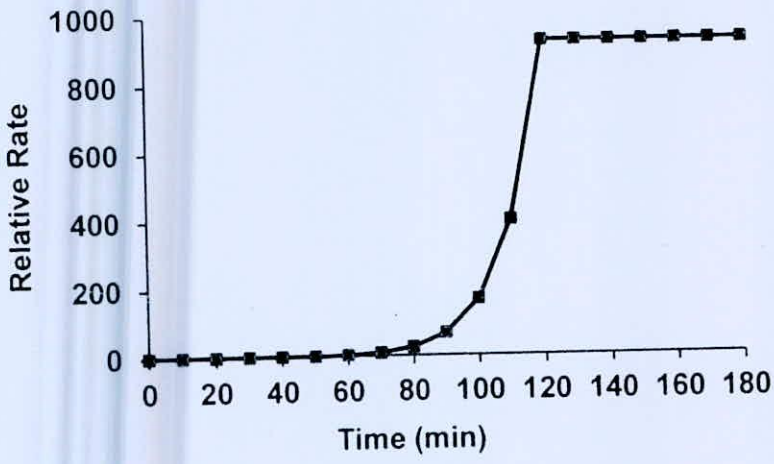


Figure for Q. 3(a).

L-3/T-2/CHE **Date: 05/04/2023**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHE 473** (Biochemical Engineering I)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

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

1. (a) What are the different types of lipids? Describe with generic chemical structures. **(08)**

(b) Given enzyme-catalyzed reaction $k_1 = 7\times10^7$ M-1 s^{-1}, $k_{-1} = 8 \times 10^5$ s^{-1} and $k_2 = 5 \times10^4$ s^{-1}. Determine if it is appropriate to use the rapid equilibrium scheme to model the kinetics of a catalyzed reaction? **(7)**

(c) Why does the sandwich ELISA method generally show a higher degree of sensitivity compared with the direct-binding ELISA method? **(08)**

(d) Rapid Antigen test is one of the fastest methods to detect covid positive patients. With the help of relevant schematics explain the mechanism and mention the components involved in the process. **(12)**

2. (a) A chemostat study was performed with yeast. The medium flow rate was varied and the steady-state concentration of cells and glucose in the fermenter were measured and recorded. The inlet concentration of glucose was set at 100 g/L. The volume of the fermenter contents was 500 mL. The inlet stream was sterile. **(10+5=15)**

Flow rate F, mL/hr	Cell Conc. C_x, g/L	Substrate Concrete. C_s, /g/L
31	5.97	0.5
50	5.94	1.0
71	5.88	2.0
91	5.76	4.0
200	0	100

(i) Find the parameters of the Monod equation.

(ii) What should be the range of the flow rate to prevent washout of the cells?

(b) Develop a comparison table for the three modes of fermentation used in the industries. **(12)**

Contd P/2

CHE 473

Contd... Q. No. 2

(c) List the typical steps involved in insulin production in the pharmaceuticals industries. **(08)**

3. (a) What is C-ELISA? How is it different than regular ELISA? Explain with its specific applicability. **(10)**

(b) Name the eight macronutrients required for cell growth and mention their main physiological function. **(12)**

(c) What are the classification of microorganisms on the basis of carbon source? List few major carbon sources used in the fermentation industries. How would you differentiate bacteria in the laboratory based on Gram reaction? **(4+3+6=13)**

4. (a) "Allosteric enzymes do not follow the Michaelis-Menten Kinetics" – explain in details. **(07)**

(b) Write down the reaction scheme for substrate inhibition and explain with the help of relevant plots. Derive the equation for the maximum substrate concentration. **(10)**

(c) To determine the kinetic properties of an enzyme, in the presence and absence of two inhibitors (I-1 and I-2), a student of experiments were performed at pH 7.5 in presence of 0.1 M KC1. The substrate was varied between 1 and 20 mM at 25°C. The following data were obtained: **(18)**

Velocity, nanomol/min			
[S], mM	no inhibitor	5 mM I-1	10 mM I-2
1	2.5	1.17	0.77
2	4	2.1	1.25
5	6.3	4	2
10	7.6	5.7	2.5
20	9	7.2	2.86

With the help of Linewever-Burk Plot, estimate the K_m and V_{max} for each set of data. What type of inhibitors are I-1 and I-2?

Contd P/3

CHE 473

SECTION – B

There are **FOUR** questions in this section. Answer **Q. No. 5** is **Compulsory** and carries 45 marks. Answer any 2(two) questions from Q. No. 6 to 8. These are 30 marks each.

5. (a) For a textile wastewater treatment facility in Bangladesh, what design and operational factors will you consider to choose between biological trickling filters and activated sludge wastewater treatment processes? **(15)**

(b) What is the difference between pasteurized milk and UHT milk from a sterilization point of view? What drawbacks may you encounter in batch steam sterilization of culture media or products such as milk? Explain with temperature profile how continuous sterilization is a valid alternative to batch sterilization of milk. **(15)**

(c) How do different process parameters affect composting? Explain the compost maturity assessment process with a flowchart. **(15)**

6. (a) Briefly explain the purposes and sub-purposes of pasteurization in preserving orange juice and liquid egg. **(6)**

(b) Explain how ionizing radiation can be used as a method of sterilization in food preservation? **(6)**

(c) Explain the mechanisms of biological processing and cold treatment processing in related to food processing. **(6)**

(d) Explain why Benzoic acid is used as a chemical preservative for foods like pickle relishes, tomato ketchup, and apple cider? **(6)**

(e) Explain the role of microorganisms in the nitrogen cycle. **(6)**

7 Different sterilization methods are applied to materials, equipment, and products in the pharmaceutical and biotechnology industries. Which industrial sterilization method(s) are chosen for the following cases in such industries? Briefly explain your reasons for selecting each case's most appropriate and corrosion-effective sterilization method(s). **(30)**

Case No.	Material, Equipment, or Product to be Sterilized	Type of Material, Equipment, or Product	Physical State of Material to be Sterilized
i.	Microbiological equipment and apparatus	Permanent or disposable equipment	Solid
ii.	Injectable solid drugs	Product	Solid
iii.	Laminar flow air	Supply	Gas
iv.	Sterile rooms	Permanent equipment	Solid
v.	Fats	Nutrient	Liquid
vi.	Sterile process water	Supply	Liquid
vii.	Disposable filters	Disposable equipment	Solid
viii.	Silicone oils	Supply	Liquid
ix.	Sterile room air	Supply	Gas
x.	Vials	Disposable supplies	Solid

CHE 473

8. (a) Draw a schematic diagram of an activated sludge unit of a biological waste treatment. Label it properly and derive steady-state material balance equations for biomass and rate-limiting substrates in an activated-sludge tank. Assuming the substrate is not separated in the settling tank, derive an equation for solids' residence time in the sludge tank. **(12)**

(b) A domestic waste with an inlet BOD_5 of 350 mg/l must be treated to reduce the exit BOD_5 level to ≤ 10 magnitude/l. The inlet flow rate is 200 m^3/h. Kinetic parameters have been estimated for waste as $\mu_m = 0.50\ h^{-1}$, $K_s = 70$ mg/l of BOD_5, $Y^M_{X/S} = 0.58$ mg MLVSS/mg BOD_5, and $k_d = 0.0025\ h^{-1}$. A waste treatment unit of 1,200 m^3 is available. Assume a recycle ratio of 0.40 and $X_e = 0$. If you operate at a value of θ_c = 120 h, find S and determine if sufficient BOD_5 removal is attained in a well-mixed activated-sludge process to meet specifications. What will be X and the sludge production rate from this process? **(18)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-2 B. Sc. Engineering Examinations 2020-2021

Sub: **CHE 481** (Environmental Science I)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

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

1. (a) Explain that

"ESP' is more efficient process to separate very small particles from gases compared to centrifugal separator." **(10)**

(b) Estimate the collection efficiency of the electrostatic precipitator describe below for a particle 154 μm in diameter having a drift velocity of 0.184 m/s. What is the effect of reducing the plate spacing to one-half of its current value and doubling the number of plates? **(15)**

ESP specifications : Height = 7.32 m

Length = 6.10 m

Number of passages = 5

Plate spacing = 0.28 m

Gas flow rate = 19.73 m^3/s

$$\eta = 1 - \exp\left(\frac{Aw}{Q_g}\right) \qquad w = \frac{qE_pC}{6\pi r\mu}.$$

(c) Describe the particle separation mechanisms of bag filter. – *illustrate* with diagram. **(10)**

2. (a) Propose the mitigation of the breathing loss of VOC from Storage tank? - *Illustrate* with diagram. **(10)**

(b) *Propose* the suitable conditions of scrubbing fluid to remove SO_2 from lean waste gases effectively? –- *Illustrate* them with figure. **(10)**

(c) *Calculate* the breakthrough time for toluene on an adsorption h=bed of activated carbon that is 0.75 m thick and 5.0 m^2 in cross section. The operating parameters for the bed are as follows: **(15)**

Gas flow rate = 1.185 kg/s

Gas temperature = 25°C

Bed density = 450 kg/m^3

Inlet pollutant concentration = 0.00350 kg/m^3

Langmuir parameters: a = 465; b = 3,000

Contd P/2

CHE 481

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

Width of adsorption zone = 0.045 m

$$v_f = \frac{(Q_g)(1 + bC_g^*)}{ap_s p_g A_c} \qquad t_B = \frac{Z_r - \delta}{v_f}$$

3. (a) It has estimated that the emission of SO_2 from a coal-fired power plant is 1, 656.2 g/s. Calculate the concentration of SO_2 at a point 4 km downwind and 0.2 km perpendicular to the plume centerline (y = 0.2 km) on an overcast summer afternoon and the wind speed is 4.50 m/s. if there is an inversion with a base height of 200 m. **(15)**

(Note: "Centerline" Implies y = 0.)

Stack parameters:

Height = 120.0 m

Diameter = 1.20 m

Exit velocity = 10.0 m/s

Temperature = 315°C

Atmospheric conditions:

Pressure = 95.0 kPa

Temperature = 25.0°C.

(b) Briefly discuss key differences between major Air pollution models. Sketch a typical stack emission profile and label the major parameters of the Gaussian dispersion model. **(10)**

(c) "Stratospheric oxygen ground level is beneficial to living beings whereas Stratospheric level oxygen is detrimental to living beings" *Explain it.* **(5)**

(d) Give an outline of photochemical smog formation in the atmosphere. **(5)**

4. (a) *Discuss* the different Noise Rating Systems. **(8)**

(b) *List* key parameters of the Control of Noise Source by Redress and *Illustrate* them. **(15)**

(c) *Describe* the Threshold Shift of human ears. **(6)**

(d) Consider the case where a noise level of 90 dBA exists for five minutes and is followed by a reduced nose level of 60 dBA for 50 minutes. Calculate the equivalent continuous equal energy level for the 55-minutes period? Assume of a five-minute sampling interval. **(6)**

Contd P/3

CHE 481

SECTION – B

There are **FOUR** questions in this section.

Question No. 5 is Compulsory. Answer any **TWO** form the rest.

5. (a) What are the major goals of "The Clean Water Act of 1972"? Classify industries based on ECR 1997. How can you get a clearance certificate for green and red category industry? **(11)**

(b) A l-L sample contains 22 g of casein ($C_8H_{12}O_3N_2$). If 18 g of bacterial cell tissue ($C_5H_7NO_2$) is synthesized per 50g of casein consumed, determine the amount of oxygen required to complete the oxidation of casein to end products and cell tissue. The end products of oxidation are carbon dioxide (CO_2). ammonia (NH_3), and water. Assume that the nitrogen is not incorporated in cell-tissue production to convert to ammonia. **(12)**

(c) When advance oxidation process (AOP) should be applied? Classify AOP based on the way of hydroxyl radical production in wastewater treatment, Compare it with the adsorption process. **(12)**

6. (a) A city discharges 25 million gallons per day of domestic sewage into a stream with a typical flow rate of 250 cubic feet per second (cfs). The velocity of the stream is approximately 3 miles per hour. The temperature of the sewage is 21°C, while that of the stream is 15°C. The 20°C sewage BOD_5 is 180 mg/L, while that of the streams BOD_5 is 1.0 mg/L. The sewage contains no dissolved oxygen, but the stream is 90% saturated upstream of the discharge. At 20°C, deaeration constant (the BOD rate constant) is estimated to be 0.34 per day while reaeration constant is 0.65 per day. **(28)**

i) Determine the critical-oxygen deficit and its location.

ii) Also estimate the 20°C BOD_5 of a sample taken at the location.

Derive all the necessary equations. Assume a reasonable value for any data missing.

(b) Illustrate bacterial growth with respect to time. What are the limiting factors? **(7)**

7. (a) Design two flocculation basins by determining the basin volume, tank dimensions', required input power, impeller diameter, and rotational speed using the following parameters and the manufacturer's data: **(27)**

Design flow rate in the process = 11.5×10^3 m^3/d

Flocculation t = 30 min

There flocculator compartments with G = 70, 50, 30 s^{-1}

Water temperature = 25°C

Contd P/4

CHE 481

Contd... Q. No. 7(a)

Motor efficiency = 80%

Place impeller at one-third the water depth

From manufacturer's data the following impellers are available:

Impeller type	Diameter			Impeller constant
Radial	0.3	0.4	0.6	5.70
Axial	0.8	1.4	2.0	0.31

(b) Briefly discuss with illustration of different aeration techniques used in wastewater treatment process and their key selection criteria. **(15)**

8. (a) An adsorption study was conducted by adding varying amounts of activated carbon to a series of seven flasks containing 500 mL of feed water used in soft drink preparation having an initial TOC of 20 mg/L. The flasks were agitated for 14 h, and the residual steady-state TOC concentrations were determined. Plot the Langmuir adsorption isotherm from the data presented below and determine the values of the appropriate constants. **(20)**

Flask No.	Carbon Dosage (magnitude)	Final TOC (magnitude/L)
1	0	20
2	4.4	14
3	9.7	10
4	14	7.0
5	28	4.0
6	56	2.6
7	140	0.8

(b) Illustrate the organic conversions in anaerobic systems. How much methane gas can be generated through complete anaerobic degradation of 2 kg COD at STP. **(15)**

TABLE 6-5
Key to stability categories

Surface Wind speed (at 10 m) (m/s)	Day[a]			Night[a]	
	Incoming solar radiation			Thinly overcast or ≥ 4/8 Low cloud	≤ 3/8 Cloud
	Strong	Moderate	Slight		
<2	A	A–B	B		
2–3	A–B	B	C	E	F
3–5	B	B–C	C	D	E
5–6	C	C–D	D	D	D
>6	C	D	D	D	D

[a] The neutral class, D, should be assumed for overcast conditions during day or night. Note that "thinly overcast" is not equivalent to "overcast."

Notes: Class A is the most unstable and class F is the most stable class considered here. Night refers to the period from one hour before sunset to one hour after sunrise. Note that the neutral class, D, can be assumed for overcast conditions during day or night, regardless of wind speed.

"Strong" incoming solar radiation corresponds to a solar altitude greater than 60° with clear skies; "slight" insolation corresponds to a solar altitude from 15° to 35° with clear skies. Table 170, Solar Altitude and Azimuth, in the Smithsonian Meteorological Tables, can be used in determining solar radiation. Incoming radiation that would be strong with clear skies can be expected to be reduced to moderate with broken (5/8 to 7/8 cloud cover) middle clouds and to slight with broken low clouds.

Source: D. Bruce Turner, *Workbook of Atmospheric Dispersion Estimates*.

Attach With Answer scripts

Figure For Question 3(a)

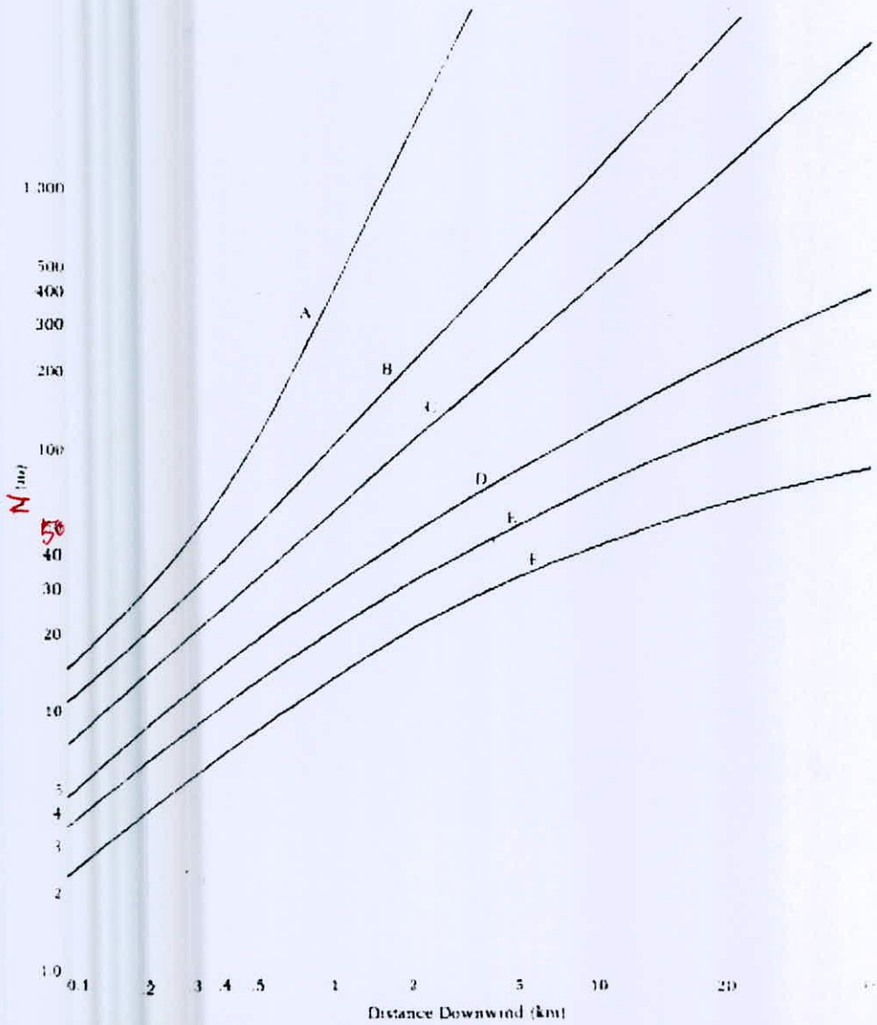


FIGURE 6-21
Vertical dispersion coefficient. (*Source:* Turner, *Workbook of Atmospheric Dispersion Estimates.*)

Attach With Answer scripts

Figure For Question 3(a)

= 6 =

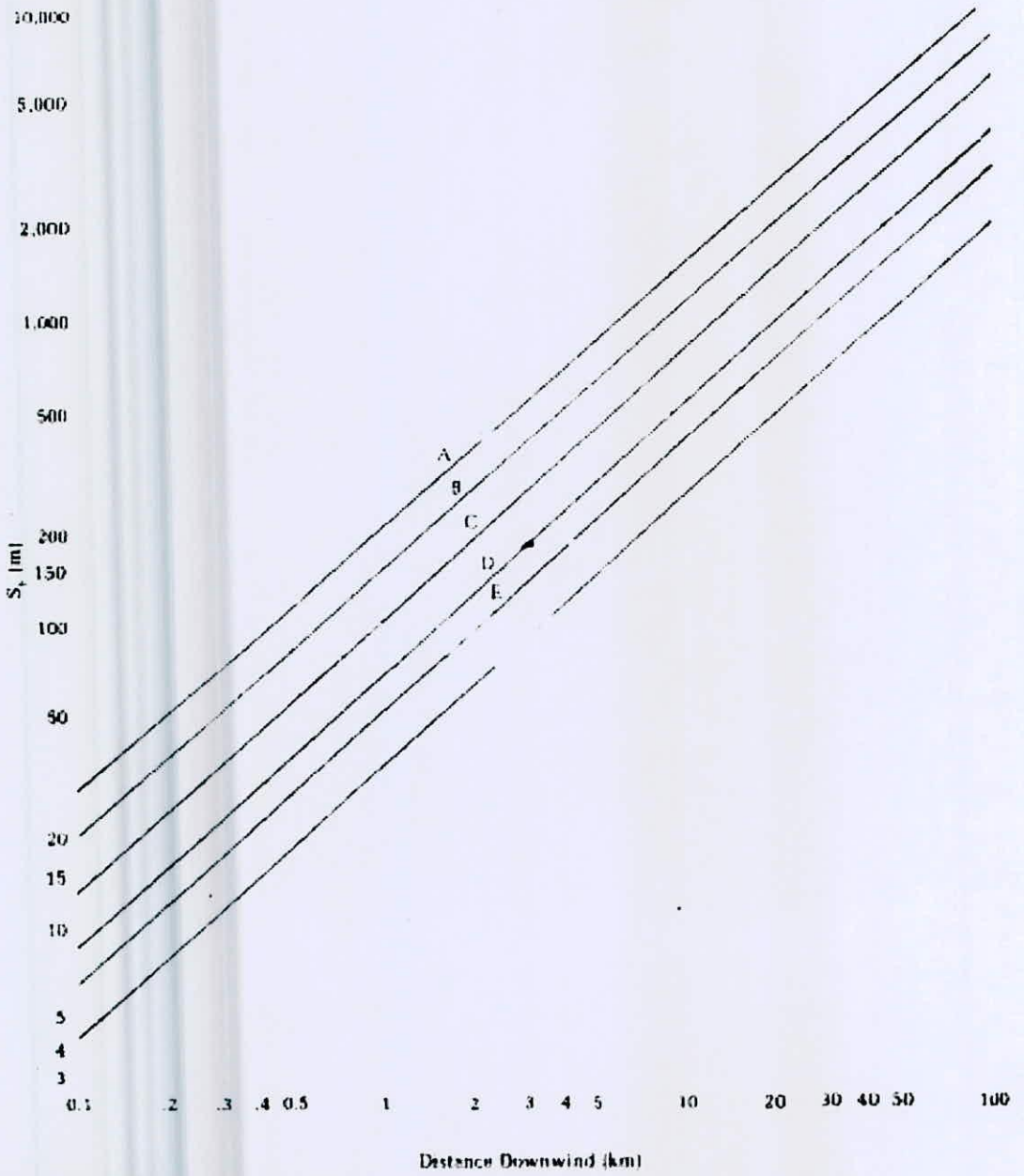


FIGURE 6-20
Horizontal dispersion coefficient. [*Source:* Turner, *Workbook of Atmospheric Dispersion Estimates* (U.S. Department of Health, Education and Welfare, Public Health Service, National Center for Air Pollution Control Publication No. 999-AP-28), Washington, DC: U.S. Government Printing Office, 1967.]

Attach With Answer scripts

Figure For Question 3(a)